Horizon 2020

INVESTMENT COMPONENT | MeHSIP-PPIF

MeHSIP-PPIF

PHASE II

Extension of Al-Ghadir Wastewater Treatment Plant - Lebanon

Environmental and Social Impact Assessment

TA 2008/S 140-186933 (RG/2008/01/FSF)

December 27, 2012

MeHSIP-PPIF

Mediterranean Hot Spot Investment Programme Project Preparation and Implementation Facility







Working program for project preparation

Name of Underlying Project:	MeHSIP-PPIF
	Mediterranean Hot Spot Investment Programme
	Project Preparation and Implementation Facility
Date:	27/12/2012
Version:	3

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Certified EIA practitioners by the Ministry of Environment according to Lebanese Laws & Regulations

REVISION	DATE	DESCRIPTION	PREPARED BY (AUTHOR)	REVIEWED BY
0	03/10/2012	ESIA Pre-draft Report	R.Kayal, M. Kahi, B. Shamas, N.Medawar, W. Halabi, B. Idriss, R. Ghanem, Cady Nasr	R.Khoury, S. Papageorgiou , G. Akl, T. Young
1	19/11/2012	ESIA Draft Report	R.Kayal, M. Kahi, N.Medawar, W. Halabi, B. Idriss, R. Ghanem, Cady Nasr	R.Khoury, S. Papageorgiou , G. Akl, T. Young
2	27/12/2012	ESIA Final Report	R.Kayal, M. Kahi, N.Medawar, W. Halabi, B. Idriss, R. Ghanem, Cady Nasr	R.Khoury, S. Papageorgiou , G. Akl, T. Young

Document nr: 5080309/30/DG/121

Disclaimer

The programme is financed under the FEMIP Support Fund. This Fund utilises non-repayable aid granted by the European Commission in support of EIB investment activities in the southern Mediterranean countries, assisting promoters during different stages of the project cycle.

The authors take full responsibility for the contents of this report. The opinions expressed do not necessarily reflect the view of the European Union nor that of the European Investment Bank.





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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 Establishmen
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
СНР	Cogeneration of Heat-Power
СНР	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
НАР	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 Organizations
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).

<u>Legislative Framework Relevant to the Project</u>

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:

- <u>Project Component 1:</u> The construction of networks in the Al-Ghadir WWTP Drainage

 Area
- <u>Project Component 2:</u> The extension and upgrade of the existing Al-Ghadir Preliminary Treatment Facility.

<u>Description of Project Component 1 - Construction of Networks</u>

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.

<u>Description of Project Component 2 - WWTP Extension and Upgrade</u>

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 this 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 this 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	Phase II 2030-2050 Upgrade the WWTP to secondary level of treatment by 2030						
		Complete the remaining Networks to serve 22.5% of PE					
Total For Networks							
Total For Trea	atment Plant Exte	ension 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 <u>aerobic</u> 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 (SO₂), 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,



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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 o.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



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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 lawenforcement 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



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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.

FNVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

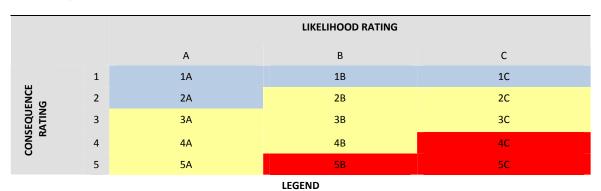
Impact Assessment Methodology

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 reassessed.



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



Consequences		Likelihood	Acceptab	ility
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 O	perati	ion Imp	oacts V					res
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	Summary of WWTP Construction and Operation Impacts With Mitigation Measures								
Impact/Pathway	Water Resources	Air Quality	Acoustic Environment	Landscape	Land Use	Soil & Sediments	Biodiversit y	Socio- Economic	Occupation al 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 **Excavation and Trenching** 3В **Job Creation** 6C **Land Expropriation** 2C 4A **Traffic Generation Operation Phase General Operation** 1A 1A 6C 6B 6B 4B Oil Spills **3B Wastewater Leakages 3**A **Public Health** 6C

Summary of Networks' Construc	tion an	d Ope	ration	Impac	ts Wit	h Mitig	ation	Measu	ires
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 TechniquesRaising 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 	Implementation: Contractor	Included in contractor cost
		 Adopting and implementing IFC guidelines for the prevention and control of hydrocarbon / chemical releases 	Supervision: Supervision Consultant	
		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. 		
Air quality	General construction	 Using well designed, well maintained and well operated equipment/vehicles 	Implementation:	Included in
		 Employing environmentally friendly equipment (higher fuel efficiency, air pollution control devices). 	Contractor	contractor cost
		 Installing diesel particulate filters on construction equipment 	Supervision: Supervision Consultant	
		 Watering-down work area/s particularly near sensitive receptors 	Supervision sonsultant	
		 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.		



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	Included in contractor cost
			Supervision: Supervision Consultant	
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:	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 	Supervision Consultant 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 TechniquesRaising Construction Workers' Awareness	Implementation: Contractor	Included in contractor cost
			Supervision: Supervision Consultant	
	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 	Implementation: Contractor	Included in contractor cost
		 Adopting and implementing IFC guidelines for the prevention and control of hydrocarbon / chemical releases (International Finance Corporation's Environmental, Health, and Safety General Guidelines) 	Supervision: Supervision Consultant	
		 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.		
	Dredging activities	Using Silt CurtainsReducing velocity of dredging	Implementation: Contractor	Included in contractor cost
		 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 	Supervision: Supervision Consultant	



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	Implementation: Contractor	Included in contractor cost
		 Employing environmentally friendly equipment (higher fuel efficiency, air pollution control devices). 	Supervision: Supervision Consultant	
		 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 		
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	Implementation: Contractor	Included in contractor cost
		All vehicles and machinery should be maintained in good repair	Supervision:	
		 Any machinery, which is intermittent in use, should be shut off in periods of non-use 	Supervision Consultant	
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	Included in contractor cost
			Supervision: Supervision Consultant	
Soil and sediments	Land excavation and trenching works, oil	 Adhering to proper waste management practices Keeping all equipment well maintained and adopting a # 	Implementation: Contractor	Included in contractor cost
	spills, and solid and liquid waste generation		Supervision: Supervision Consultant	
	Land reclamation/	Using silt curtains	Implementation:	Included in
	dredging activities	 Reducing velocity of dredging 	Contractor	contractor cost
		 Decreasing the time-frame over which the dredging operation is to take place 	Supervision:	
		 Confining dredging operations to calmer sea states 	Supervision Consultant	



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	Implementation: Contractor	Included in contractor cost
		 Raising the awareness of workers on the respect and preservation of wildlife 	Supervision:	
		 Spreading excavated topsoil containing pollen and roots of the original vegetation upon completion of construction works 	Supervision Consultant	
		 Conducting a biodiversity assessment over the network routes prior to the start of works on networks 		
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 	Contactor Supervision consultant Municipalities	Included in contractor cost
		 Developing an "Archaeological Intervention Plan" in coordination with the DGA 	Local committee	
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)	Implementation: Contractor	Included in contractor cost
		 Warning staff about potential construction hazards 	Supervision:	
		 Ensuring that qualified and accessible first-aid is provided at all times 	Supervision Consultant	
		 Posting signs throughout the construction area 		



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 	Plant operator(s)	Industrial pollution abatement plan:
		• The preparation, implementation and monitoring of an industrial pollution abatement		Preliminary survey:

Impacted VEC	PROJECT ACTIVITY (Impact/ Pathway)	MITIGATION MEASURES	INSTITUTIONAL RESPONSIBILITIES	COST ESTIMATE
		program in the Al-Ghadir drainage area		~300,000 USD
		Ensuring redundancy in the WWTP designEnsuring adequate training of plant operators		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 H2S and NH3) remain below threshold values at the nearest receptors 	Plant operator(s)	Odor simulation study: 10,000 USD
		 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 		
	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 (NaOCI, NaHSO₃), oils, and fuel to be used onsites Providing hand railing at all access corridors above and around all open treatment units, (except where sidewalls extend 21.1 meters above ground level); 	Plant operator(s)	Included in operator cost
		 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. 		



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.

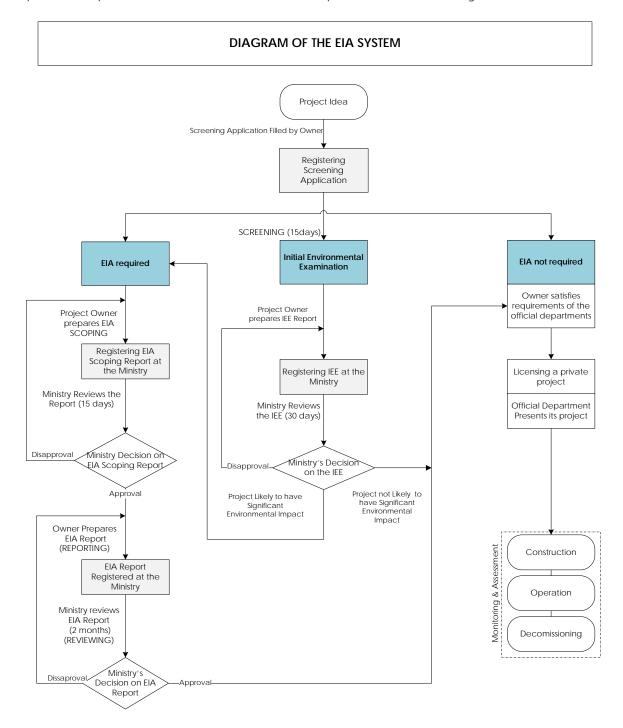


Figure 1.1 EIA Process as per Decree No. 8633 (EIA Decree)



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 asneeded 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 GUIDFLINES

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		
рН	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
рН	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 ALLO	DWABLE LIMITS FOR RECEIVIN	IG 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
oliform 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
lexavalent 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 + NH₃),NO₃-N, NO₂-N

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
рН	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)< td=""></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)< td=""></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)< td=""></pe<100.000)<>
PO ₄ ³⁻ (mg P/I)	5	-
Total Coliform 37°C (MPN/100 ml)	2000	-
Salmonellae:	absence	-

¹ Optional

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^{**}For discharges in close distance to bathing water, a stricter environmental limit value could be necessary



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

	LIMIT FOR NOISE LEVEL DB(A)		
REGION TYPE	DAY TIME (7:0018:00.)	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
1/2	110
1/4	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/m³)	AVERAGING PERIOD
	350	1 hour
Sulfur Dioxide (SO ₂)	120	24 hours
	80	1 year
	200	1 hour
Nitrogen Dioxide (NO ₂)	150	24 hours
	100	1 year
0 (0)	150	1 hour
Ozone (O ₃)	100	8 hours
0 14 14 (00)	30000	1 hour
Carbon Monoxide (CO)	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/m³ (for new facilities) 500 mg/m³ (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, TI	As, Co, Ni, Se, Te	Sb, Pb, Cr, CN, F, Cu, Mn, Pt, Pd, Rh, V, Sn	-						
	GASEOUS INORG	ANIC POLLUTANTS							
Group I	Group II	Group III	Group VI						
AsH3, CICN, COCI2, HP	HBr, Cl2, HCN, HF, H2S	HCl not mentioned at Group I	SOX, NOX						
	CANCER CAUSI	NG 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	To reduce intentional and unintentional production of POPs	Regulates the emissions of POPs from waste burning
Signed by Lebanon in 2001	To develop country-specific implementation plans for this purpose	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 <u>Energy efficiency measures</u> <u>Reconstruction</u>
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
А	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.
В	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.
С	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.
- 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

Mediterranean Hot Spot Investment Programme



Project Preparation and Implementation Facility (MeHSIP-PPIF)

A TA operation funded by the European Union - FEMIP Support Fund

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< th=""><th>6< pH <7</th><th>pH ≥7</th></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 FRAMFWORK

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. <u>Law 221 of 29 May 2000</u> 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:
 - o Monitoring, studying and estimating the volume of water resources and estimating water needs and uses in all regions;
 - o 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;
 - o 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;
- o Public relations and informing citizens about water issues and conservation; and
- o 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 km² (area served by the six (6) former water authorities known as Beirut, Jbeil, Barouk, Metn, Ein el Delbe and Kersouan²). 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.

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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.

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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)

MUNICIF	PALITY
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
	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
32.	Ghobeyre Hadath
33.	Haret el Sett
34.	Haret Hreik
35.	Houmale
	Kahhale
	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 Mol 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

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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		WATEI RESOURG			URBAN PLANNING/	STANDARDS	ENFORCE-	MARINE ENVIRONMENT	PROTECTION OF Natural	Wastewater Discharge	SOLID WASTE MANAGEMENT	Issuing Permits
	INFRASTRUCTURE	диашту &	SANITATION	DISTRIBUTION	ZONING	SLATION		Protection	Resources			
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/	STANDARDS	ENFORCE-	Marine Environment Protection	PROTECTION OF NATURAL RESOURCES	Wastewater Discharge		Issuing Permits
	INFRASTRUCTURE	QUALITY &	DISTRIBUTION &SUPPLY	ZONING	SLATION		PROTECTION	NESOURCES			
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 $\,\mathrm{m}^3/\mathrm{s}$, and the current pumping station has a capacity of 2.6 $\,\mathrm{m}^3/\mathrm{s}$.

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	Lab	oratory Resi (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	60	60	600	After screens	481	1050	734
mg/L				After aerated de-gritters	402	894	585
Volatile Suspended Solids	not available	not available	not available	After screens	177	630	380
mg/L				After aerated de-gritters	154	570	307
COD mgO₂/L	125	125	500	After screens	376	986	677,3
				After aerated de-gritters	327	824	556,8
BOD ₅ mgO₂/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	30	30	60	After aerated de-gritters			
of Kjeldahl-N)	10	10	10	After gerated de militaria	-	-	-
Total Phosphorous mgP/L Iron total (Fe) mg/L	10 5	10 5	10 5	After aerated de-gritters	0,46	- 5.72	2,12
` , ,				After agrated de-gritters		5,72	
Copper total (Cu) mg/L Chromium total (Cr) mg/L	1,5 2	0,5 2	2	After aerated de-gritters After aerated de-gritters	0,06	0,92 0,24	0,43
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	0,19	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)	3	3	Not available	After aerated de-gritters	12	19	14
mg/L	3	3	Not available	Arter derated 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 o.3° (Costain, 1995). The deviation affects the last o.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 m³/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 m³/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.

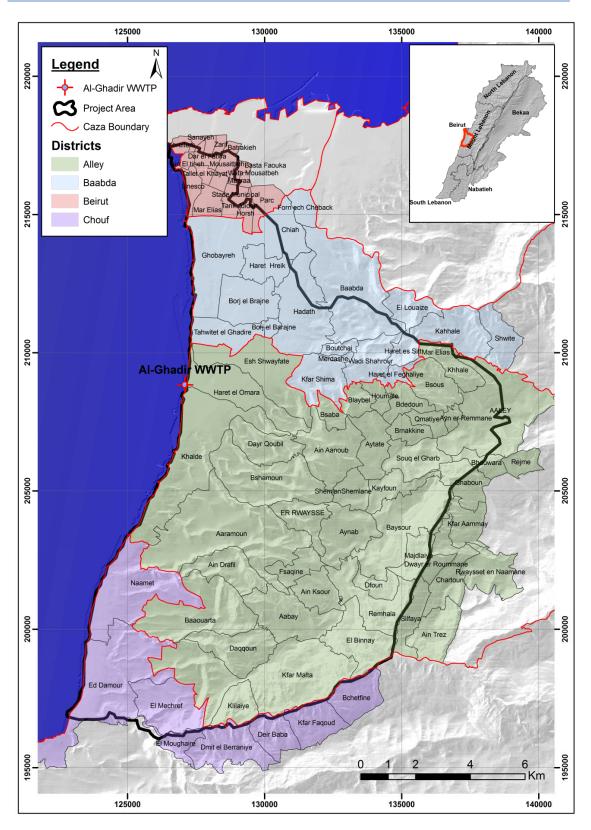


Figure 3.3 Project Location and Study Area



3.4 PROJECT COMPONENTS

The proposed Project consists of two main components:

- <u>Project Component 1:</u> The construction of networks in the Al-Ghadir WWTP Drainage Area.
- <u>Project Component 2:</u> 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:

- 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 Mazraaa3. 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.

³Areas 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, V	ILLAGES, SETTLEMENTS	POPULATION	LENGTH OF SECONDARY EXISTING	LENGTH OF SECONDARY SEWERS TO BE EXECUTED (m)
ZONE	NAME		SEWERS (m)	
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 this 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 this 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:
 - o Initial Lifting Pumping Station;
 - Screening; and
 - o Aerated De-gritting Chambers.
- Primary Treatment Unit (lamella settling tanks);
- Secondary Treatment Unit, including:
 - Anoxic tanks;
 - Aeration tanks;
 - o Secondary Settling Tanks; and
 - Chlorination/de-chlorination tanks.
- Sludge Treatment Facilities, including:
 - o 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;
 - o Anaerobic Digestion Treatment, for mixed sludge;
 - o Mechanical Dewatering of digested sludge; and
 - Storage of dewatered sludge.
- Biogas Utilisation Unit, including:
 - Biogas Collection and Storage;
 - o Combined Heat Power (CHP) Engines, for power production; and
 - o Emergency Flaring Station.

Project Preparation and Implementation Facility (MeHSIP-PPIF)

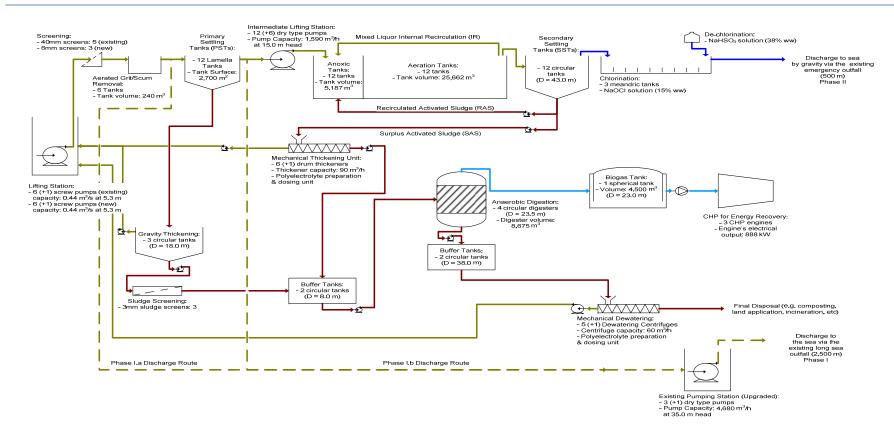


Figure 3.4 Flow chart of the CAS treatment option (Source: Extension of Al-Ghadir WWTP - Feasibility Study Part II a: Development of Alternative Processes for the WWTP. 2012



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 (m²)	VOLUME REQUIREMENTS (m³)	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 (m³/h) HEAD (m)				
PHASE I							
<u>Preliminary Treatment</u>	Preliminary Treatment						
Lifting Screw Pumps	6	1	1,584	5.3			
Intake Screens	3	1	Bar Spacing: 6mm, Indicative dimensions WxH: 2400 mm 5000 mm				



	NO OF	STANDBY	TECHNICAL SPECIFIC	ATIONS FOR EACH ITEM	
EQUIPMENT	DUTY ITEMS	ITEMS	CAPACITY (m³/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			
<u>Primary Treatment</u>					
Lamellas in PSTs	12		m	ellas media LxWxH: 30.0 m x 9.0 x 2.0 m	
Surface and Bottom Scrapers	24		•	ers L x W: 9.0 m x 0.30 m erval 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			pped with sludge scrappers and nhopper	
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 Po	wer Input: 30 kW	
Biogas Blowers	6	3	250	5.0	
Biogas Storage Tank	1			eter 23.0 m and Height 20.0 m ty 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, fra	ame 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			LxWxH: 30.0 m x 23.0 m x 8.0 m ridge Crane: 45 tones	
Spiral Heat Exchangers	4	2			
Dual-fuel Boiler	4				
Biogas Burner and Flare Stack	1		990		



	NO OF	STANDBY	TECHNICAL SPECIFIC	CATIONS FOR EACH ITEM	
EQUIPMENT	DUTY ITEMS	ITEMS	CAPACITY (m³/h)	HEAD (m)	
Buffer Tank prior to Dewatering	1				
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			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 Syst	tem for Mechai	nical 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	
<u>Miscellaneous</u>					
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		ive dimensions WxH: 1600 mm x	
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 Pov	ver Input: 18.5 kW	
Aeration Tanks					
Aeration Blowers	16	2	14,732	6.8	

FOLUDIATAIT	NO OF	STANDBY	TECHNICAL SPECIFIC	CATIONS FOR EACH ITEM	
EQUIPMENT	DUTY ITEMS	ITEMS	CAPACITY (m³/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			with sludge scrappers and scum opper	
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	l Dosing Syst	em for Mecha	nical Thickening		
Polyelectrolyte Solution Preparation and Storage Tank	1	1	Volume of	f Tank: 1.30 m3	
Polyelectrolyte Solution Tank Mixer	1	1			
Polyelectrolyte System Building	1		Dimensions of the Building	g 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, fr	ame 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					
NaOCI Solution Tank	1		Volume o	of Tank: 70 m3	



FOLUDATAIT	NO OF	STANDBY	TECHNICAL SPE	CIFICATIONS FOR EACH ITEM		
EQUIPMENT	DUTY ITEMS	ITEMS	CAPACITY (m³/h)	HEAD (m)		
Dosing Pumps	3	3	0.15	5.0		
<u>De-chlorination System</u>						
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
Α	Mobilization and Demobilization	LS	1
В	Dredging Works		
B.1	Dredging under toe for Accropodes	m^3	25,640
С	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 N	1 ³ /S)							
Domestic commerce and industry	m³/s	1.47	1.81	2.04	2.31	2.47	2.58	2.74	2.96
Inflow and infiltration	m³/s	0.20	0.25	0.28	0.32	0.34	0.36	0.38	0.41
Average flow (total)	m³/s	1.67	2.06	2.32	2.64	2.81	2.93	3.12	3.38
Peak flow	m³/s	2.57	3.06	3.39	3.78	3.99	4.14	4.36	4.66
WET SEASON	- FLOWS (IN N	1 ³ /S)							
Domestic commerce and industry	m³/s	1.47	1.81	2.04	2.31	2.47	2.58	2.74	2.96
Inflow and infiltration	m³/s	1.02	1.13	1.13	1.12	1.03	0.89	0.95	1.03
Average flow (total)	m³/s	2.49	2.94	3.17	3.44	3.50	3.47	3.69	3.99
Peak flow	m³/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 m³/day for Phase I (I.a & I.b) and 345,044 m³/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 NaOCI & 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
NaOCI solution 15% (I/day)	-	10,152
NaHSO ₃ solution 38% (I/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 m³/day, while the respective value for Phase II is about 324 m³/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	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)		6o Million	
I.A	2020	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	2030-	Upgrade the WWTP to secondary level of treatment by 2030	160 Million	
П	2050	Complete the remaining Networks to serve 22.5% of PE	8 ₃ Million	
Total For Networks				
Total For Treatment Plant Extension and Upgrade 242				

^{*} 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 <u>aerobic</u> 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 <u>AEROBIC</u> 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) <u>and</u> 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 m³/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 o.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 °C). Only one major plant in region in Ajman (UAE) with capacity of 81,000 m³/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

Opti on	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	a) Upgrade to Secondary Treatment b) Extension of Anaerobic Sludge Treatment for Secondary Sludge
			BOD removal: 25%-30%	BOD removal: 96%
ASP	Less odour nuisance;Simple open source technology;Small volumes of sludge	Large land footprint;High electrical operating costNo biogas is production and no electricity	a) Extension of Preliminary Treatment	a) Upgrade to Secondary Treatment b) Aerobic Sludge Treatment for
ASI	 Likely low capital costs; low mechanical and electrical content for achieving all ELVs. 	recovery; • Wetter volumes of sludge need disposal	BOD removal: 5%-10%	Secondary Sludge BOD removal: 96%
SBR	Well proven process;Likely low investment costSmall 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	a) Upgrade to Secondary Treatment b) Extension of Anaerobic Sludge Treatment for Secondary Sludge
			BOD removal: 25%-30%	BOD removal: 96%
MB BR	industrial wastewater pollutants;	 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	a) Upgrade to Secondary Treatment b) Extension of Anaerobic Sludge Treatment for Secondary Sludge
	Energy recovery		BOD removal: 25%-30%	BOD removal: 96%



Opti on	Advantages	Key Issues of Concern	Phase I	Phase II
MB R	 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; 	a) Extension of Preliminary Treatment b) Upgrade to Primary Treatment (Settling Tanks) c) Anaerobic Sludge Treatment for Primary Sludge	a) Upgrade to Secondary Treatment b) Extension of Anaerobic Sludge Treatment for Secondary Sludge
		Need for ultra-fine pre-screeningUncertainty on membrane life	BOD removal: 25%-30%	BOD removal: 96%
UAS B	 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 	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)	a) Upgrade to Secondary Treatment b) Extension of Anaerobic Sludge Treatment for Secondary Sludge
		 Difficulty of proven energy recovery at this scale Potential odours and increase in the oxygen requirement of the effluent sulphate. 	BOD removal: 60%-70%	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 Mol 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?	177	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			
Addit	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	Pain 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	Ministry of Industry (MoI)	Beirut and Mount Lebanon Water & Wastewater Establishment (BMLWWE): Main issues are with the quarries and slaughterhouses		
6	Need to understand exact sources of pollution/risk to plant 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	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.		
	Need to take odors resulting from the pumping and lifting stations into consideration		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		cover budget
	Need to separate the industrial wastewater from the municipal wastewater – especially slaughterhouses which contribute the most to high pollution levels in the Ghadir River		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.
	Need to separate Wastewater discharge from storm water culvert		CDR:
	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		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.
	impacts from odors. Treated wastewater from the plant could be used for irrigation.		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.)	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
	Lack of interest/commitment from industries themselves		
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
Addit	ional comments collected in writing		
10	Plant location is ideal (distant from residential areas)	BMLWWE	-
	Need to monitor contractor's implementation of measures suggested in EMP		



NC	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	Mol	-
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



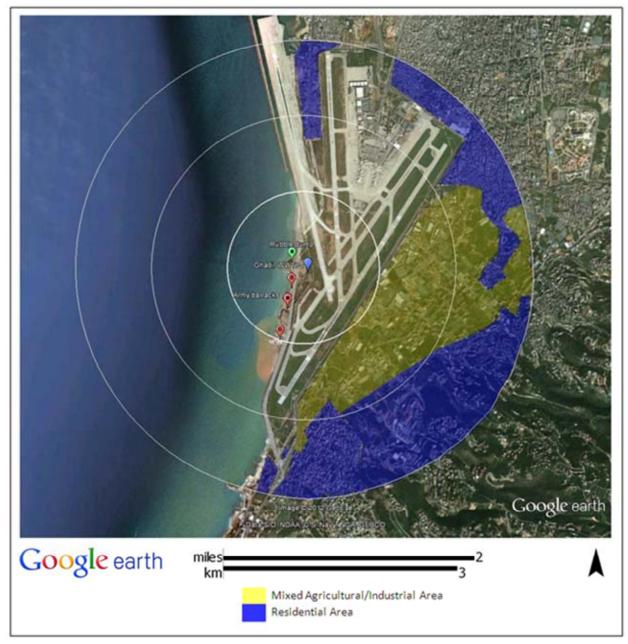


Figure 6.2 Aerial view of Sensitive Receptors within a Radius of 1, 2, and 3 Km from the WWTP



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.

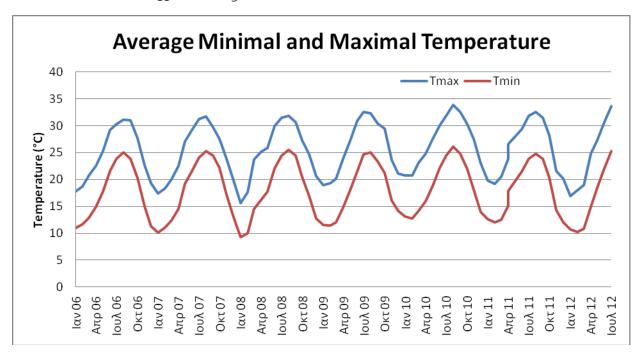


Figure 6.3 Average Max & Min Temperatures at Beirut Airport Weather Station (Jan.o6-Jul.12)

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).

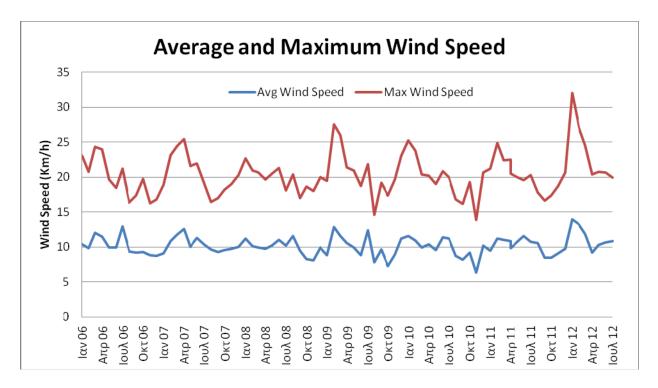


Figure 6.4 Maximum & Average Wind Speed Data recorded at Beirut Airport Weather Weather Station (Jan.o6-Jul.12)



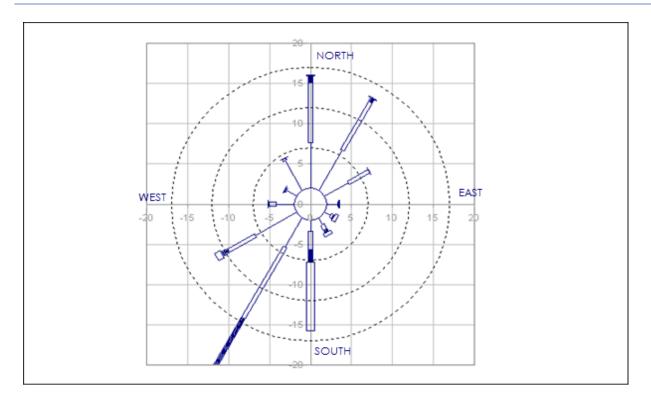


Figure 6.5 Wind Direction near Al Ghadir WWTP (Source: MOEW/UNDP/CEDRO. 2011. The National Wind Atlas of Lebanon).

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.



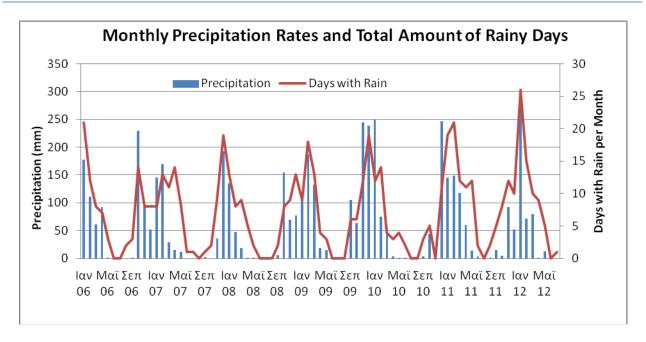


Figure 6.6 Monthly Precipitation Rates and Total Amount of Rainy Days Recorded at Beirut Airport Weather Station (Jan.2006 – July 2012)



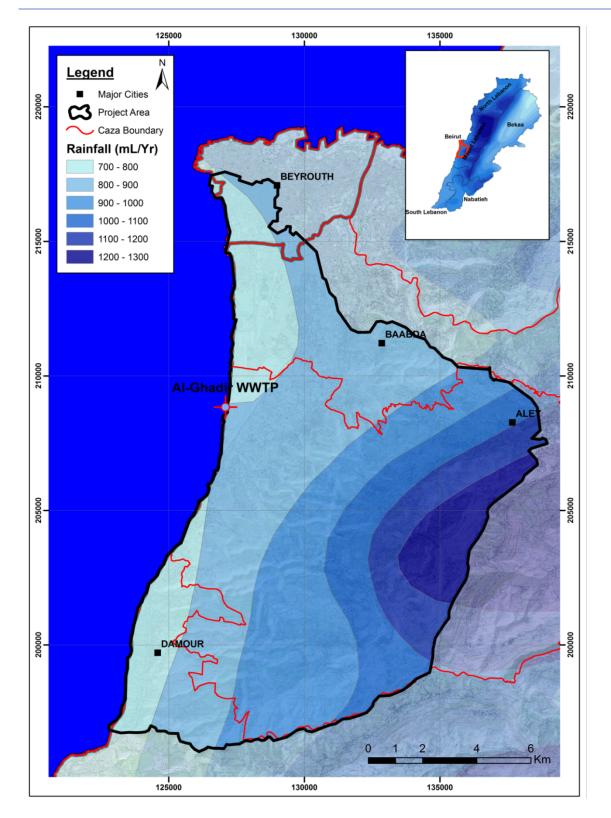


Figure 6.7 Rainfall Map of the Study Area

Mediterranean Hot Spot Investment Programme



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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 (NO₂) and Sulphur Dioxide (SO₂) (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 (SO₂), 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.

NO2 levels in Beirut are mainly attributed to traffic (Afif et al. 2008). The yearly average of 2005 was recorded to be $67\mu g/m_3$. It reached its peak in December with $178\mu g/m_3$ and drops to $17\mu g/m_3$ in May (Afif et al. 2008). NO2 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.

SO2 levels are mainly attributed to traffic and central heating burners (Saliba et al. 2006 & Afif et al. 2008). The monthly average of SO2 concentration in samples collected in Beirut varied between $13\mu g/m_3$ in summer 2004 and $25\mu g/m_3$ in winter 2004-2005 (Saliba et al. 2006). Another study conducted between December 2004 and July 2006 showed a yearly average of 8.11 $\mu g/m_3$ (Afif et al. 2008). SO2 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 μ g/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 quideline values.



Table 6.1 Review of Literature on Ambient Air Quality in Beirut

Region	Parameter	Description	Period	Mean concentra tion (μg/m3)*	Averaging Period	Maximum Allowable Limits for Ambient Air Pollutants (μg/m3) (Decision 52/1)**	Referenc e
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
Beirut	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
America n Universi ty 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)	Shaka & Saliba 2004
Bourj Hammo ud	PM2.5	Urban Area	Febuary 2004 to January 2006	0.039	Annual Average	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)	Saliba et al. 2007

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Region	Parameter	Description	Period	Mean concentra tion (μg/m3)*	Averaging Period	Maximum Allowable Limits for Ambient Air Pollutants (μg/m3) (Decision 52/1)**	Referenc e
_						10 (guideline)**	
	PM10-2.5	Urban Area	Febuary 2004 to January 2005	0.065	Annual Average	-	Saliba et al. 2007
America n Universi ty 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
America n Universi ty 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.



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6.2.3 ACOUSTIC ENVIRONMENT

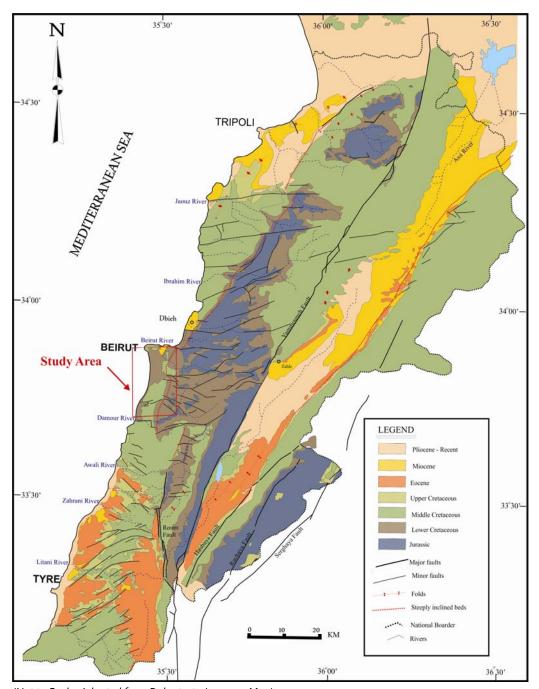
The area is expected to be subjected to relatively high noise levels, mainly associated with the contiguous Airport activity and the average traffic flows on the adjacent secondary road.

6.2.4 GEOLOGICAL SETTING

The drainage basin of the Ghadir WWTP extends over an area of around 173 km² 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



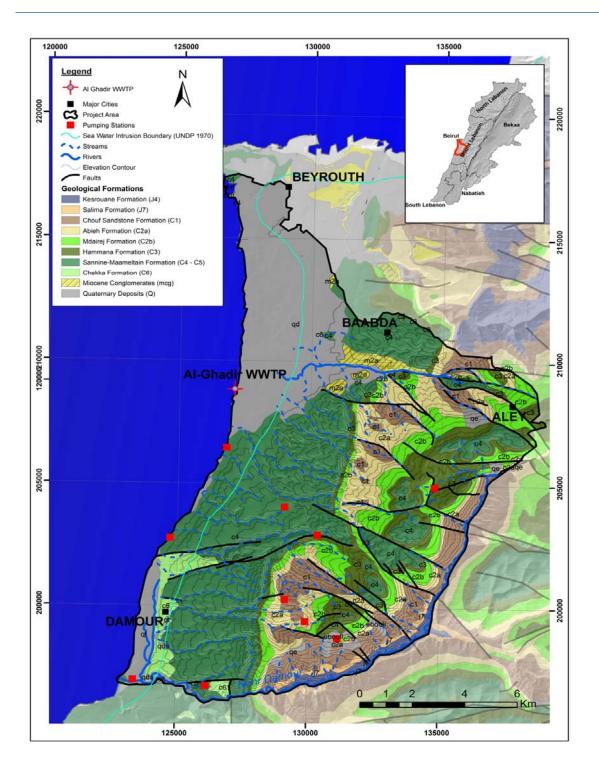


Figure 6.9 Geological Map of the Study Area (Adapted from Duberteret 1/50,000)





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/ Alluvial Deposits and Miocene Deposits conglomerates (gravel, Sand, (Q/ mcg) Silt and Clay)		Few tens of meters	Semi-aquifer
	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
Cretaceous	Albian	Hammana Formation (C3)	Green calcareous marl and detrital limestone and sand	~100	Aquiclude
Cictaccous	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 (BC1)	Highly ferruginous red to white sandstone, with localized volcanic (BC1), marls and lignites	200-220	Semi-Aquifer
Jurassic	Tithonian	Salima Formation (J7)	Yellowish oolitic limestone and marls	0-40	Aquiclude
JuidSSIC	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.

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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.



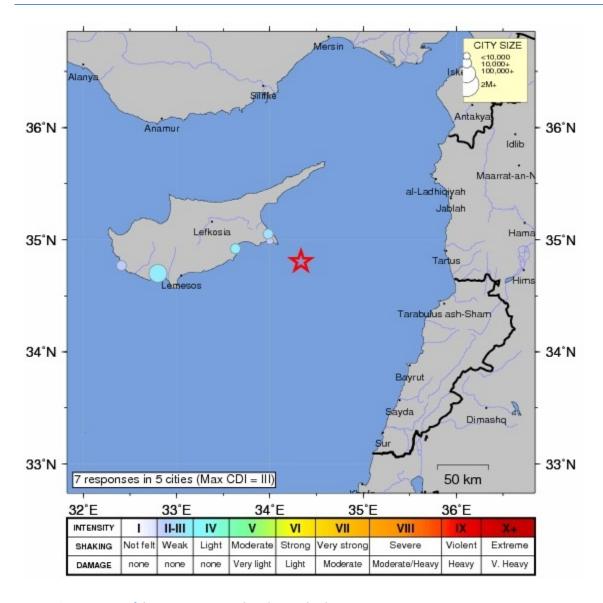


Figure 6.10 Location of the Most Recent Earthquake Nearby the Region



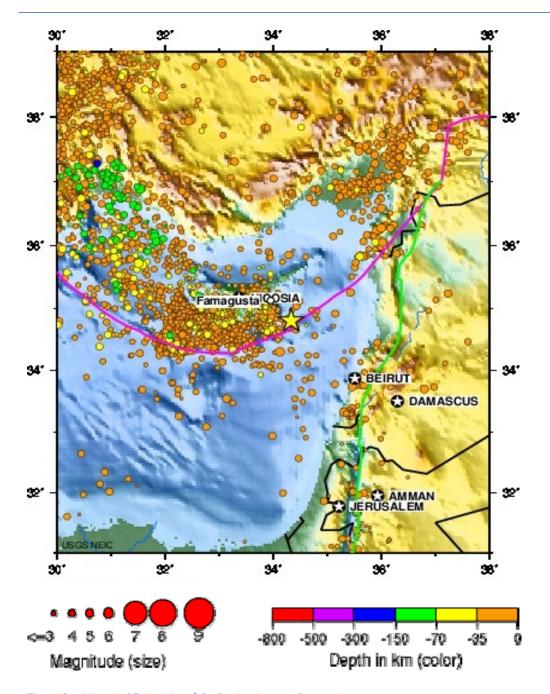
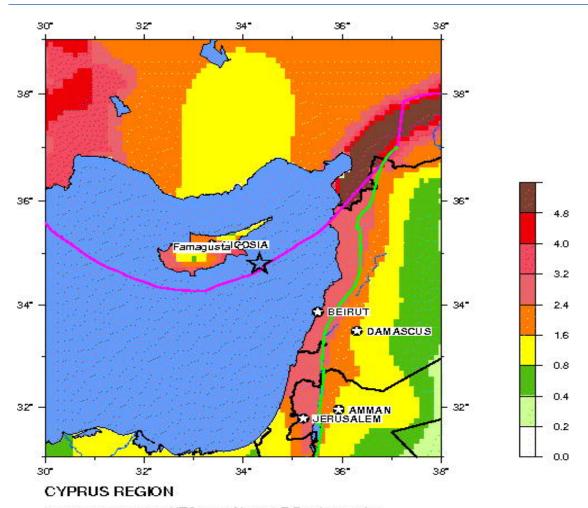


Figure 6.11 Historical Seismicity of the Region (1990 to Present)





2012 07 28 23:29:49 UTC 34.80N 34.33E Depth: 35.5 km

Peak Ground Acceleration (m/s²) with 10% Probability of Exceedance in 50 Years

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-CNRS⁴".

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 (°C), 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	х	Υ	Depth (m)	Approximate Distance to Shore (m)
А	-341997	-36519	Surface	2.430
В	-341997	-36519	20	2.430
С	-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
В3	-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

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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



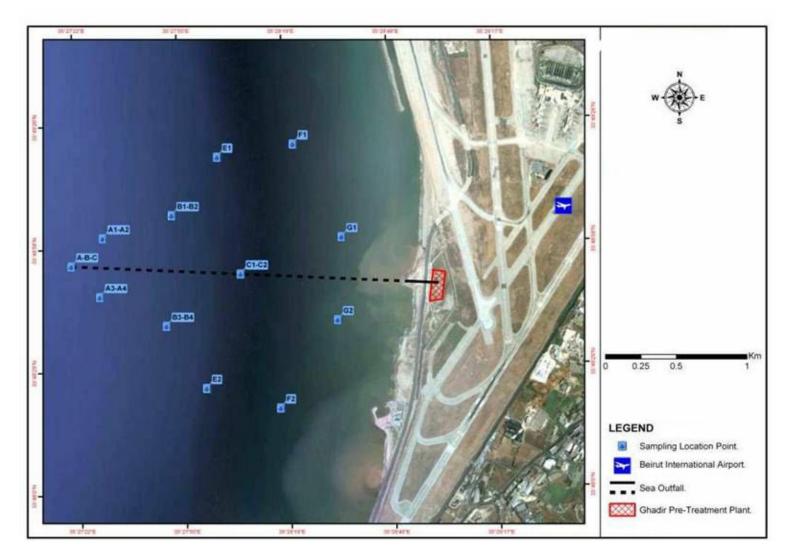


Figure 6.13 Distribution of sampling points (2002 – 2007) (Source: Feasibility Study Part I : Project background and baseline data. 2012)



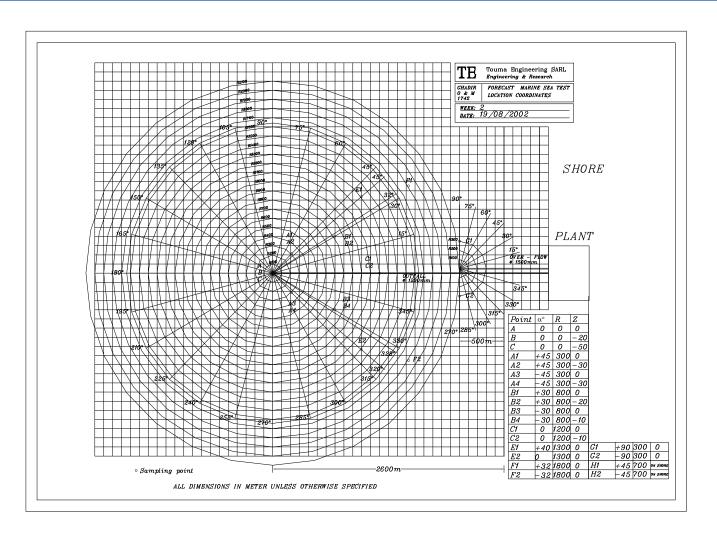


Figure 6.14 Schematic illustration of the 2002 - 2007 sampling campaign – distribution of sampling *locations*

(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 23.1°C 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 (°C)		Coliform Count (colonies/100mL)		рН	
Point							Acceptabl	Aaximum e Value) / le Value)⁵	6 to 9 (Gui	de Value)
	Average	Peak	Average	Peak	Average	Peak	Average	Peak	Average	Peak
Α	6,22	7,7	36,85	38,11	23,19	28,55	797	3000	9,27	9,57
В	5,98	7,16	37,24	38,22	23,02	28,49	520	1650	9,32	9,71
С	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
А3	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
В2	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)

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	Oxygen Content (ppm)		Salinity (ppth)		Temperature (°C)		Coliform Count (colonies/100mL)		рН	
Point							Acceptabl	Maximum le Value) / le Value) ⁵	6 to 9 (Gui	ide Value)
В3	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 gomg/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.



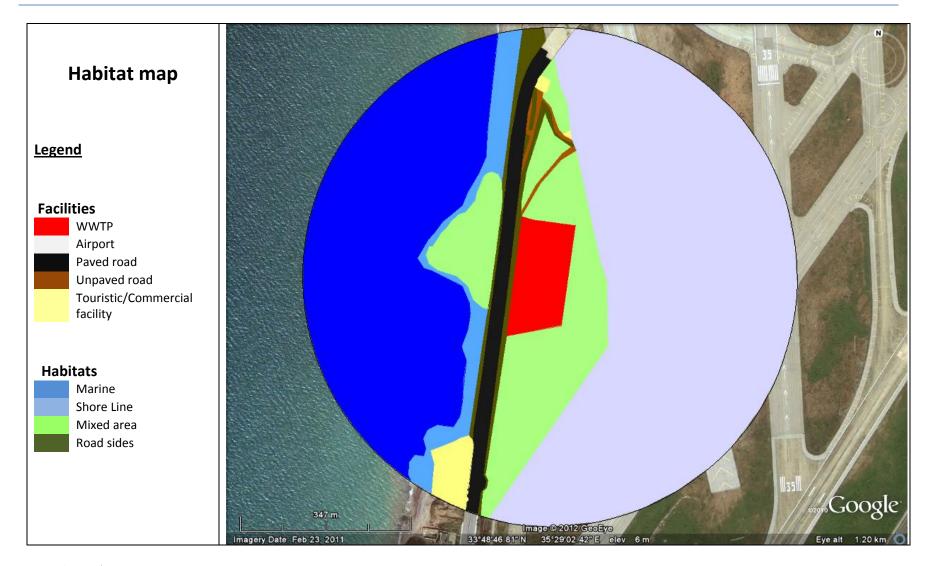


Figure 6.15 Habitat map



Mixed habitat

This 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 such as: Ricinus communis, Datura metel, Inula sp, Chrozophora tinctoria, Heliotropium hirsutissimum, Verbascum sinuatum, Alhagi maurorum and Oryzopsis miliacea.

Other species observed represent the different micro habitats found within this area, such as the *Capparis spinosa* and the *Washingtonia robusta*, or species which mainly belong to humid areas such as the *Phragmites australis* and *Erigeron (Conyza) canadense*, and the *Nicotiana glauca* mainly found in coastal areas.



Figure 6.16 Mixed habitat in different survey points



Shoreline habitat

As shown in the habitat map (Figure 6.15), the shoreline habitat faces the WWTP and follows the coastline. It can be divided into two main parts:

- The shoreline, considered as a typical sea shore habitat, covered with coastal plant species such as: *Nicotiana glauca, Solanum nigrum,* Cakile aegyptia *and* Beta *vulgaris maritime; and*
- The second part of the shore line, mainly covered with algae and other marine plant species.







Figure 6.17 Shore line habitat in different survey points

Roadside Habitat

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.







Figure 6.18 Road sides Habitat in different survey points



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Marine habitat

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.

6.3.1.2.2 Flora species

Three (3) study points, shown on Figure 6.19, were thoroughly surveyed during the field visit. In each of the study points, the number of different species was evaluated. A list of flora species observed on site is provided in Figure 6.19, while Figure 6.20, Figure 6.21 and Figure 6.22 display some of the pictures collected.

As a conclusion of the rapid field visit, two major types of species were identified:

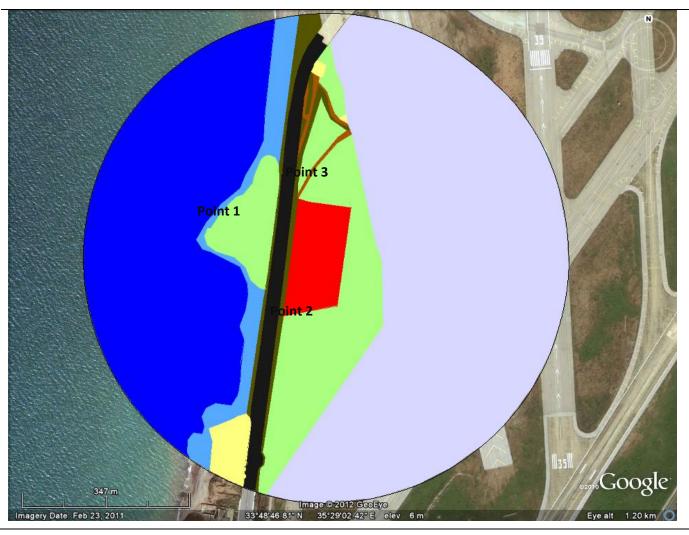
- Species that are originally considered as coastal species; and
- Common species that belong to dump areas.

The highest ecological interest in terms of flora is related to the presence of coastal species. They are strongly related to the habitat type they occur in.

It should be noted that no endemic, rare, endangered or protected species were identified within the buffer zone 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.





Species observed in Point 1

Cakile aegyptia
Chrozophora tinctoria
Datura metel
Erigeron (Conyza) canadense
Heliotropium hirsutissimum
Inula sp
Nicotiana glauca
Ricinus communis
Salsola Kali
Solanum nigrum
Plantago sp
Capparis spinosa
Washingtonia robusta
Beta vulgaris maritime

Species observed in Point 2

Oryzopsis miliacea Inula sp Verbascum sinuatum

Species observed in Point 3

Echinops sp Alhagi maurorum Phragmites australis

Figure 6.19 List of flora species observed in different survey points





Cakile aegyptia

Datura metel



Beta vulgaris maritima



Erigeron (Conyza) canadense



Chrozophora tinctoria



Heliotropium hirsutissimum





Figure 6.20 Pictures of observed species in point 1



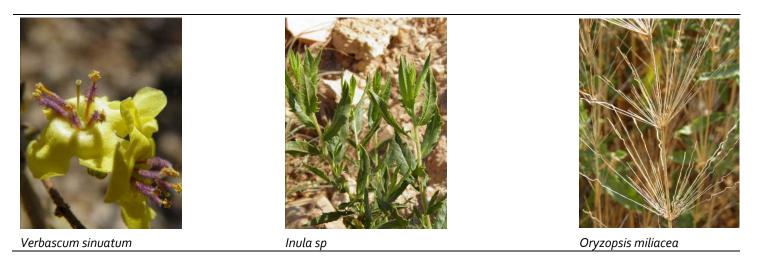


Figure 6.21 Pictures of observed species in point 2

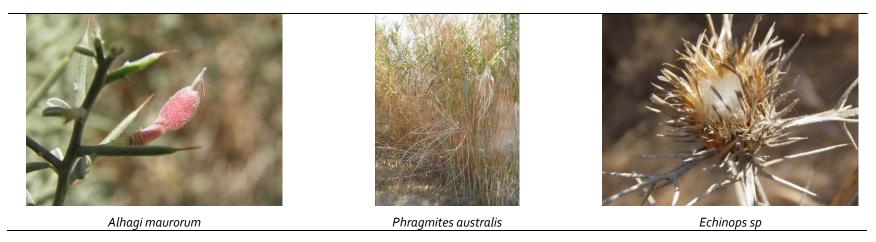


Figure 6.22 Pictures of observed species in point 3



Table 6.5 List of observed species

LATIN NAME	ENGLISH NAME	FRENCH NAME	ARABIC NAME	FAMILY NAME	НАВІТАТ	CHARACTERISTICS/COMMON USAGE
Nicotiana glauca	Tobacco-shrub	Nicotiane d'un vert bleuaitre	التنب <u>ك</u> شجرة	Solanaceae	Coastal areas.	Venomous
Ricinus communis	Common Palma- Christi	Ricin Common	شــــائـع خروع	Euphorbiaceae	Waste ground Fairly common around	Toxic seeds Medicinal, ornamental plant
Datura metel	Hairy throne –apple	Stramoine metel	مشعرة داتــورة	Solanaceae	towns. Waste ground	Venomous
Solanum nigrum	Black nightshade	Morelle noir	الثعلب عنب	Solanaceae	Sandy ground	Medicinal plant
Cakile aegyptia	Egyptian sea-rocket	Coquillier d'Egypte	البحر رشاد	Brassicaceae	Seashore	Has the potential to become a noxious weed.
Inula sp				Asteraceae	Rocks near sea, waste ground roadsides	-
Chrozophora tinctoria	Turnsole	Chrozophore des teinturies	غ <u>بیري</u>	Euphorbiaceae	Waste ground	Medical and edible use
Heliotropium hirsutissimum	Hairy heliotrope	Heliotrope herisse	الشمس رقيب مقنفذ	Boraginaceae	Waste ground	-
Erigeron (Conyza) canadense	Canadian fleabane	Conyze du Canada	كنــدا كزنـــيزا	Asteraceae	Humid fields	Noxious weed
Capparis spinosa canescens	Spiny caper	Caprier epineux	وبر كبر	Capparidaceae	Common, walls, rocks	-
Salsola Kali	Prickly saltwort	Soude Kali	القلــــي حرض	Chenopodiaceae	Fairy common on coastal sands	-
Plantago sp	Plantain	Plantain	الحمل لسان	Plantaginaceae		-

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LATIN NAME	ENGLISH NAME	FRENCH NAME	ARABIC NAME	FAMILY NAME	НАВІТАТ	CHARACTERISTICS/COMMON USAGE
Washingtonia robusta	Mexican Fan Palm		مروحي نخيـــل	Arecaceae		Ornamental tree
Verbascum sinuatum	Sinai mullein	Molene sinuee	بوصـــــير متعــرج	Scrophulareaceae	Waste ground	
Alhagi maurorum	Sinai manna	alhage – des – maures	عــاقول	Fabaceae	Waste places	Noxious weed
Phragmites australis	Southern reed	Phragmite austral	قصب المكانس	Poaceae	Near water	Important in terms of industrial use, baskets, mats, pen tips, and a rough form of paper
Beta vulgaris maritime	Sea garden beet	Bette maritime	بحـري ســلق	Chenopodiaceae	Waste ground	-
Oryzopsis miliacea	Millet Mountain- rice	Oryzopsis faux- millet	بريــــة مكنســـة	Poaceae	Waste ground	Ornamental grasses



6.3.1.3 FLORA IN THE SERVICE AREA (NETWORKS)

The service area covers an area of about 176Km², encompassing 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.

The network area will be referred to as "Assessment Area" throughout this sub-section.

6.3.1.3.1 Description of Vegetation Communities

The bio–ecological approach was used in the floristic diversity study presented in this section. Accordingly, two levels and series of vegetation can be revealed in Lebanon, which are the Mediterranean and pre-steppe Mediterranean, each divided into different sub-units⁶ as shown in Figure 6.23 below.

Based on Figure 6.23, the Assessment Area is located within the Thermomediterranean and the Eumediterranean zones. These are described below, and the floral diversity they may hold is assessed based on the types of mother rocks present in each area.

6.3.1.3.2 Thermomediterranean Zone

This zone rises from the coast to around 500m altitude, on the western slopes of Mount Lebanon. From the point of view of the mother rock, 3 situations need to be taken into account:

1st situation: on limestone

- The Caroubier-Lentisque series is the warmest. Represented here and there on the Lebanese coast, this series is presented either: a) in the form of scrubland, where Pistacia lentiscus L. is dominant and where Myrtus communis L. is relatively abundant. Ceratonia siliqua L.is always present, but generally sparse because it is very sensitive to human activities, or b) in the form of woods of Pinus halepensis Mill, especially to the south of Beirut, or Pinus brutia Ten. May also be widespread.
- The series of Quercus calliprinos Webb. covers most of the Thermomediterranean zone on compact limestone. Altitudinal leveling of the series goes from the sea-side to around 400-500m.

2nd situation: on marl and marly limestone

- Marly substrata are widespread at low altitude. Vegetation is dominated by the Conifers: Pinus brutia
 Ten, which is the most common, Pinus halepensis Mill. And Cupressus sempervirens L. also occupy a
 considerable part.
- The distribution of Pinus halepensis Mill. Is fragmentary in Lebanon. The only community to the north of Beirut is that of Sahel Byblos and it appears to have been planted. It is only south of Baabda that this species becomes abundant, forming pure communities or mixed with Pinus brutia Ten,of which the southern limit appears to be in Lebanon.

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⁶ Valuing Mediterranean Forests –Towards Total Economic Value, University of Padova, Italy- 2005





3rd situation: on sandstone

- All the pinewoods at low altitude on sandstone substrata, especially those situated to the east of Beirut, must be added to the series of Pinus pinea L. the same is true for the old communities to the south of the town.
- The arborescent communities of the series of Pinus pinea L. take the form of pure pinewoods, sometimes with Pinus brutia Ten.

6.3.1.3.3 Eumediterranean zone

The Eumediterranean zone falls between 500 m and 1000 m on the western slopes of Mount Lebanon. It'supper limit is a little higher in the southren part of the eastren slopes of the same chain. From the point of view of the mother rock, 2 situations should be taken into consideration:

1st situation: on limestone

- The series Quercus calliprinos Webb. is the most widespread territorially. It is the most important climatic species on the whole of the Mediterranean slopes of Lebanon.
- The Mediterranean series of Quercus infectoria Oliv. corresponds to the caducifoliated oak grove within the limits of the evergreen oak grove. It is always found on deep soil exposed to the north and in the thalwegs.
- The Mediterranean series of Pinus brutia Ten. and Cupressus sempervirens L. are found mostly in the north of the country. Arborescent groups are either pure pinewoods or mixed with cypresses. The latter, in certain places, may form pure communities.

2nd situation: on sandstone

The Mediterranean series of Pinus pinea L. Covers most forests of umbrella pines. They are especially well developed in central Lebanon.



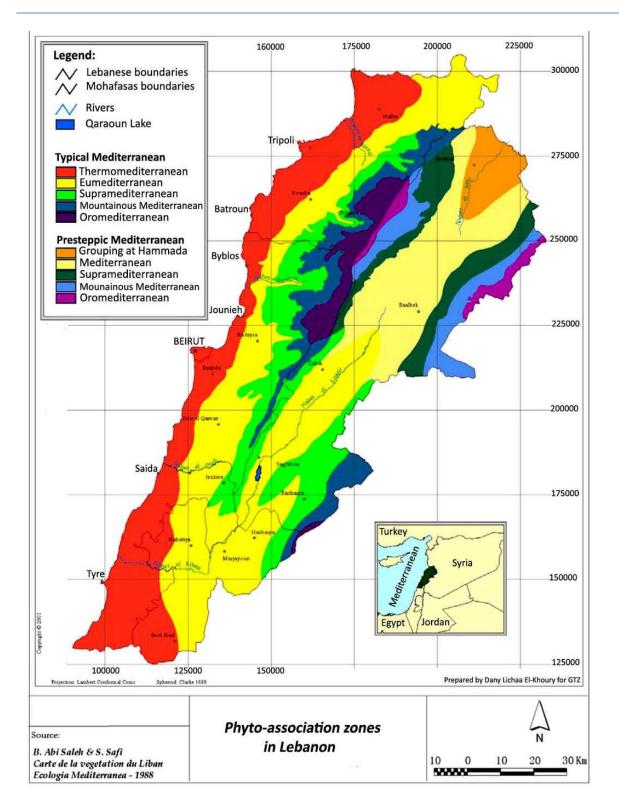


Figure 6.23 Map of typical and pre-steppe Mediterranean vegetation zones in Lebanon. Source: Abi- Saleh and Safi (1998)



6.3.1.3.4 Land use

The land use in the Assessment Area differs widely as shown in Figure 6.24. The percentage and the area of each type of land use are presented in Table 6.6.

Table 6.6 Percentage and area per type of land use

TYPE OF LAND USE	ТҮРЕ	AREA (M2)	%
Agricultural Land	Agricultural Land	41405500	23.43
Artificialized Land	Dense Urban Tissue	8433380	4.77
	Moderately Dense Urban Tissue	5612690	3.18
	Sparse Urban Tissue	22847800	12.93
	Undeveloped Artificialized Land	9009360	5.10
	Green Artificialized Land	733352	0.42
	Commercial or Industrial Area	3046370	1.72
	Informal Moderately Dense Urban Tissue	454304	0.26
	Equipment	727169	0.41
	Informal Dense Urban Tissue	3939740	2.23
	Touristic Resort	65096	0.04
	Airport	4802140	2.72
	Informal Sparse Urban Tissue	275681	0.16
Herbaceous Vegetation	Herbaceous Vegetation	19469600	11.02
Permanent Streams	Permanent Streams	68828	0.04
Unproductive Land	Unproductive Land	172136	0.10
Wooded land	Mixed Dense Forest	2526160	1.43
	Mixed Sparse Forest	2690440	1.52
	Shrubland	11002500	6.23
	Shrubland (Scattered Trees)	10298200	5.83
	Woodlands or Burnt Areas	134768	0.08
	Urban Sprawl on Dense Forest	348964	0.20
	Dense "Pinus spp" Forest	3238010	1.83
	Dense "Quercus spp" Forest	7641130	4.32
	Other Types of Dense Deciduous Forests	14073	0.01
	Urban Sprawl on Sparse Forest	1962950	1.11
	Sparse "Pinus spp" Fforest	7536590	4.27
		6909170	3.91
	Sparse «Quercus spp» Forest	0909170	J.J1
	Sparse «Quercus spp» Forest Other Types of Sparse Deciduous Forests	199285	0.11



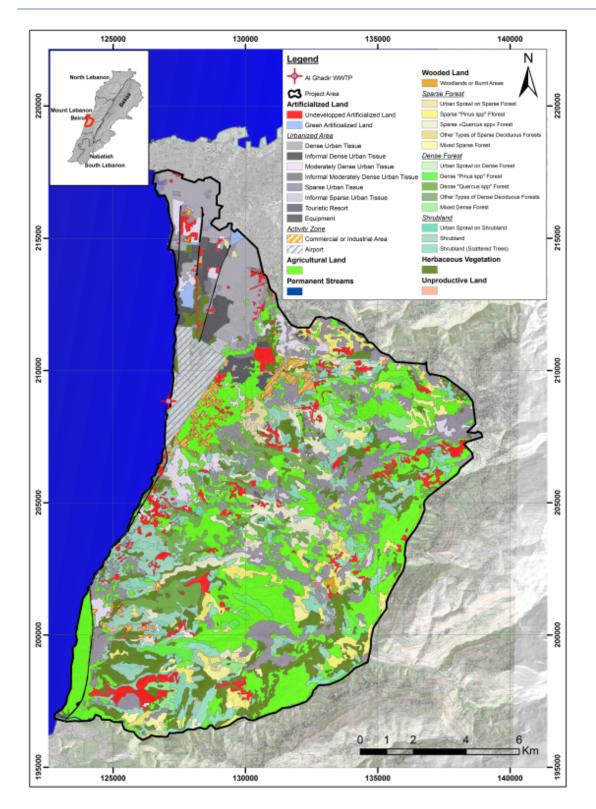


Figure 6.24 Land use map in the area of assessment (Network Area)

Mediterranean Hot Spot Investment Programme



Project Preparation and Implementation Facility (MeHSIP-PPIF)

A TA operation funded by the European Union - FEMIP Support Fund

6.3.1.3.5 Forests in the area of assessment

According to the forest map in Lebanon (Figure 6.25), 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.



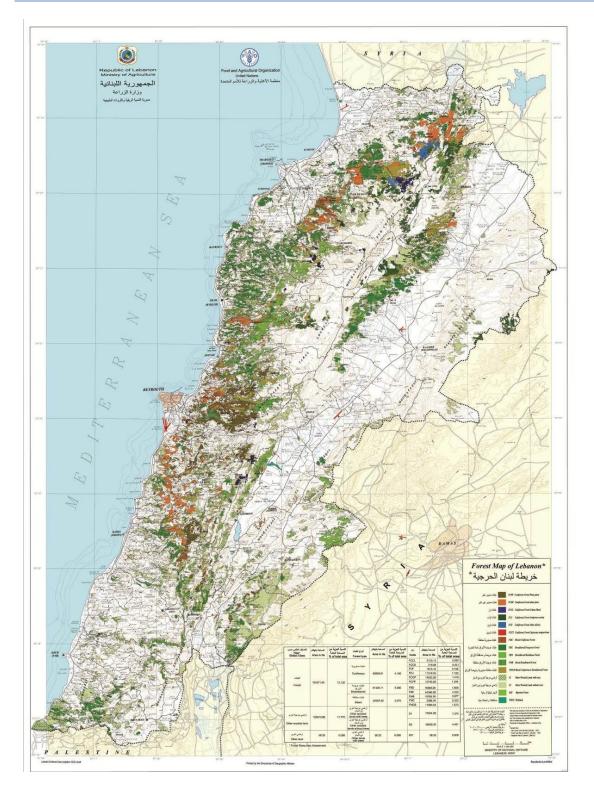


Figure 6.25 Forest map of Lebanon





6.3.2 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 (MoE, 2010). Identified species currently close to extinction in Lebanon include the wolf, the wild cat, the mongoose and the squirrel, whereas the rare species include shrews, bats, the weasel and spiny mouse. However, a variety of vulnerable species such as the four species of bats, the wild boar, and the common field mouse still exist (MoE, 1998).

The terrestrial fauna in Lebanon counts 2085 species. The fresh water ecosystems count 987 species of which the invertebrates constitute 656 species. Pouring into rivers a great variety of untreated chemicals substances from factories together with untreated organic waste from the sewers of residential zones brings about deep changes in the biocenotic structure of these rivers.

Marine ecosystems contain 1685 species of fauna of which 50 species of fish are caught and are of economic interest, the number of taxons of zooplankton found in Lebanese waters so far amounts to 747 species.

It is difficult to perform a complete faunal survey; however, information was collected from available literature such as the MoA/UNEP biodiversity study, 1996, as well as from personal contacts, interviews with locals and researchers, and species encountered during the field visit

Furthermore, several species remain unknown and may not have been included in this report due to the lack of comprehensive studies and long term monitoring projects.

6.3.2.1 INVERTEBRATES AND INSECTS

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. Also, a wasp hive was documented (Figure 6.26)



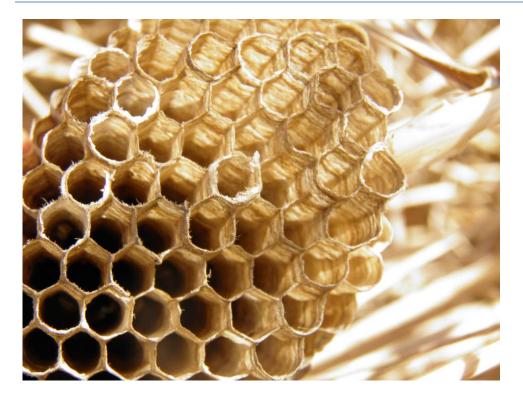


Figure 6.26 Wasp hive

6.3.2.2 AMPHIBIANS AND REPTILES

There are in total 5 reported species of amphibians in Lebanon: 4 species of frogs and toads, and 1 species of salamander. However, this list was identified as "undoubtedly incomplete" (MoA/UNEP, 1996). Reported species of reptiles in Lebanon is 43.

No endangered amphibians' species were recorded in Lebanon according to IUCN references. However, a high percentage of threatened reptiles are recorded. Reptiles are considered as a very important portion of fauna diversity in the country, as it is reported as one of the reptiles with highest species richness on average in the Mediterranean basin (see Figure 6.27 and Figure 6.28)



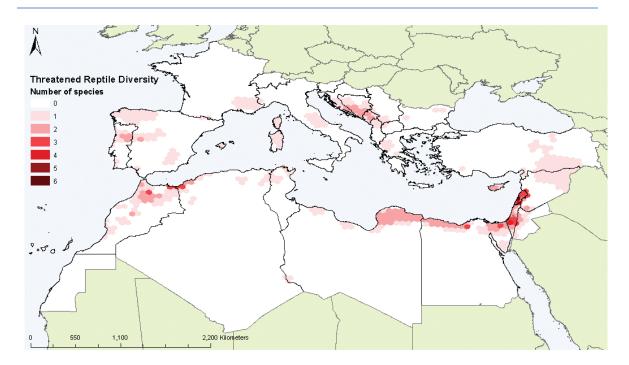


Figure 6.27 Species Richness of Threatened Reptiles in the Mediterranean Basin

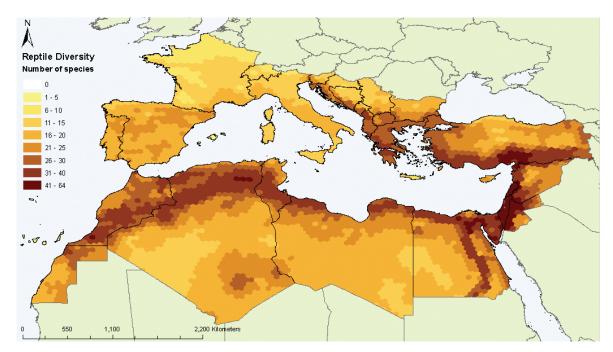


Figure 6.28 Species Richness of Reptiles in the Mediterranean Basin



6.3.2.3 MAMMALS

There are 52 reported mammal species in Lebanon; in addition 7 are already extinct. Bats make up the largest single group of mammals (16 species). About one third are rare, and another 39% are vulnerable species or species in apparent danger (Ecodit, 2001). According to the national biodiversity study (MoA/UNEP 1996), 7 mammal species are already extinct from the Lebanese wild lands

6.3.2.4 BIRDS

There are 337 bird species noted in Lebanon, of which 65 species that have strayed into the region, 100 nesting species, 170 migratory species that winter here, 2 recently introduced species, and 10 with no recent data. Although there are no endemic species in Lebanon there is however a semi-species (Alectoris chukar) and some Asian breeds. Rare and quite rare species make up 26.5 % of all species observed in Lebanon or mainly 37 species. According to the analysis of the national biodiversity report study team (MoA/UNEP, 1996), the avifauna of the forests of the high mountains is as large as that of the Bekaa (71 species). The forests and woods of Mount Lebanon provide shelter to 87 species, which is considered as an underestimation due to the difficulty to spot migratory birds in thick woods.



Figure 6.29 Birds observed around the WWTP area on September 5, 2012

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. Later, studies mainly focused on determining phytoplankton species with little interest on other species.

A summary of marina fauna and flora is found in Table 6.7 and Table 6.8.



Table 6.7 Fauna Found in the Lebanese Marine Environment (source: Lakkis, 1996)

MARINE FAUNA	DESCRIPTION
Ichtyofauna	Some 325 species of fish have been identified in the Lebanese water, of which 28 originate
	from the Red Sea. Of those 325 species, 281 are bony, and 43 are cartilaginous.
	A total of 404 species of crustaceans reported in Lebanese waters, 16 species of which are
Crustaceans	crabs and the remaining are species of shrimps and crayfish. Sand dredging operations
	particularly affect the distribution and abundance of these species.
	354 species of molluscs exist in Lebanon. Six species of cephalopods have been identified,
Molluscs	with cuttlefish, sepia, and octopus being the most common and commercially exploited.
	Gastropods and bivalves are also common but have no commercial value.
5	Several species of sea urchins and sea cucumbers exist usually on soft limestone and
Echinoderms	sandstone.
	Some 21 species of sponges have been identified in the Lebanese waters, and their fishing
	has been long established in the Lebanese tradition particularly in the Sarafand area,
Porifera	namely Spongia officinalis and Hippospongia equina. These sponges live on rocky bottoms
	and have been exploited for commercial purposes.

In addition, more than 60 species were found to have commercial interest due to their economic or recreational value. A summary of these species is given in Table 6.8.

Table 6.8 Marine Species of Commercial Value (Source: Lakkis, 1996)

ТҮРЕ	SPECIES NUMBER	SCIENTIFIC NAME
Porifera	2	Spongia officinalis, Hippospongia equina
Molluscs	4	Pinctada radiata, Charonia lampas, Octopus vulgaris, Sepia officinalis
Crustacean	3	Portunus pelagicus, Maja squinado, Scyllarides latus
Echinoderm	1	Paracentrotus lividus
Ichtyofauna	50	Not available

6.4 SOCIO-ECONOMIC AND CULTURAL CONTEXT

6.4.1 GENERAL OVERVIEW

6.4.1.1 POPULATION

In the Feasibility Study Part I: Project background and baseline data (2012), the projected population figures as given by different studies were compared. The projection methodology adopted by the FS 2000 was considered as the most reliable one, and have been followed after certain adaptations to reflect changes since the year 2000. The area is divided in four zones taking



into consideration social and geographical criteria along with population movements, during and after the war, for the future projections.

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. The total population estimates per zone till 2050 are provided in Table 6.9.

Table 6.9 Total population estimates, per zone till 2050

Zone	2015	2020	2025	2030	2035	2040	2045	2050
Zone 1- Aley	59.077	65.288	72.156	79.746	88.131	97.401	107.645	118.966
Zone 2- Baabda	45.948	50.781	56.121	62.025	68.546	75.756	83.723	91.458
Zone 3- Southern Beirut	854.000	950.000	1.036.500	1.093.000	1.130.000	1.154.000	1.171.000	1.182.000
Zone 4- Naame- Damour	90.661	100.698	131.771	216.215	239.705	244.101	248.983	254.406
Total	1.049.686	1.166.767	1.296.548	1.450.986	1.526.382	1.571.258	1.611.351	1.646.830

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

6.4.1.2 EDUCATION⁷

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 (Central Administration for Statistics, 2008). However, rates start declining for the 15-19 age group and reach their lowest for the 25-29 age group. Observed enrolment rates are slightly lower for the Southern Suburb compared to the rest of Mount Lebanon and the city of Beirut, particularly for the 15-19 age group.

6.4.1.3 EMPLOYMENT⁷

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%). However, economic activity rates show major disparities when disaggregated by sex. This is particularly true for the Southern Suburb of Beirut, where only 16.1% of females are economically active compared to 72.3% of males (Central Administration for Statistics, 2008).

Furthermore, the unemployment rate in the Southern Suburb of Beirut is the highest in Lebanon, reaching 14.1%. Beirut and Mount Lebanon, excluding the Southern Suburb of Beirut, follow, with unemployment rates of 10% and 8% respectively (Central Administration for Statistics, 2008).

The economic activity rates and unemployment rates for the two Governorates encompassing the Study Area are presented in Table 6.10 and Table 6.11.

⁷ It is to be noted that the socio-economic data presented in these sub-sections refers to a larger area that encompasses the Study Area without being strictly restricted to it.



Table 6.10 Economic activity rates by Governorate in the Study Area (Source: Central Administration for Statistics, 2008)

Governorate	Females (%)	Males (%)	Females & males (%)
Beirut	32.2	70.2	49.1
Mount Lebanon (excluding the Southern Suburb)	30.8	68.5	49.0
Southern Suburb of Beirut	16.1	72.3	44.0

Table 6.11 Unemployment rates by Governorate in the Study Area (Source: Central Administration for Statistics, 2008)

Governorate	Females (%)	Males (%)	Females & males (%)
Beirut	8.2	11	10.0
Mount Lebanon (excluding the Southern Suburb)	10.5	8.1	8.9
Southern Suburb of Beirut	19.9	12.8	14.1

Workers in the Study Area mainly work in the trade and services sectors (respectively 52%, 43% and 37% in the services sector; and 24%, 23%, and 26% in the trade sector; for residents of Beirut, Mount Lebanon excluding the Southern Suburb, and the Southern Suburb of Beirut). The processing industry sector comes third, employing 16.3% and 16.8% of workers in Mount Lebanon and the Southern Suburb of Beirut respectively, and 9% of workers in Beirut.

Over 85% of workers work for private sector companies and institutions, while the rest are employed by public sector and international/non-governmental institutions and organizations.

6.4.1.4 INCOME⁷

Average salaries in Lebanon amounted to 679,000 LBP (about 350 EUR) in 2007, while the median salary amounted to 560,000 LBP (about 280 EUR) (Central Administration for Statistics, 2008). Large disparities can be observed in the Study Area, with residents of the Southern Suburb of Beirut earning about 35% less (average salaries) than those in Beirut (Table 6.12).

Table 6.12 Average and median salaries in the Study Area

Governorate	Average Salary (lbp, in thousands)	Median Salary (lbp, in thousands)
Beirut	909	700
Mount Lebanon (excluding Southern Suburb of Beirut)	767	600

Southern Suburb of Beirut	<i>577</i>	500

Source: Central Administration for Statistics. Living Conditions of Households - The National Survey of Household Living Conditions. Beirut: Central Administration for Statistics, Ministry of Social Affairs, UNDP. 2008.

Similarly, the Average Household Income in Lebanon, as assessed in 2007, ranged between 1,586,200 LBP (about 800 EUR) and 751,500 LBP (about 380 EUR). Again, the rate observed for the Southern Suburb of Beirut is the lowest in the area (Table 6.13) (Central Administration for Statistics, 2008).

Table 6.13 Average Household Income in the Study Area

Governorate	Average household income (lbp, in thousands)
Beirut	1,586.2
Mount Lebanon (excluding Southern Suburb of Beirut)	1,327.8
Southern Suburb of Beirut	813.2

Source: CAS. Living Conditions of Households - The National Survey of Household Living Conditions. Beirut: Central Administration for Statistics, Ministry of Social Affairs, UNDP. 2008.

6.4.2 INDUSTRIAL ZONES IN THE GHADIR DRAINAGE AREA

Major industrial areas within the Ghadir drainage area are the 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 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. Nevertheless, and as discussed in section 3.2.1.2.2, elevated concentrations of certain pollutants such as Fe, Cd, Ni, Hq and CN observed in the wastewater currently reaching the plant may be explained by discharge of industrial wastewater into the municipal sewage network and the Ghadir River.

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), this situation is likely to improve in the near-tomedium future, assuming that a suitable enforcement mechanism is developed and adequate resources are allocated by the Competent Authorities.

6.4.3 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.



6.4.4 BEACH RESORTS NEAR THE WWTP

Three beach resorts are located at the direct vicinity of the WWTP's site: one entirely enclosed beach club for women, where most activities occur at the level of the enclosed pool; and 2 other small beaches mainly frequented by locals. These are shown in Figure 6.1 and discussed under section 6.1.

6.4.5 ARCHAFOLOGY 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".

6.4.6 TRAFFIC

Most roads in the project area are in good condition, especially major axes leading from and to the Beirut International Airport (BIA). Few remaining internal roads remain in poor condition. Public transportation services are mainly provided by public and private mini-vans and "taxi-services".

6.4.7 SOLID WASTE MANAGEMENT

6.4.7.1 MUNICIPAL SOLID WASTE

Approximately 700 to 1000 tons of solid waste is produced within 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.

The following facilities currently exist in the Greater Beirut Area (Figure 6.30 and Figure 6.31):

- Two facilities for sorting and processing municipal waste (Aamroussiyeh and Karantina);
- One composting plant for sorted organic material (Coral composting plant);
- One warehouse facility for storing and shredding bulky and recyclable materials (located along the seashore, next to the entrance of the Borj Hammoud dump site);
- One landfill site for the disposal of sorted MSW in the form of balled waste supposed to be consisting primarily of inert materials (Naameh); and
- One landfill for the disposal of inert and bulky materials (Bsalim).

After fully utilizing cells (1) and (2) of the Naameh sanitary landfill site, an additional area of 62,000 m² was prepared for a new cell (3). The latter has been used as a sanitary landfill for the solid waste produced by Greater Beirut and some areas in Mount Lebanon. The Council of Ministers (CoM) approved, under Decision of 28/6/2006, the expropriation of an additional area of about 25,000 m² for expanding the Naameh landfill (about 7Km from the the Ghadir WWTP).



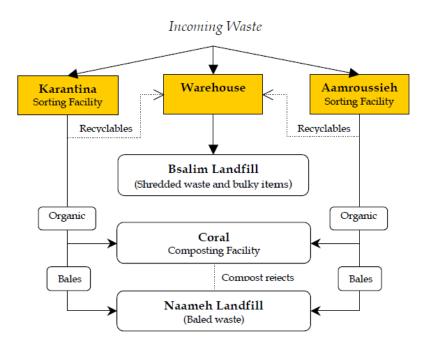


Figure 6.30 Solid waste management scheme for the Greater Beirut Area (Source: Extension of Al-Ghadir WWTP Feasibility Study Part I : Project background and baseline data. 2012)

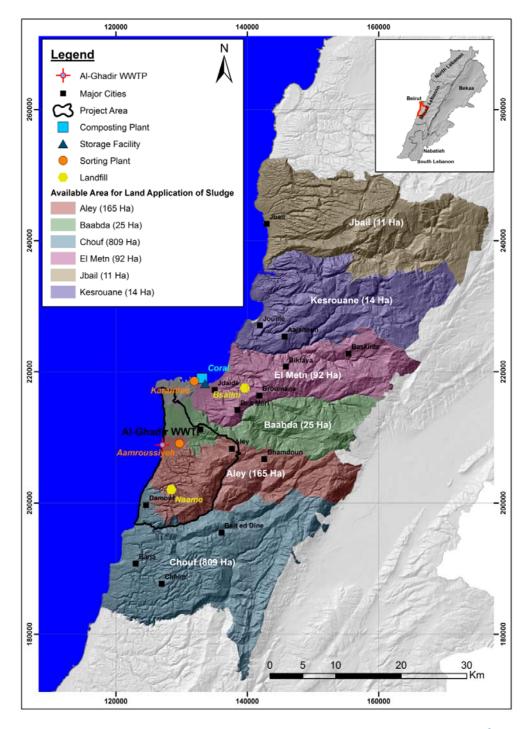


Figure 6.31 Solid waste management facilities & available area for sludge application per governorate (Source: Extension of Al-Ghadir WWTP Feasibility Study Part I: Project background and baseline data. 2012)

⁸ Note: "Available Surface Area For Sludge Reuse" represents the sum of multiple areas/patches of land scattered over each District.



6.4.7.2 RECENT DEVELOPMENTS ON SOLID WASTE MANAGEMENT STRATEGY AT NATIONAL LEVEL

In June 2006, the CoM approved the Solid Waste Management Plan prepared by the CDR, whereby sites for solid waste treatment, composting and landfilling were selected covering all regions in Lebanon. The plan divided the country into four service areas (regions):

- Service area 1: Beirut Mount Lebanon;
- Service area 2: North Lebanon;
- Service area 3: Bekaa; and
- Service area 4: South Lebanon.

Waste-to-energy plants (incinerators) for large cities, such as Beirut, Tripoli and Saida were introduced by decree of the CoM (September I, 2010). The 2006 plan remained favourable for other regions, without however restricting the possibility of studying the implementation of waste-to-energy technology for these regions.

The CDR has recently (end of 2010) launched a tender for consultancy service to integrate private international companies in solid waste management. The services consist of street cleansing, as well as collection, transportation, recycling and disposal of solid waste (including sludge) by integrating waste-to-energy through incineration.

A waste-to-energy feasibility study is currently being finalized by the CDR. The purpose of the study is to evaluate the feasibility of implementing waste-to-energy facilities as part of an integrated national solid waste master plan. The main rationale behind the need for such facilities is scarce land availability and the difficulty to identify suitable and socially acceptable sites for landfilling.

6.4.7.3 SLUDGE MANAGEMENT

There is no national sludge management strategy adopted. The feasibility of national "waste to energy" strategy is being assessed, as discussed above, and if found to be feasible, could accommodate the disposal of sludge from WWTPs.



7 FNVIRONMENTAL AND SOCIAL IMPACTS

Based on previous relevant and similar environmental studies and on concerns identified by technical experts and regulatory agencies; and in response to regulatory requirements and comments received from the stakeholders and project proponents during informal meetings and public consultation meetings, the following environmental and socio-economic aspects and impact categories were selected by the study team to be further studied as part of the ESIA study:

- Impacts on water quality;
- Impacts on air quality and the acoustic environment;
- Impacts on land use/landscape;
- Impacts on soil;
- Impacts on biodiversity;
- Socio-economic impacts;
- Impacts on archaeology and cultural heritage; and
- Impacts on public and occupational health and safety.

Potential impacts are identified and assessed **for both the construction and operation phases** of the Project (both components – WWTP upgrade and networks construction), based on the methodology described in the following sub-sections.

7.1 METHODOLOGY: IMPACT IDENTIFICATION AND ASSESSMENT

7.1.1 GENERAL APPROACH

The type, nature (positive, negative, direct, indirect), magnitude, timing (during design, operation), duration (short term/temporary, long term/permanent) and significance of impacts are assessed in this section. The evaluation approach is a **Receptor-Specific Analysis** approach addressing the various sources of impacts from the Project's construction and operation phases.

The general evaluation process will include the following stages:

- **Step 1:** Identification of project-related activities (sources) and environmental aspects;
- Step 2: Identification of potential impacts to the environment (physical, biological, human, cultural);
- Step 3: Evaluation and assessment of the related unmitigated impact significance;
- Step 4: Identification of Best Practicable Environmental Options (BPEO); and
- **Step 5:** Re-evaluation and assessment of the mitigated impact significance.



7.1.2 IMPACT IDENTIFICATION PRE-SCREENING LEVEL

The screening methodology that is adopted for the purpose of this EIA comprises a preliminary screening process followed by a more delicate and detailed secondary screening process.

The pre-screening process includes a thorough desk study review of wastewater treatment plants implemented in other parts of the world and Lebanon. This pre-screening stage highlighted some of the major impacts that might be coupled with normal operations based on the literature research and the nature of the surrounding environment.

The key issues identified were further investigated and evaluated based on planned project operations including proposed activities, time duration, national Lebanese regulations and the social and environmental baseline information collected. The team then channeled the results to a secondary screening process.

7.1.3 IMPACT EVALUATION SECONDARY SCREENING LEVEL

The purpose of a secondary screening level is to analytically screen the wide range of possible sources and potential impacts which were previously highlighted. This screening stage further assesses the impacts in terms of their significance, reversibility, likelihood of occurrence and geographical and temporal extents.

In the secondary screening level, impacts were classified based on the types outlined in Table 7.1, then ranked into six levels of significance detailed in Table 7.2. Then, the likelihood of the occurrence of the impact was rated according to the criteria outlined in Table 7.3.Impact rating scores were then assigned according to the Likelihood of Occurrence (A. High, B. Medium and C. Low) cross-tabulated with a Consequence Rating Criteria including the consequence and significance levels. The scale is illustrated in Table 7.4.

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 reassessed.



Table 7.1 Impact Classification

Direct impacts	Those that arise from activities that form an integral part of the project (e.g. new infrastructure)
Indirect/ secondary impacts	Those that arise from activities not explicitly forming part of the Project (e.g. noise changes due to changes in road traffic flows on existing roads resulting from the operation of Project)
Cumulative impacts	Those that result from the incremental impact of an action added to other actions
Residual impacts	Those that will continue to occur even after the implementation of suitable mitigation measures (e.g., land scarring)
Temporary impacts	Those that persist for a limited period only (reversible), due for example to particular construction activities (e.g. noise from excavation works)
Permanent impacts	Those that result from an irreversible change to the baseline environment (e.g. land-take for facility operation) or which persist for the foreseeable future (e.g. air emissions from process units operation)
Positive impacts	Those that have a beneficial influence
Negative impacts	Those that have a minor, moderate or major negative influence



Table 7.2 Consequence Assessment Criteria

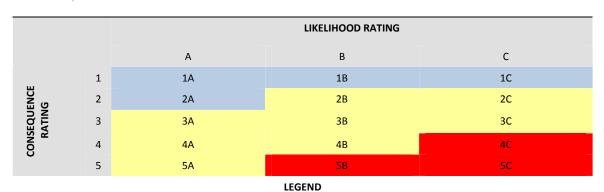
CRITERIA	CONSEQUENCE RATING
 Massive impact over a large area resulting in extensive, potentially irreparable damage to a receptor. 	
 Has a measurable effect on the livelihood of those using a resource over a period of years. Massive impact over a large area resulting in extensive, potentially irreparable damage to a site of social and/or cultural importance. 	5. Catastrophic
 Long term or continuous impact resulting in substantial adverse changes in a receptor, well outside the range of natural variation. Unassisted recovery could be protracted. 	
 Area of effect is extensive and/or encompasses an area that supports a statistically significant proportion of a receptor population or ecosystem. 	4. Major
 Has a measurable effect on the livelihood of those using a resource over a period of months. Significant damage / impact to a site of social and/or cultural importance. 	
 Moderate adverse changes in a receptor or area that supports a receptor population. Changes may exceed the range of natural variation though potential for recovery within a few years without intervention is good. 	
 Area of effect encompasses an area that supports either a moderate or minor proportion of a receptor population or ecosystem. 	3. Moderate
 Long term (> 5 years) changes over an area which is not considered to be a receptor. 	
 Has a measurable effect on the livelihood of those using a resource over a period of weeks. 	
 Moderate damage to a site of social and/or cultural importance. 	
 Minor adverse changes in a receptor. Changes will be noticeable but fall within the range of normal variation and be typically short-lived, with unassisted recovery possible in the near term. However, it is recognised that a low level of impact may remain. 	
 Medium term impact (1-5 years) in an area that does not encompass a receptor or whose impact is highly localised within a RECEPTOR. 	2. Minor
 Long term impact over a discrete, small area which does not support a receptor. 	
 May be noticed but does not affect the livelihood of those utilising a resource. 	
 Minor impact to a site of social and/or cultural importance. 	
• Short term changes in an ecosystem that are unlikely to be noticeable (i.e. fall within the scope of natural variation). Area of effect is restricted to the immediate vicinity of the source.	
 Has no discernible effect on the environmental resource as a whole and is likely to go unnoticed by those who already use it. 	1. Negligible
 Negligible impact to a site of social and/or cultural importance. 	
Changes that result in a net positive impact to an ecosystem, environment or population.	Beneficial

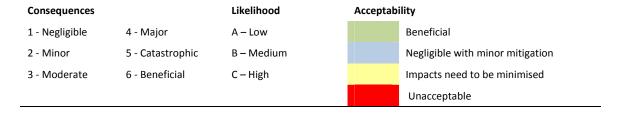


Table 7.3 Likelihood Evaluation Criteria

LIKELIHOOD TO OCCUR	CATEGORY	SCORE
Impact is highly likely or certain to occur under normal operating/ construction conditions	High	С
Impact may possibly occur under normal operating/construction conditions	Medium	В
Impact is unlikely to occur under normal operating/construction conditions but may occur in exceptional circumstances	Low	А

Table 7.4 Environmental Impact Assessment Management Matrix (Consequence and Significance versus Likelihood of Occurrence)





7.1.4 FORMAT OF IMPACT ASSESSMENT RESULTS

For each receptor, the different types of impacts are analyzed for both Project Components (referred to as "Networks" and "WWTP"), first for the Construction phase and then for the Operation Phase. Whenever applicable, impacts are analyzed separately for Phase I and Phase II of Component 2 (WWTP).

A single matrix was then developed to summarize all identified impacts during each phase for the WWTP and Networks, first assuming project execution without any mitigation measures (Table 7.18 and Table 7.16); then assuming the implementation of proposed mitigation measures (Table 7.19 and Table 7.17).



7.2 CURRENT SOURCES OF CUMULATIVE IMPACTS

Potential sources of cumulative impacts (*impacts caused by other past, present or reasonably foreseeable activities together with the project*) around the Project Site include, but are not limited to:

- Uncontrolled discharges of industrial and municipal wastewater uncontrolled discharges into the Ghadir River Basin and Ghadir WWTP Drainage Area and to the Mediterranean Sea near the Project Site;
- Air and noise emissions from airplanes and vehicular traffic around the Project Site;
- Air and noise emissions from vehicular traffic around networks construction sites; and
- The solid waste (rubble) dump located at the direct vicinity of the Project Site (mainly rubble).



7.3 IMPACTS ON WATER RESOURCES

Impacts on groundwater, surface water, and seawater guality are identified and assessed here.

7.3.1 CONSTRUCTION PHASE

Identified impacts on water resources during construction are mainly associated with the following:

- Possible groundwater and surface water pollution due to oil spills;
- Possible groundwater and surface water pollution from excavation and trenching works;
- Seawater pollution from land reclamation/dredging activities;
- Possible alteration of natural stormwater drainage; and
- Possible impact from water consumption.

These impacts are further described and assessed in the following sub-sections.

7.3.1.1 IMPACT FROM OIL SPILLS AND SOLID WASTE GENERATION

Networks Construction

The major potential sources of accidental spills during Construction of Project Component 1 and of Project Component 2 (Phase I and Phase II) include storage and re-fuelling of diesel supplies for power generation, lubricating oil as part of routine equipment operations, and equipment maintenance.

Fuel leakages contain BTEX such as benzene and toluene and methyl tertiary butyl ether (MTBE). These monocyclic aromatic hydrocarbons tend to readily evaporate from surface spills and biodegrade under aerobic and anaerobic conditions given their relatively good solubility and volatility, particularly MTBE and benzene. Whereas diesel spills consisting of BTEX; Poly Aromatic Hydrocarbons (PAH), chlorinated hydrocarbons, as well as heavy metals such as Nickel, Copper, Chromium and Zinc persist in the receiving environment, and when mixed with sediment, they tend to adhere and accumulate due to their low evaporation and biodegradability.

Construction activities are also likely to generate considerable volumes of solid waste including empty cement bags, piles of sand and dirt due to excavation, etc. Inappropriate waste handling and disposal practices may potentially result in soil, groundwater and surface water contamination due to leaching and runoffs.

Unlike the WWTP which is entirely located over one type of geological formation, the network pipelines are located along various geological formations outcropping in the study area, ranging from formations acting as aquiclude with low permeability (such as Chekka Formation and the Hammana Formation) to major national aquifers (such as the Kesrouane Formation and the Sannine Formation) (refer to Figure 6.9).

The Abeih (C2a), Hammana (C3), and Chekka (C6) Formations act as aquicludes, causing limited direct infiltration to deep aquifers. They therefore do not pose major threats in case of oil spills or major solid waste depositions.



The Sannine-Maameltein (C₄-C₅), Kesrouane (J₄), Mdairej (C₂b) and Quaternary Deposits (Q), on the other hand, act as aquifers. These have high direct infiltration to aquifers, and thus pose a major threat in case of spills and leaching. The Chouf Sandstone Formation(C₁) and Miocene Conglomerates (mcg) act as semi-aquifer, and pose medium-level threats.

Most caution should thus be taken during the construction of networks spanning areas where Sannine-Maameltein (C4-C5), Kesrouane (J4), Mdairej (C2b), Quaternary Deposits (Q), Chouf Sandstone (C1) and Miocene Conglomerates (mcg) Formations outcrop.

It is to be noted, however, that groundwater in the area closest to the coast has already been subject to considerable pressure (see Seawater intrusion boundary on Figure 6.9).

The impact of oil spills and solid waste generation on groundwater during networks construction is thus generally evaluated as **moderate**, **temporary** and of **medium likelihood of occurrence (3B)**. The impact nevertheless depends on the location and on the sensitivity of outcropping geological formations, and is to be considered and mitigated accordingly once construction works start.

The occurrence of accidental spills and leaks could be minimized, if not prevented, by the following mitigation measures:

- Scheduling the works for the dry season if possible;
- Progressively carrying out rehabilitation of disturbed areas as soon as practicable following completion of work in each area. Rehabilitation will include reinstatement of soil, surface levelling, re-vegetation and mulching;
- Immediately remediating any localized erosion;
- Adopting and implementing IFC guidelines for the prevention and control of hydrocarbon / chemical releases (IFC, 2007);
- Conducting routine inspection procedures and maintenance of equipment for risk minimization;
- Ensuring availability of oil spill response kits on the work area;
- Use secondary containment basins for long term storage of lubricants and fuels possibly used on site; and
- Promoting "good housekeeping" practices during construction, operation and maintenance.

In order to decrease the likelihood of spills occurring and mitigate the potential impacts of such incidents in the Project area, the following requirements should be addressed:

- Fuel, oil and chemicals should be stored in specifically designated areas on site, particularly on an impermeable base within a suitability contained area. Any storage tanks should be positioned to minimize the risks of damage by impact, and should be of sufficient strength and structural integrity;
- Drip trays should be installed underneath equipment such as diesel generators to contain leakages. Drip trays should be well maintained and kept drained of rainwater;
- Employees should be trained to be capable of dealing with small scale spill hazards;
- Inspection should be thoroughly practiced; and
- Collect and reuse or dispose of accordingly all used oils generated on the construction site.



The Project Proponent should envisage the development of a spill contingency plan by the Contractor. In the case of an important spill (>100 L), the operator should request quick assistance from local or foreign companies specialized in soil remediation directly upon spill reporting by site engineers. In the case of a small spill (<10 L-100 L), containment of spill and contamination could be performed on site by adopting the following:

- Immediate reporting of spill to contractor representative;
- Stopping the source of spill (closing valve, seal pipe, seal hole or as appropriate);
- Checking for hazards, flammable matters on site;
- Immediate cleaning of the spill by removing affected top soil layer by trained employees;
- Treating the removed soil as hazardous waste;
- In-situ sampling of soil in the vicinity and underneath the spill for potential contamination;
- According to sampling results, proposing a disposal method to be approved by the MoE;
 and
- Adopting dry cleaning techniques (to the extent- possible) to decrease resultant wastewater, and to avoid flushing of spills to deeper soil layers.

An additional measure consists in 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.

With mitigation measures in place, the potential oil leaks and spills and leaching from Solid Waste associated with construction activities over networks are expected to have a low likelihood and minor effect (2A).

WWTP Construction

Impacts resulting from oil spills and solid waste generation during WWTP construction are similar to those identified for the Networks' construction.

Should such spills occur over the WWTP on shore construction area, the contaminants would infiltrate the Quaternary deposits, and reach groundwater levels. If spilled on concrete/asphalt surfaces, the contaminants would be carried towards surface water bodies, mainly the sea water in this case, causing adverse impacts. Such events would cause changes in the water quality which would exceed the normal range of variation, but where there is potential for recovery within a few years even without intervention. Spills occurring off-shore during Phase II would directly impact seawater and marine sediment quality and should be handled with even greater care.

The impact of oil spills and solid waste generation on groundwater during construction of the WWTP (phase 1 &2) is thus evaluated as **moderate**, **temporary** and of **medium likelihood of occurrence** (3B).

Mitigation measures proposed to reduce the impact from oil spills and solid waste generation during WWTP's construction are similar to those identified for the Networks' construction. Additional mitigation measures aiming at preventing oil spills during Phase II (land reclamation and construction over reclaimed land) are to be investigated, if need be, in light of an updated Environmental Impact Assessment Study prior to the start of Phase II and once detailed information on planned dredging and land reclamation activities are made available.



With the above mitigation measures in place, the potential oil leaks and spills associated with construction activities of the WWTP (phase Ib)are expected to have a low likelihood and minor effect (2A). Impacts related to Phase II are to be further investigated as part of an updated EIA.

7.3.1.2 IMPACT FROM DREDGING ACTIVITIES

WWTP Construction - Phase II

The major environmental concern in relation to conventional dredging and reclamation activities includes the potential adverse impacts on the benthic environment (species and habitat) and seawater quality. Impacts on these receptors are associated with the disturbance to the seabed and categorized into direct impacts (substrate removal and/or alteration of bottom hydrography and topography and sediment composition) and indirect (enhanced turbidity and sedimentation rates, release of chemical substances and changes in hydrographic regime and land-use). The type and nature of the impact varies in terms of reversibility and severity according to the contamination type and load already existing in the sediments.

By breaking the cohesions of the sediment particles, dredging normally causes to some extent an increase of turbidity that may be regarded as an indicator for potential ecological impacts, as resuspension of sediments may give rise to the following:

- Spread of sediments and associated contaminants in the surroundings of the dredging site;
- Transport of sediments, particularly of finer fractions, and possibly adsorbed contaminants from the dredging area to other (possibly more sensitive) areas, possibly resulting in an increase of contaminant concentrations there;
- Release of nutrients resulting in potential risk of eutrophication;
- Introduction of new species either from ballast water released by the dredger or by physical transport (wave movement...);
- Consumption of oxygen (oxygen depletion), generally limited to the direct surroundings of the dredging site. Substances, which consume oxygen, nutrients and harmful materials, bonded to the sediments, can relatively easily be released into the water and thus reduce its oxygen content or cause an increase in the concentration of nutrients or harmful materials.
- Impact on pelagic and benthic organisms such as decrease of primary production due to smothering from reduced transparency of the water column;
- Mixing of interstitial water with sea water. Turbidity plumes and re-suspension may change the physical/chemical equilibrium, with a potential to release contaminants into the water; and
- Bioaccumulation of heavy metals and other petroleum-based contamination released from contaminated sediments.

Given the localized nature of the project, the area of effect is restricted to the vicinity of the source, and any potentially released contaminants and sediments are likely to disperse within a relatively short time-frame.

Nevertheless, it is recommended that this impact be more duly analyzed as part of an updated EIA study specific to reclamation activities prior to the start of Phase II; once there is more information on planned dredging activities available.



It can be assumed that impacts associated with sea bed disturbance such as release and spread of pollutants trapped in sediments during dredging activities, have a **high** likelihood of occurrence and are considered of **moderate** effect (3C).

Mitigation measures aiming at reducing re-suspension of sediments and increases in turbidity levels include:

- Using Silt Curtains and ensuring that lower end of 'skirt' is resting upon the seafloor, and
 ensuring that top of the 'skirt' is always above the surface of sea;
- Reducing velocity of dredging;
- Decreasing the time-frame over which the dredging operation is to take place; and
- Limiting dredging operations to calmer sea states;
- Ensuring proper disposal of dredged material; and
- Conducting a seawater quality analysis as part of an updated EIA prior to the start of works on Phase II.

With this in place, dredging activities are expected to have a **medium** likelihood of occurrence while still having **moderate** effects (2B).

7.3.1.3 IMPACT FROM WATER CONSUMPTION

Networks Construction

Water needs during the construction of the networks component are also associated with consumption of drinking water by construction workers, and the use of water as a raw material and for pumping tests. These are also expected to be relatively limited, although more important in extent given the large area of coverage and the estimated total length of networks to be constructed (about 80 Km of primary networks and about 707 Km of secondary and tertiary sewers).

The impact on groundwater and surface water resources due to consumption during the Networks construction is thus evaluated as **temporary**, **minor**, and of **medium likelihood of occurrence (2B)**.

It is advised that the contractor adopts water saving techniques and raises construction workers' awareness on the matter so as to avoid overconsumption.

With this in place, the impact on groundwater due to consumption during construction of the network is reduced to **negligible** of **medium likelihood of occurrence (1B).**

WWTP Construction

Water consumption constitutes a source of pressure on groundwater resources. Water needs during construction of the WWTP (phase 1 & 2) are mainly associated with:

- Consumption of drinking water by construction workers; and
- Use of water as a raw material in the construction process.

Water requirements during construction are estimated in Table 7.5.



Table 7.5 Estimated Water Needs during Construction

Type of Water Consuming Activity	Daily Estimated Consumption (m³/day)	Total Estimated Need (m³)
Construction workers	3	N/A
Concrete Batching – Phase I	N/A	5,200
Concrete Batching – Phase II	N/A	24,000

These relatively low consumption levels are expected to cause minor changes in water availability, which would be short-lived and likely to go unnoticed.

The impact on groundwater and surface water resources due to consumption during the WWTP construction is thus evaluated as temporary, minor, and of low likelihood of occurrence (2A).

It is advised that the contractor adopts water saving techniques and raises construction workers' awareness on the matter so as to avoid overconsumption.

With this in place, the impact on groundwater due to consumption during construction of the WWTP is reduced to negligible with low likelihood of occurrence (1A).

7.3.2 OPERATION PHASE

Identified impacts on groundwater, surface water and seawater resources during WWTP and Network Operation are mainly associated with the following:

- An overall improvement in groundwater, surface water and seawater quality due to upgraded wastewater treatment and reduced uncontrolled discharges;
- Localized seawater pollution due to the use of the emergency outfall during plant failures and possible overflows (PS);
- Possible groundwater and surface water pollution due to oil spills;
- Possible groundwater and surface water pollution due to wastewater leakages; and
- Negligible reduction in groundwater and surface water availability due to consumption.

These impacts are further described and their significance evaluated in the following sub-sections.

7.3.2.1 OVERALL IMPACT ON GROUNDWATER, SURFACE WATER, AND SEAWATER QUALITY

Given the nature of the Project, which aims to improve wastewater treatment and extend network connections in the Study Area, an overall positive impact on surface water, groundwater, and sea water resources is expected to arise, mainly due to:

- Improved quality of discharged effluents;
- Reduced uncontrolled discharges into the sea; and
- Reduced uncontrolled discharges into the Ghadir River and other water courses in the Al-Ghadir WWTP drainage area.



Networks Operation

An overall positive impact is expected to result from the operation of the networks once completed, mainly due to:

- The termination of uncontrolled discharges of untreated sewage into the environment, currently frequently observed, thus reducing diffuse pollution of groundwater, surface water and seawater resources, while at the same time reducing the risk of proliferation of odors, negative visual impacts, and disease vectors;
- The elimination of pollution of stormwater drainage channels, currently also used as raw sewage recipients; and
- The elimination of the need for septic tanks (although not very frequently used in the Study Area) which typically cause water pollution due to leakages resulting from poor installation and maintenance.

It is important to note, however, that this positive impact is conditional upon 1) the construction of the networks and 2) their connection to the WWTP. If completed but not connected, only the type of pollution would change from diffuse to a point and much more intense source of pollution.

The completion of Network Connections over the entire Al-Ghadir Drainage Area is thus highly likely to result in a **long-term beneficial** impact (**6C**) on water quality in the Study Area.

WWTP Operation - Phase I

During Phase I.b of the project (2020-2030) the upgrade to primary treatment will result in BOD removal in the range of 25%-30%, representing a clear improvement on current preliminary treatment processes achieving 5-10% BOD reduction. Expected effluent quality for different parameters when the treatment is upgraded from preliminary to primary level, and the long sea outfall is used, is described in Table 7.6.

Table 7.6 Expected Effluent Quality after Upgrade to Primary Treatment (Phase I.b) (Source: Extension of Al-Ghadir WWTP - Feasibility Study Part II a: Development of Alternative Processes for the WWTP. 2012)

Parameters	Expected quality after primary treatment
Flow (m ³ /s)	3.44
(wet weather average)	
BOD ₅ (mg/L)	257
TSS (mg/L)	203
NH ₄ -N (mg/L)	65
Total P (mg/L)	9
Total Coliforms	1.00E+07
(MPN/ 100 mL)	

When compared to required ELVs, the required dilution ratio for each of the parameters can be calculated. These are shown in Table 7.7, while near-field dilution factors for various current speeds are shown in Table 7.8.



Table 7.7 Required dilution factors to achieve ELVs (Source: Extension of Al-Ghadir WWTP - Feasibility Study Part II a: Development of Alternative Processes for the WWTP. 2012)

Parameters	Expected Effluent Quality (mg/l)	ELV (mg/l)	Required Dilution Ratio
BOD ₅ (mg/L)	257	25	10.28
TSS (mg/L)	203	60	3.38
NH ₄ -N (mg/L)	65	30	2.17
Total P (mg/L)	9	5	1.80

Table 7.8 Near-field dilution factors for different current speeds (Source: Extension of Al-Ghadir WWTP - Feasibility Study Part II a: Development of Alternative Processes for the WWTP. 2012)

Turthu. Development of Attenuative Processes for the www		
Current Speed (m/s)	Dilution Factor	
0.01	42.47	
0.02	84.94	
0.03	127.41	
0.04	169.88	
0.05	212.35	
0.06	254.82	
0.07	297.29	
0.08	339.76	
0.09	382.23	
0.1	424.70	
0.11	467.17	
0.12	509.64	
0.13	552.11	
0.136	577.59	

As shown in Table 7.8, the lowest dilution is in the order of 42, well above the highest required dilution as presented in Table 7.7 (10.28 for BOD_5). It is thus highly likely that sufficient dilution will take place before any of the contaminants reach the surface.

Table 7.9 represents the expected far-field dilution factor for various current speeds and their respective effect on total coliforms potentially reaching the shore.



Table 7.9 Total Coliforms reaching bathing waters (Source: Extension of Al-Ghadir WWTP - Feasibility Study Part II a: Development of Alternative Processes for the WWTP, 2012)

Development of Alternative Prod CURRENT	DILUTION	TRAVEL TIME	NUMBER OF
(m/s)		(hr)	COLONIES REACHING THE
			COAST/100ml
0.01	183.86	57.72	0
0.02	367.72	28.86	0
0.03	551.58	19.24	0
0.04	735.44	14.43	0
0.05	919.30	11.54	0
0.06	1,103.16	9.62	0
0.07	1,287.01	8.25	0
0.08	1,470.87	7.22	0
0.09	1,654.73	6.41	0
0.1	1,838.59	5.77	1
0.11	2,022.45	5.25	2
0.12	2,206.31	4.81	3
0.13	2,390.17	4.44	5
0.136	2,500.48	4.24	6

Observations from the previous table indicate that even for the highest current speeds, the discharge is distant enough to allow dilution to minimize if not eliminate Coliforms presence in bathing waters. Sea water quality at the level of the discharge is also expected to improve as a result of the upgrade of the treatment level from preliminary to primary.

As such, the upgrade of the WWTP to Primary Treatment under the Project's Phase I will result in a long-term beneficial impact (6B).

WWTP Operation - Phase II

Secondary wastewater treatment, and specifically under the Conventional Activated Sludge treatment system, produces a highly treated and well-nitrified effluent that meets secondary effluent quality standards. In addition, in designs where disinfection is incorporated, as in the case of the Ghadir WWTP, bacterial population in the discharged effluent is significantly suppressed.



Expected effluent quality after secondary treatment is described in Table 7.10.

Table 7.10 Expected Effluent Quality after Upgrade to Primary Treatment (Phase II)

PARAMETERS	EXPECTED QUALITY AFTER SECONDARY TREATMENT	ELV	BATHING WATER CRITERIA
Flow (m ³ /s) (wet weather average)	3.99 (2050)	-	-
BOD ₅ (mg/L)	25	25	-
TSS (mg/L)	35	60	-
NH ₄ -N (mg/L)	7	30	-
NO ₃ -N (mg/L)	20	30	-
Total P (mg/L)	7	5	-
Total Coliforms (MPN/ 100 mL)	500	-	500

All parameters are equal or below the ELV threshold and in line with EU limits. The slight exceedance of phosphate will easily be compensated by near-field dilution even at very low current. Total Coliforms are also in line with the bathing water criteria requirements. The effluent can thus be safely discharged using the short outfall with no negative impacts on seawater or on its potential users.

A significant improvement is expected to occur as a result in comparison with the current situation where the short outfall is being used as an emergency overflow, whereas wastewater is discharged directly into the sea after a simple preliminary treatment (if not with no treatment at all).

As such, the upgrade of the WWTP to Secondary Treatment under the Project's Phase II is **highly** likely to result in a **long-term beneficial** impact (**6C**) on seawater quality.



7.3.2.2 IMPACT FROM PLANT FAILURE CONDITIONS

WWTP Operation

Operational upsets potentially resulting in the use of the existing emergency short outfall are likely to occur, particularly due to incidental industrial discharges and stormwater overflows reaching the plant. Although temporary in nature and small in scale, such events can have negative impacts on seawater quality. In such cases, untreated treated wastewater is likely to be momentarily discharged directly into the sea (via the short sea outfall during Phase I and via the long outfall in Phase II), causing moderate to minor changes in seawater quality (especially if compared to the current situation) and which would be relatively confined in time and space.

During Phase II, the long sea outfall would be used as emergency outfall. In this case, the impact of plant failure conditions would be significantly less as compared to the current situation that the short outfall is used for excessive untreated wastewater discharges.

With no mitigation measures in place, the impact from plant failures are expected to be minor, temporary, and of medium likelihood to occur (2B).

Main recommendations aiming to reduce the likelihood of occurrence of operational upsets include:

- Proper management coupled with continuous and effective monitoring and maintenance;
- The preparation, implementation and monitoring of an industrial pollution abatement program in the Al-Ghadir drainage area;
- Ensuring redundancy in the WWTP design; and
- Ensuring adequate training of plant operators to minimize the risks and effects of abnormal conditions.

With such measures in place, the risk of plant upset is reduced both in frequency and in magnitude.

As a result, the impact on water resources from plant upset conditions after implementation of the proposed mitigation measures is expected to be **minor**, **temporary**, and of **low** likelihood of occurrence (2A).

7.3.2.3 IMPACT FROM OIL SPILLS

Networks Operation

Impacts resulting from oil spills during Networks operation, as well as mitigation measures proposed to reduce them, are in all ways similar to those identified for the WWTP's operation below.

WWTP Operation

Apart from minor spills or leakages from fuel storage for power generation at the WWTP during its operation, no major risks of spills can be anticipated. The impact and likelihood of such events is considered similar to that occurring during construction (refer to section 7.3.1.1).

The impact of oil spills on groundwater during operation of the WWTP (phase 1 &2) is thus evaluated as **moderate**, and of **low likelihood of occurrence (3A)**.



Mitigation measures are also similar to those suggested to mitigate the risk of oil spills and leakages during construction.

With mitigation measures in place, the potential oil leaks and spills associated with operation activities of the WWTP (phase 1 & 2) are expected to have a **low** likelihood and **minor** effect (2A).

7.3.2.4 IMPACT FROM WASTEWATER LEAKAGES

Networks Operation

The failure of sanitary infrastructure components can be attributed to the failure of:

- Pumps;
- Pump Station Power;
- Force main;
- Complete Pump Station Failure; or
- Gravity Sewer.

The major potential source of network leakage during operation is due to breakage of a network pipeline or to flooding of lifting pumps as a result of power blackouts or failure. Force mains operate under pressure and are typically a smaller diameter conduit with relatively thin walls (potential for accidental failure during work on adjacent utilities), resulting in the likelihood or risk of a total force main failure being greater than that of a trunk gravity sewer. Although the failure of a force main is generally rare, a force main may fail by collapse because of poor construction practices like improper bedding / backfill and compaction or a material flaw. Another scenario would be accidental breakage during subsequent construction or geotechnical investigation activities. Force mains may also become blocked at an unknown location due to sedimentation and/or build-up of grease.

Power for the operation of pumping stations will be provided through EDL and the village's generator during blackouts. Complete pumping station failure is unlikely but can be catastrophic when it occurs. Such failure could be a combination of local power outage and failure of the backup diesel generator.

A gravity sewer may fail by collapse due to improper bedding / backfill and compaction or a material flaw. The cause can be improper installation or the removal of fine particles within the bedding by pipe infiltration. Gravity sewers may also become blocked at an unknown location due to build-up of debris, grease and/or roots intrusion. A gravity sewer will likely continue to convey flow after a partial failure occurs. The likelihood of a gravity sewer pipe failure is small, especially for total failure of a large diameter trunk sewer since some flow will usually continue to pass. However, corrosion problems resulting from H2S generation can accelerate the possibility of failure in unprotected concrete pipe and manhole structures, especially on those sections near the discharge of a long forcemain.

The network pipelines are located along various geological formations outcropping in the study area, ranging from formations acting as aquiclude with low permeability (such as Chekka Formation and the Hammana Formation) to major national aquifers (such as the Kesrouane Formation and the Sannine Formation).

The ten (10) pumping stations are located South of the WTTP, where five (5) pumping stations are located on the Sannine Formation, two (2) pumping stations are located on the Quaternary Deposits, one (1) pumping station is located on the Chouf Sandstone, one (1) pumping station is





located on the Abieh Formation, and one (1) pumping station is located on the Hammana Formation (Figure 7.1).

The pumping stations and network pipes located on aquicludes (Abeih and Hammana Formations) have limited direct infiltration of wastewater to deep aquifers without posing major threats. On the other side, the pumping stations and network pipelines located on aquifers (Sannine Formation and Quaternary Deposits) or semi-aquifers (Chouf Sandstone Formation) have high direct infiltration of wastewater to aquifers, and pose a major threat in case of breakage or failure.

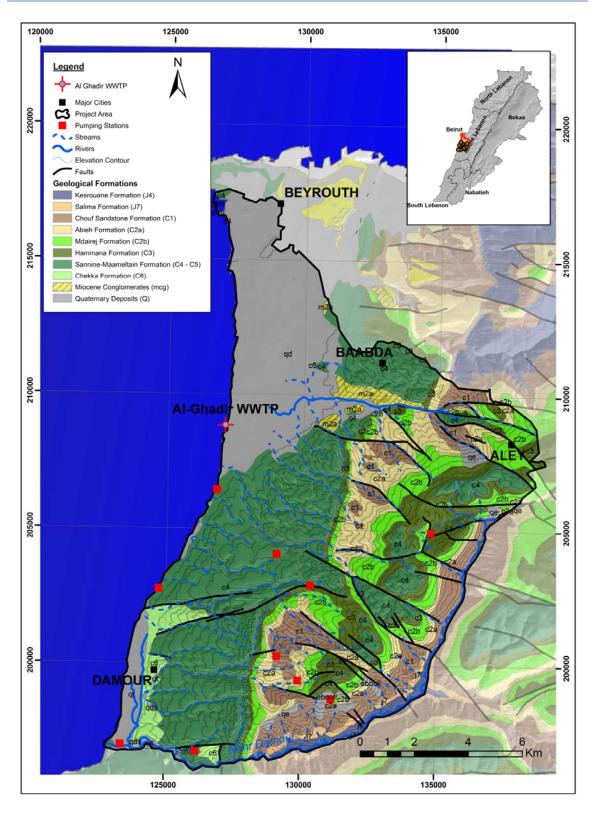


Figure 7.1 Geological Map showing Location of Pumping Stations in the Service Area



Project Preparation and Implementation Facility (MeHSIP-PPIF)

A TA operation funded by the European Union - FEMIP Support Fund

Leakage of wastewater that might occur at the river crossing is expected to cause relatively greater impact by contaminating the river locally underneath the crossing as well as downstream.

Despite the fact that the likelihood of network leakage is **low**, its effect is considered **moderate (3A)** when no mitigation measure is in place.

The Project Proponent shall envisage the development of a network leakage contingency plan by the Contractor. The following mitigation measures are recommended:

- Ensure proper bedding, backfilling and compaction of soil during the construction of the network;
- Network pipes should ideally be made of HDPE which is resistant and durable;
- Regular inspection and maintenance of electrical and mechanical components at pumping stations;
- The installation of pressure monitors on force mains allows the early detection of leaks in the network;
- Twinning of the force mains (dual force mains) provides a backup system in case repairs to the sewer are needed;
- The installation of an emergency flow line or bypass chambers also allows to divert sewage flow in case repairs to the sewer are needed;
- An emergency storage pond can be constructed near lifting stations for storage of wastewater in case of pump failure;
- In case of complete pump failure, wastewater storage within the collection system itself is a preferable solution to a discharge to the environment;
- A standby generator with sufficient capacity to start-up and maintain the firm capacity
 of the station is needed to ensure the continued operation of lifting stations in case of
 generator failure during power blackouts, and to avoid flooding in such cases;
- Regular testing (monthly) of back-up power (generator) at pumping stations;
- Establish a flow monitoring program to observe changes in flow patterns;
- Undertake an extensive monitoring program within the wastewater collection system to evaluate the levels of H2S within the system and avoid corrosion;
- Carry out flushing and a CCTV program to observe gravity sewer condition and monitor changes every 5 years;
- Subject locations where sediment accumulation or other issues of concern have been noted to increased maintenance activities;
- Periodically swab force mains;
- Implement a comprehensive alarm system at the pump station, monitoring numerous parameters covering station operation and the status of standby generator system;
- Immediately report any leakages to municipal/governmental representative; and
- Stopping the source of leak (close valve, seal pipe, seal hole or as appropriate) as soon as possible.

With the above mitigation measures and contingency plan in place, the potential network losses associated with normal project operational activities are expected to have a low likelihood and minor effect (2A).



WWTP Operation

The major potential source of leakage during the operation of the WWTP (Phase I and II) is the breakage of a pipeline or leakage from all tanks.

The WWTP is located along geological formations with medium to high permeability and medium to high porosity, allowing direct infiltration of wastewater to underlying aquifers and/or migration towards neighbouring surface bodies. Such occurrences may heavily impact water quality since the wastewater would be leaking prior to receiving any treatment.

Despite the fact that the likelihood of piping and tanks leakage during operation of the WWTP (phase I & II) is **low**, its effect is considered **Significant (4A)**, when no mitigation is in place.

The Project Proponent shall envisage the development of a network leakage contingency plan by the Contractor. In the case of a breakage in a network pipe, containment of spill and contamination could be performed on site by adopting the following:

- Ensuring the proper insulation of pipes and tanks during WWTP construction;
- Stopping the source of leak (close valve, seal pipe, seal hole or as appropriate); and
- Immediate cleaning of the spill by trained employees.

With the above mitigation measures and contingency plan in place, the potential network losses associated with construction activities of the WWTP (phase 1 & 2) are expected to have a **low** likelihood and **Minor effect (2A)**.

7.3.2.5 IMPACT FROM WATER CONSUMPTION

Networks Operation

Water consumption for networks operation is likely to be insignificant. No impact is thus to be expected here.

WWTP Operation

The current water consumption at the Preliminary Treatment Facility is limited to water consumed by around four (4) people currently operating the plant, in addition to water used for laboratory purposes and maintenance. The potential "additional water consumption" for operating the plant once upgraded relates to the increased number of personnel (28 during Phase I and 32 during Phase II), in addition to increased volumes needed for general operation activities (mainly for the preparation of aquatic solutions), maintenance, cleaning and laboratory analyses. The estimated requirements are shown in Table 7.11.



Table 7.11 Estimated Water Requirements during Operation

UNIT	ESTIMATED DAILY CONSUMPTION (m³/day)					
PHASE I						
Personnel (28 in total, 50L/person/day)	1.4					
General Operation	1,300					
PHASE II						
Personnel (32 in total, 50L/person/day)	1.6					
General Operation	2,400					

While the water consumption by the personnel can be considered negligible, water consumed by the operation process will noticeably increase as compared to the current situation. Nevertheless, part of this amount of phase II can be replaced by reused water to save freshwater consumption.

The impact on groundwater resources and surface water due to consumption during operation of the WWTP (phase I & II) is thus evaluated as **long-term**, **moderate**, and of **high likelihood of occurrence** (3C).

It is advised that the operators adopt water saving techniques coupled with proper training and awareness raising among personnel so as to avoid overconsumption, especially in maintenance and cleaning.

By adopting the proposed mitigation measures, the impacts on groundwater resources due to consumption during operation of the WWTP (phase 1 & 2) would become **minor** with **a medium likelihood to occur (2B)**.

7.4 IMPACTS ON AIR OUALITY

7.4.1 CONSTRUCTION PHASE

WWTP and Network Construction

Construction is a source of dust emissions and gases that can have temporary impacts on local air quality. The primary sources of air emissions during WWTP and networks construction include:

- Combustion and exhaust emissions from diesel-fuelled equipment, generators and transport vehicles; and
- Airborne particulates (dust) from soil excavation and transportation.

Dust emissions would vary from day to day depending on the level of activity and the prevailing weather. In addition to particulate emissions from earth moving, combustion emissions from fuel-powered construction equipment may create a temporary impact on local air quality. Diesel emissions count about 40 hazardous air pollutants (HAP) as reported by the EPA (2002). However, the main air pollutants likely to be associated with these emission sources include: Nitrogen Oxides

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 (NO_x) , Sulfur Dioxide (SO_2) , Carbon Dioxide (CO_2) , Carbon Monoxide (CO), and Particulate Matter (PM).

Table7.12 summarizes the impacts associated with potential air emissions, while Table7.13 summarizes the impacts associated with dust generation.

Table7.12 Environmental Impacts of Major Air pollutants from Combustion Sources

EMISSION	ENVIRONMENTAL IMPACT
Oxides of Nitrogen – NOX	NO2 is a toxic gas, even at relatively low concentrations. NOX also contributes to the formation of acidic species, which can be deposited by wet and dry processes. NOX can also increase the formation of ozone at ground level when mixed with VOCs in the sunlight atmosphere. NO is a relatively innocuous species, but is of interest as a precursor for NO2.
Sulfur Dioxide – SO2	SO2 is a toxic gas, and is known to contribute to acid rain deposition (wet SO2 and dry), which may impact ecosystems (soil, water bodies). Direct health effects potentially causing respiratory illness.
Particulates – PM10	Particulate matter is a complex mixture of organic and inorganic substances present in the atmosphere in either solid or liquid form. Particulate matter is inhaled and deposited within the respiratory pathways, leading to a variety of health effects.
	PM10 (i.e. particulate matter with a diameter of less than 10 μ m) is able to penetrate deeply into the lungs. An association has been established between elevated concentrations of PM10 and excess short term mortality and morbidity rates.
Carbon Monoxide – CO	Carbon monoxide (CO) is a colorless, odorless gas that is slightly less dense than air. When inhaled, the gas is absorbed into the bloodstream and combines with hemoglobin in the blood to form carboxyhemoglobin (COHb).
	The affinity of hemoglobin for CO is more than 200 times greater than for oxygen. The result is that CO acts as a poison by reducing the amount of O2 that can combine with hemoglobin.
Carbon Dioxide – CO2	Carbon dioxide is a odorless and colorless gas of greenhouse effect known to contribute to global warming.
	Prolonged exposure to moderate concentrations to CO2 can cause acidosis and adverse effects on calcium phosphorus metabolism resulting in increased calcium deposits in soft tissue. Carbon dioxide is toxic to the heart and causes diminished contractile force.

Table7.13 Potential Impacts from Dust

TARGET	POTENTIAL IMPACT
Human Health	Asthma
	Nose and throat diseases
	Eyes irritation
	Skin irritation
Environment	Low visibility and haze formation
Infrastructure	Grime deposits
	Metal corrosion
	Material deterioration



Exhaust emissions are inevitable during normal operation of combustion sources. However, lack of maintenance, poor quality fuel, unnecessary idling periods, long operation period (especially for the power generators) and absence of exhaust emission control units will result in the increase of pollutants concentration emissions.

Main receptors that may be impacted by air and dust emissions around the WWTP include:

- Inhabitants of residential areas within a radius of 1 Km from the WWTP construction site;
- The neighbouring beach resorts;
- WWTP operating personnel;
- Local wild life; and
- Agricultural fields located within a radius of 1 Km from the WWTP construction site.

It is to be noted that these receptors are already subject to cumulative air pollution resulting from traffic over the secondary road and the existing rubble dump.

Main receptors that may be impacted by air and dust emissions around the **networks** construction sites include:

- Residents around the construction sites;
- Local wild life:
- Agricultural fields, forests and other ecologically sensitive areas around the construction sites.

Overall, given the scale and duration of the project, the impact of construction-related dust and emission generation (which is highly likely to occur) will result in minor adverse changes in the Study Area's ambient air quality. This change will be temporary and its effects can recover within a short period of time after the interruption of construction activities.

Accordingly, with no mitigation measures in place, this activity is likely to have a **minor** consequence level of **high** likelihood of occurrence (2C) on the overall air quality within the project area during construction.

It is recommended that various mitigation measures be adopted, including:

- Using continually well designed, maintained and operated equipment/ vehicles by the contractor. Precautionary control measures for atmospheric emissions reduction could include proper engine fuel mixtures, regularly serviced exhaust emission systems, suitable engine tuning, and purchase of diesel fuel with low sulfur content (5% sulfur content whenever available);
- Employing environmentally friendly equipment (whenever available) by the contractor such as machinery with higher fuel efficiency or those equipped with air pollution control devices to minimize exhaust emissions. Examples include vehicles equipped with two-or three-way catalytic converters;
- Installation of Diesel Particulate Filters on Construction Equipment;
- Avoiding idling vehicles and equipment engines that are left running unnecessarily;
- Watering-down work area/s particularly near sensitive receptors, at loading and unloading operations;
- Efficient scheduling of deliveries as well as establishing and enforcing appropriate speed limits over all paved and unpaved surfaces (< 40 km/h);



- Travelling on existing and paved tracks wherever possible;
- Maintaining stockpiles at minimum heights and forming long-term stockpiles into the optimum shape (i.e. stabilization) to reduce wind erosion; and
- Installing covers (manual and/or mechanical) on back loads of dump trucks and large vehicles before leaving a construction site to reduce as low as possible, if not prevent, fugitive dust emissions from being released during road transportation and vehicular movement.

The above-mentioned mitigation measures can reduce the adverse impacts on ambient air quality to a level that is noticeable but short-lived and of low significance.

Implementing the above mentioned mitigation measures is likely to reduce construction-related air emissions and consequently minimize the project impacts on overall air quality within the project area during construction to **negligible** with **medium** likelihood of occurrence (1B).

7.4.2 OPERATION PHASE

Main sources of impact on air quality during the WWTP operation mainly consist of:

- Odour generations from the WWTP and from the networks and pumping stations;
- Greenhouse gas emissions from power generation (αt the WWTP level only); and
- Emissions from sludge treatment and disposal (at the WWTP level only).

7.4.2.1 IMPACT FROM ODOR GENERATION

Network's Operation

Impacts from networks and pumping stations operation are mainly related to possible leaks and overflows in the pumping stations, which could generate slight odours. These can be prevented through proper engineering and adequate preventive measures part of a Spill Prevention and Response Plan.

WWTP Operation

Inlet works, grit channels, screening and grit handling, and sludge treatment units (storage, thickening, dewatering) are the main sources of odor. However, in many instances, odors can be reduced or prevented through normal housekeeping, improved operation, and maintenance procedures along with proper management. When kept clean, sludge transfer systems, such as conveyors, screw pumps, and conduits, will not generate odors.

Additionally, the plant will be equipped with an odour control system, which will abate odour emissions. The odour control system will be using NaOCI solution scrubbers for the oxidation of volatile odorous substances in the off-gases from the following units:

- Preliminary Treatment Unit: All existing and new works (lifting pumps, screens, grit chambers and auxiliaries) will be enclosed and connected to the odour control system.
- Primary Settling Tanks: The tanks will be covered and connected to the system.
- Gravity Thickeners: The tanks will be covered and connected to the system.
- Anaerobic Digesters





- Sludge Screens
- Buffer tanks (prior to mechanical thickening, to digestion and to dewatering)
- Mechanical drum thickeners
- Mechanical Dewatering Unit
- Dewatered sludge silos

The storage of all malodorous solid waste (screenings, grit etc) will be in closed units so as to minimize and control the risk of residual odours.

It is to be noted that persistent odours are currently observed inside and around the existing Preliminary Treatment Plant. These mainly result from the lack of well-maintained odour control units, and the storage of screenings, grits, and sludge on-site and in the open air. The Project is thus expected to result in an overall reduction in odour emissions, thus producing a **positive** impact compared to the actual baseline situation.

The predominant wind direction in the WWTP's area is South West (Figure 6.5). It is thus expected to normally draw potential residual odours towards the sea, thus sparing residential areas. Winds also blow, although less frequently, towards the North, North East and South. Under such circumstances, the closest residential areas, airport users, and vehicles crossing roads near the site, may be slightly affected. Nevertheless, such occurrences are expected to be low in frequency and temporary in nature.

With reference to the above, and due to envisaged control measures coupled with a South-Westerly predominant wind direction observed on-site, the impact on air quality from odour generations during plant operation is anticipated to be **minor** and of **medium** likelihood of occurrence (2B).

Activated sludge tanks do not normally emit an objectionable odor when a dissolved oxygen level of \geq 2 mg/L is maintained in the mixed liquor. Thus, it is essential to

- Conduct odor simulation studies for pumping stations and the WWTP during the detailed design phase of the project to confirm that emissions thresholds are met and that concentrations of odorous compounds (mainly H2S and NH3) remain below threshold values at the nearest receptors;
- Execute 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,
 which in turn minimizes the chances for the production of odorous compounds that
 might be generated in case of incomplete aeration.
- Execute 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;
- Tank mixing during off-shifts to minimize the release of trapped gas during the day;
- Provide flow regulating chambers, drainage valves, standby pumps, as well as electric standby generators to reduce the possibility of wastewater flooding. The presence of multiple aeration basins in the plant also reduces overflowing problems; and



 Proper landscaping around the facility along with the existing landscape may serve as a natural windbreaker and minimize potential odor dispersions.

The impact on air quality from odour generations during plant operation can be reduced to **negligible** and of **medium** likelihood of occurrence (**1B**) if additional mitigation measures are implemented.

7.4.2.2 IMPACT FROM POWER GENERATION AND SLUDGE TREATMENT

WWTP Operation

The daily consumption of electric power at the WWTP at full load operation during Phase I.b is estimated at 82,983 kWh, while the respective value for Phase II is 117,152 kWh. This power demand is calculated after excluding the power generated onsite by the CHP engines and refers to the full inflow of wastewater which is 286,912 m³/day for Phase I and 345,044 m³/day for Phase II.

However, energy will be recovered from sludge during both Phase I and Phase II. The recovered energy will reduce the plant's overall power demand and energy footprint, thus reducing related GHG emissions. The biogas produced from the anaerobic process will be utilised by Combined Heat-Power (CHP) engines. For this purpose, biogas from the spherical storage tank will be fed to 3 CHP engines (2 in Phase I.b and 1 in Phase II), each rated at an electrical output power of 888 kW.

A gas flaring station will be installed in addition to the CHP engines for safety reasons (Phase I.b), so as to burn the biogas in situations when the CHP engines are out of operation (malfunction, maintenance etc). In Phase II, an additional gas flaring station will be installed. Moreover, for the initiation of the anaerobic digestion process auxiliary boilers will be used to heat up the sludge.

While flaring can result in harmful air emissions, it is to be noted that it will be used for emergency cases only. Impact would thus be temporary and short.-termed. It is to be noted that if residual sludge is to be incinerated, additional air emissions are expected to arise, resulting in an off-site impact. In addition to NOx, CO₂, and CO, emissions from flaring and incineration can include unburned hydrocarbons, particulate matter, and volatile organic compounds (VOC). If the natural gas contains H₂S, emissions can include sulphur dioxide (SO₂), carbon disulphide (CS₂) and carbonyl sulphide (COS); all of which can significantly alter air quality if they reach high concentrations.

The impact on air quality from power generation during operation is evaluated as **moderate** and of **medium** likelihood of occurrence (**3B**) given the small-scale nature of the power generation plant and given the energy reuse potential.

Maximizing the energy recovery potential would ensure a reduced Project contribution to air pollution and to climate change. Other important mitigation measures relate to reducing emissions from flaring, and include:

- Choosing efficient and low-emission equipment; and
- Monitoring the heating value of the gas to maintain a stable flare.

After the implementation of mitigation measures, the impact is evaluated as **minor**, and of **low** likelihood of occurrence (**2B**).



7.5 IMPACTS ON THE ACOUSTIC ENVIRONMENT

7.5.1 CONSTRUCTION PHASE

Networks Construction

Noise generation during construction is mainly associated with:

- Construction activities, including the transportation/delivery of raw materials; and
- The operation of heavy equipment, notably excavators.

Both sources of impacts are temporary in nature as they would be interrupted as soon as construction activities are over.

Typical noise levels associated with trucks movement are reported at 74 dB(A) according to the British Standard for Noise and Vibration Control on Construction and Operation Sites (BS5228:1997). These levels are normal in general construction sites (and can go up to 85-90 dB(A)).

Most construction activities would generate average noise levels of about 10 to 19 dBALeq (h) above ambient daytime or nighttime traffic noise when these activities occurred within about 20 meters of an adjacent land use. Maximum instantaneous noise levels generated by construction activities are typically 5 to 10 dBA above existing maximum noise levels generated by traffic, with the exception of activities such as the use of a hoe ram or impact pile driver where maximum instantaneous noise levels can exceed existing conditions by up to 20 or 25 dBA, which will not be used in this project.

Table 7.14 enumerates the different noise levels for various types of construction equipment.

Table 7.14 Typical Sound Pressure Levels Reported from Construction Equipment (BS5228:1997)

CONSTRUCTION TYPE	MACHINES	NOISE LEVEL (DBA)*
	Compactors	78
	Front Loaders / Bulldozers	88
	Backhoes	76
	Tractors	71
Earth Moving	Scrapers	82
	Caterpillar Graders	84
	Pavers	74
	Dump Trucks	74
	Excavators	78
	Concrete Mixer	76
Material Handling	Concrete Pumps	81
	Cranes	81
	Pumps	82
Stationary	Generators	82
	Compressors	85



Given that the Networks area extends over a heterogeneous zone with disparate baseline noise levels, it is expected that baseline sound pressures especially in those quieter areas would rise by levels that would be noticed without however considerably affecting the livelihood of those using or residing close to the construction sites.

With reference to the above, and due to the short duration of the construction period, the impact on Sound Quality during construction is anticipated to be **moderate** and **highly** likely to occur (**3C**).

To reduce the significance of noise impacts resulting from project construction, the following measures should be implemented during project construction. The proposed measures should adequately mitigate the noise impact to a less-than significant level to receptors, particularly workers:

- Equip all internal combustion engine driven equipment with intake and exhaust mufflers that are in good condition and appropriate for the equipment;
- All vehicles and machinery to be fitted with effective exhaust silencers;
- All vehicles and machinery should be maintained in good repair and in accordance with the manufacturer's instructions;
- Any machinery, which is intermittent in use, should be shut off in periods of non-use or, where this is impracticable to be throttled back to a minimum; and
- Establish a noise complaint grievance mechanism as a measure to allow implementation of timely and effective actions to minimize impacts from noise.

With the proposed mitigation measures in place, the impact on sound quality is reduced to **minor** with a **high** likelihood of occurrence **(2C)**.

WWTP Construction

Considering that the WWTP is located close to the Airport, noise levels are generally high. Although construction activities are likely to temporarily raise baseline sound pressures, it is expected that they would be barely noticed.

Impacts on the acoustic environment resulting WWTP construction, as well as mitigation measures proposed to reduce them, are in all ways similar to those identified for the Networks' construction.

7.5.2 OPERATION PHASE

Network Operation

Noise from the network component operation is expected to arise mainly from the operation of pumping stations. Properly enclosing the stations and keeping them maintained at all times would help reduce any such impacts.

The impact on Sound Quality during operation is anticipated to be **negligible** and of a **low** likelihood to occur (1A).





WWTP Operation

Noise during WWTP operation is mainly expected to arise from heavy machinery and equipment.

The impact on Sound Quality during operation is anticipated to be **negligible** and of a **low** likelihood to occur (**1A**), given that the project is located close to the Airport where noise pollution levels are already high.

Proposed noise mitigation measures include:

- Selecting new equipment that conforms with international standards;
- Placing air blowers and other noisy equipment in isolated rooms would ensure that noise levels comply with national standards;
- Equipping all internal combustion engine driven equipment with intake and exhaust mufflers that are in good condition and appropriate for the equipment;
- Keeping equipment maintained in good repair and in accordance with the manufacturer's instructions; and
- Fencing and screening the site with a green belt to muffle any residual noise generation.



7.6 IMPACTS ON LANDSCAPE AND LAND USE

7.6.1 CONSTRUCTION PHASE

7.6.1.1 IMPACT ON VISUAL AMENITY

WWTP and Networks Construction

No major impacts are expected to result from construction activities related to the WWTP upgrade or those related to the networks, apart from temporary decreased visual amenity and aesthetics due to the temporary storage of construction material and machinery on-site. The impacts are likely to be noticed by inhabitants and users of the area, without however considerably affecting their livelihoods.WWTP Construction works (phase Ib and phase II), however, will be additionally visible by air plane travelers, and may constitute a greater visual impact.

While the impact of the project's Construction on the landscape is **highly** likely to occur, it is expected to be **minor** and **temporary** (2C).

Impacts during construction can be mitigated through hoarding or boundary fencing around construction sites, sensitively designed to fit into the existing environment when looking from outside.

With mitigation measures in place, the **temporary** impact on the landscape from construction activities can be reduced to **negligible** levels with a **high** likelihood of occurrence (**1C**).

7.6.1.2 IMPACT ON LAND USE

Networks Construction

Networks may cross agricultural land, potentially requiring the removal of trees or affecting agricultural areas. Consequently, the land will lose its agricultural value. This impact would be irreversible, but it is not highly likely to occur given that the routing can always be moderately modified to avoid any significantly sensitive areas. Additionally, secondary and tertiary networks will, to the extent possible, follow existing road routes.

The consequence of the Project's impact on land use during the construction phase is considered to be **moderate** and of **medium** likelihood of occurrence (3B).

However, appropriate measures can be taken to reduce the impacts on land use, mainly through the avoidance of sensitive areas. Recommended mitigation measures related to tree relocation include:

- Relocating the trees to a different land with the same specification; the neighbouring farmers would take in these trees;
- Preserving any removed roots and avoiding damaging them to the extent possible; and
- Avoiding the use fertilizers for a period of time exceeding one year to avoid damaging the vulnerable roots.

With the proposed measures in place, the consequence of the impact on land use can be reduced to **minor** and its likelihood of occurrence to **low (2A)**.



7.6.2 OPERATION PHASE

Networks and WWTP's Phase I and Operation

No major impacts are expected to result from the WWTP in its first phase and from the networks during Operation.

WWTP Operation - Phase II

Necessary land reclamation for upgrading to secondary treatment (Phase II) will result in a permanent but localized disturbance of the coastline. Due to the limitation on maximum facility height imposed by the proximity to the airport, it is expected that the facility would not significantly obstruct the sea view. Nevertheless, the plant is expected to be highly visible from air planes, from the beach resorts located south of the Plant and from residential areas north of it, thus irreversibly impacting the coastline view. Given the plant's crucial environmental function, combining a progressive and well-thought architectural design with awareness campaigns would improve the general public's perception and acceptability towards it, hence reducing the visual disturbance.

Nevertheless, it is recommended that this impact be more duly analyzed as part of an updated EIA study specific to reclamation activities prior to the start of Phase II in 2030 according to the project implementation plan.

It is thus expected that the impact from the WWTP in its phase II will have a **moderate** and **long-term** impact on the landscape (3C).

To mitigate negative impacts resulting from the existence of wastewater treatment facilities on the landscape, the following steps are recommended:

- Maintaining cleanliness within the treatment plant (preventing spillovers, cleaning roads and ground, etc.);
- Appropriate landscaping of the plant grounds with planting of suitable trees, grass, and flowers;
- Fencing and screening the site with appropriate trees to obstruct the plant components from onlookers and area inhabitants (all along with some noise reduction); and
- Analyzing the land reclamation's impact on the landscape as part of an updated EIA prior to the start of works on Phase II.

With this in place, the **long-term** impact would be reduced to a **minor** level of significance with a **medium** likelihood to occur (**2C**).

7.7 IMPACTS ON SOIL AND SEDIMENTS

7.7.1 CONSTRUCTION PHASE

Impacts on soil and sediments resulting from the WWTP's and Networks construction include:

 Soil pollution from excavation and trenching works, oil spills, and solid and liquid waste generated during construction; and



 Sediments contamination from land reclamation/dredging activities (Phase II of component 2 only).

7.7.1.1 IMPACT FROM EXCAVATION AND TRENCHING WORKS, OIL SPILLS, AND SOLID AND LIQUID WASTE GENERATION

Networks and WWTP (Phase I) Construction

The Project's disturbance to soil resulting from excavation and trenching works is restricted to construction areas and limited to pipeline corridors and tunnel alignments. Additional civil works may be required for the construction and/or upgrade of access roads to the construction sites.

The major potential sources of accidental spills during construction include storage and re-fuelling of diesel supplies for power generation, lubricating oil as part of routine equipment operations, and equipment maintenance. Fuel leakages contain BTEX such as benzene and toluene and methyl tertiary butyl ether (MTBE). These monocyclic aromatic hydrocarbons tend to readily evaporate from surface spills and biodegrade under aerobic and anaerobic conditions given their relatively good solubility and volatility, particularly MTBE and benzene. Whereas diesel spills consisting of BTEX; Poly Aromatic Hydrocarbons (PAH), chlorinated hydrocarbons, as well as heavy metals such as Nickel, Copper, Chromium and Zinc persist in the receiving environment, and when mixed with sediment, they tend to adhere and accumulate due to their low evaporation and biodegradability.

Should such leakages occur, significant long term changes in soil quality are likely to be observed. However these impacts would be localized given the relatively small volume of oil to be stored on-site.

Additionally, waste handling and disposal practices throughout the course of the site preparation activities and construction works pose potential risks of soil contamination either through direct contamination (if hazardous) or through the generation of contaminated leachate. The main waste streams expected to be generated include:

- Inert solid waste stream (construction waste (concrete, wood, steel, rock spoil), domestic / putrescibles and packaging and green/organic waste);
- Liquid waste streams (grey water, sanitary wastewater and hydrotest water); and
- Non-inert waste streams (recovered solvents / chemicals, acids, paints, fuel and oils, hydrotest water-if mixed with additives).

If not mitigated, the impact on soil from physical disturbance, from potential oil spills, and from solid and liquid waste generated is expected to be **moderate**, **temporary**, and of **medium likelihood** to occur (3B); as any changes in soil quality would be of small-scale and relatively confined nature.

Mitigation measures proposed include:

- Adopting minimum safe operating widths and using existing tracks whenever possible to minimize the size of the area impacted by trenching and excavation works;
- Adhering to proper waste management practices to reduce the risk of soil contamination through leaching; and
- Keeping all equipment well maintained and adopting a Spill Prevention and Response Plan to reduce the risks of leaks happening.



When mitigation measures are applied, the impact on soil during construction can be reduced to minor, temporary, and low likelihood of occurrence (2A).

7.7.1.2 IMPACT FROM LAND RECLAMATION/DREDGING ACTIVITIES

WWTP Construction - Phase II

As mentioned in 7.3.1.2, dredging activities for land reclamation are likely to result in substrate removal and/or alteration of bottom hydrography and topography and sediment composition; indirectly causing changes in turbidity and sedimentation rates, release of chemical substances, and changes in hydrographic regime and land-use.

Breaking the cohesion of the sediment particles may give rise to the following:

- Re-suspension of sediments;
- Spread of sediments and associated contaminants in the surroundings of the dredging site; and
- Transport of sediments, particularly of finer fractions to other (possibly more sensitive) areas.

Nevertheless, it is recommended that this impact be more duly analyzed as part of an updated EIA study specific to reclamation activities prior to the start of Phase II.

If not mitigated, impacts from dredging activities on sediments are **highly** likely to occur. They would, however, be **localized**, **temporary**, and of **moderate** severity (3C).

Mitigation measures aiming at reducing re-suspension of sediments are similar to those suggested under 7.3.1.2, and include:

- Coordinating with the Directorate General of Land and Maritime Transport;
- Using Silt Curtains and ensuring that lower end of 'skirt' is resting upon the seafloor, and ensuring that top of the 'skirt' is always above the surface of sea;
- Reducing velocity of dredging;
- Decreasing the time-frame over which the dredging operation is to take place;
- Confining dredging operations to calmer sea states; and
- Conducting a sediment analysis over the dredging locations as part of an updated EIA prior to the start of works on Phase II.

The above mitigation measures would reduce the likelihood of re-sedimentation to **medium** levels, and its impact to **minor** and **temporary** (2B).

7.7.2 OPERATION PHASE

Networks Operation

The networks operation is expected to have an overall **positive** impact on soil quality mainly as a result of the reduction of uncontrolled wastewater discharges in the Study Area.



Nevertheless, localized negative impacts of limited intensity may result from leaks in networks, if not well managed and maintained. Proper engineering and adequate preventive measures, in addition to the adoption of a Spill Prevention and Response Plan, can reduce the related risks.

As such, the Project is **likely** to have a **long term, beneficial** impact on soil quality in the Study Area once fully operational (**6B**).

WWTP Operation

Impacts on soil during operation are expected to result mainly from:

- Solid waste streams and sludge generated at the Plant; and
- Localized modified hydrodynamic regime due to reclaimed land offshore.

Solid waste streams will mainly be limited to office domestic waste, laboratory waste, sanitary wastewater, chemicals, fuel oil and sludge. Given that the WWTP will be operated by 28 to 32 staff (during Phase I and Phase II, respectively), it is anticipated that around 15 kg of domestic solid waste and around 1.6 m³ of sanitary wastewater will be generated daily. The daily sludge production at full load operation of the WWTP during Phase I is calculated at 162 m³/day, while the respective value for Phase II is about 324 m³/day.

Sludge generated at the WWTP may cause a negative off-site impact on soil if not properly treated and disposed of. However, sludge dewatering and stabilization will be applied on-site, rendering it suitable and safe for transport and disposal in landfills or energy recovery facilities. Application of the pre-treated sludge on agricultural lands is not considered at the moment due to industrial discharges to the receiving network which may considerably affect sludge composition and quality.

During Phase II, localized modified hydrodynamic regime due to the newly reclaimed land offshore may affect sediment transport processes and coastal erosion. It is recommended that this impact be more duly analysed as part of an updated EIA study prior to the start of Phase II.

The impact on soil during plant operation is thus expected to be **negligible** and of **low** likelihood to occur (1A).

7.8 IMPACTS ON BIODIVERSITY

Main identified impacts on biodiversity during the construction phase are associated with the following:

- Habitat loss or destruction and vegetation loss due to physical damage from clearance activities and vehicular transport during construction; and
- Altered abiotic/site factors due to wastewater leakages and oil spills during operation.

These impacts are further described and their significance evaluated in the following sub-sections.

Additional potential impacts are summarized in Table 7.15.

Table 7.15 Potential Negative Impacts on Biodiversity



POTENTIAL IMPACT	CAUSE
Habitat loss or destruction	Construction works
Altered abiotic/site factors	Soil compaction, erosion
Mortality of individuals	Destruction of vegetation (Planted fruit trees)
Loss of individuals through emigration	Following disturbance or loss of habitat
Habitat fragmentation	Habitat removal and/or introduction of barriers
Disturbance	Due to construction noise, traffic, or presence of people
Altered species composition	Changes in abiotic conditions, habitats (not present in this case)
Vegetation loss	Soil contamination due to disposal of oils and waste material

7.8.1 CONSTRUCTION PHASE

Networks Construction

As mentioned in the biological environment baseline chapter (6.3), the networks area contains different types of lands (i.e agricultural lands, artificialized lands, herbaceous vegetation, permanent streams, unproductive land and wooded land), represented in Figure 6.24.

The main impacts from site clearance and civil works related to networks construction involve the loss of vegetative cover that supports natural habitats of the site fauna. Any significant damage to vegetation cover or flora will result in further loss of vulnerable feeding sources for local fauna. Construction activities will have a direct local impact on invertebrates such as snails, scorpions, spiders, beetles also ants; crickets and locusts along with small vertebrates (lizards, small mammals) present on the site area on soil cover and within the top soil layer. Any significant loss or disturbance of the fragile ecosystem of the listed above species could have negative impacts on the other animals feeding sources although this impact expected to be minor in general.

Most sensitive areas identified in the Study Area are as follows:

- Areas covered by herbaceous vegetation, highly important in terms of ecological value.
 Although these only constitute 0.16% of the Study Area, they need to be dealt with carefully if crossed by networks, through the preservation of excavated top soil and revegetation of the disturbed areas with common local species.
- Agricultural lands, covering 23, 43% of the Study Area. Besides their importance in terms
 of coverage, these lands will see the removal of trees and crops, affecting both the
 vegetation cover and the livelihoods of farmers. Any affected trees should be re-planted
 in neighbouring lands so as to minimize vegetation loss.
- Wooded lands, mainly consisting of Pinus and Quercus forests, and covering around 31% of the network area. These have been heavily degraded during the last 10 to 20 years.
 Caution should thus be observed in such lands to avoid further degradation and habitat destruction.
- Vegetation close to permanent streams, representing an ecosystem which is already under pressure in Lebanon due to pollution and misuse of water streams. Construction of networks close or through permanent streams should be avoided or minimized to the extent possible.



It is advised that a more detailed study over the networks area be undertaken prior to the start of works and as they proceed, in order to identify additional ecological sensitivities along chosen routes.

The impacts from networks construction on local fauna and flora are thus expected to be **significant** if not mitigated, and of **medium** likelihood of occurrence (**3B**).

Mitigation measures to minimize the impacts on the local flora and fauna include:

- Confining vehicular movements to defined roads;
- Keeping with minimum safe operating width and using existing tracks whenever possible to minimize impacted area size;
- Preserving excavated top soil and re-vegetating disturbed areas by seeding common species such as herbs and shrubs;
- Supervising the implementation of the proposed Waste Management and Spill Contingency plans;
- Raising the awareness of workers on the respect and preservation of wildlife during construction and operation phases;
- Spreading excavated topsoil containing pollen and roots of the original vegetation at the
 peripheries around the WWTP upon completion of construction works in order to
 regenerate and reintroduce some of the native flora species present in the area; and
- Conducting a biodiversity assessment over the network routes prior to the start of works on networks.

The impacts from networks construction on local fauna and flora are thus expected to be **minor**, **short-term**, and of **low** likelihood of occurrence (2A).

WWTP Construction

As noted in the baseline study (section 6.3), vegetation is well distributed along the WWTP's area, even over the rubble dump facing the plant. This vegetative cover is expected to have developed partly owing to the presence of the WWTP, feeding on biological matter made available by discharges through the emergency outfall.

This flora component expected to be affected during the construction phase as a result of the removal of top soil layers.. Additionally, construction activities are expected to directly and indirectly impact fauna components. Direct impacts are related to physical injuries from accidents or human activities (hunting, nest robbing, poisoning, trading, etc...). Indirect impacts are related to habitat loss and reduction in food resources due to damages inflicted on the vegetation cover.

It is to be noted that no sensitive or endangered floral species were identified on-site. No endangered or protected faunal species were observed either. However, animals documented in the baseline survey are generally mobile and tend to move away from sources of disturbance.

Direct and indirect impacts on fauna and flora would be permanent and irreversible. They will be, nevertheless, very limited in terms of geographical extension.

Construction activities are thus **highly** likely to have **permanent** but **moderate** effects on biodiversity if no mitigation measures are applied (3C).



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Mitigation measures to minimize the impacts on the local flora and fauna include:

- Confining vehicular movements to defined roads;
- Keeping with minimum safe operating width and using existing tracks whenever possible to minimize impacted area size;
- Preserving excavated top soil and re-vegetating disturbed areas by seeding common species such as herbs and shrubs;
- Supervising the implementation of the proposed Waste Management and Spill Contingency plans;
- Raising the awareness of workers on the respect and preservation of wildlife during construction and operation phases; and
- Spreading excavated topsoil containing pollen and roots of the original vegetation at the
 peripheries around the WWTP upon completion of construction works in order to
 regenerate and reintroduce some of the native flora species present in the area.

Such practices are likely to reduce the impact on biodiversity during construction to a **minor** level with **negligible** likelihood of occurrence (1A).

7.8.2 OPERATION PHASE

Network operation

The networks operation is expected to have an overall **positive** impact on biodiversity mainly as a result of the reduction of uncontrolled wastewater discharges in the Study Area.

Nevertheless, localized negative impacts of limited intensity may result from leaks in networks (discussed under section 7.3.2.4.), if not well managed and maintained. Proper engineering and adequate preventive measures, in addition to the adoption of a Spill Prevention and Response Plan, can reduce the related risks.

As such, the Project is **likely** to have a **long term, beneficial** impact on soil quality in the Study Area once fully operational (**6B**).

WWTP Operation

The improvement in surface water and seawater quality expected to result from the Project's operation is likely to **positively** impact fluvial, riparian, coastal and marine fauna and flora due to improved quality of discharges.

As such, the Project is **likely** to have **a long term, beneficial** impact on biodiversity in the WWTP's Area once fully operational (**6B**).



7.9 SOCIO-ECONOMIC IMPACTS

Given the nature of the project which will result in an overall improvement in water quality in Al Ghadir area and will gather waste water discharge in one network, it is generally envisaged that the overall social and economic impact will be positive.

However, the project is likely to generate social and economic alterations during both construction and operational phases. These are presented and discussed in the sub-sections below.

7.9.1 CONSTRUCTION PHASE

During the construction phase, negative impacts on the socio-economic characteristics of the Study Area are expected to arise from:

- The creation of temporary job opportunities;
- Permanent expropriation of land (land take); and
- Temporary traffic and disturbance of public rights-of-way and access to community resources and services around construction sites.

Nevertheless, the proximity of the site to the airport implies the need to comply with airport regulations. Close coordination with airport authorities and authorisation and/or approval of the construction plan will take place prior at all stages of the design process to ensure that maximum safety conditions are met.

7.9.1.1 IMPACT FROM JOB CREATION

Networks and WWTP Construction

During the construction phase for the WWTP and the network, the creation of job opportunities will result in direct positive impacts. These anticipated impacts would be considered beneficial and of high likelihood of occurrence yet temporary.

A **positive temporary** impact from job creation is thus to be expected on the socio-economic context during construction (**6C**).

7.9.1.2 IMPACTS FROM LAND EXPROPRIATION

Networks Construction

The main impacts expected to arise from necessary partial expropriations of land include some restrictions on land use (such as depth of excavation, planting trees, etc.). This applies to the number of plots of land where the network will cross, according to the Contractor.

The impact from partial land expropriation is thus considered **minor** and **permanent** with a **low** likelihood of occurrence (2C).

Recommended mitigation measures to minimize the impacts include the following:

- Consultation with potentially affected families prior to expropriation procedures;
- Fair and full compensation for land expropriated for the project in the public interest as stated in the Lebanese expropriation law.



Such measures would reduce the effect of expropriations on the livelihood of land owners, thus reducing the impact consequence to a moderate level.

By applying the above recommended measures, the impacts are reduced to **negligible** with **low** likelihood of occurrence (1C).

7.9.1.3 IMPACT ON TRAFFIC

Construction of the WWTP extension as well as the network activities will involve an impact on traffic due to increased traffic loads (machinery, equipment, labor...) and obstruction of access roads.

If not mitigated, obstructions during construction can have a **significant**, **temporary** impact on traffic. Nevertheless, the impact has a **low** likelihood of occurrence especially around the WWTP given the low traffic flows around it (4A).

The following measures can be put in place in order to minimize the adverse effects:

- Consultation with any potentially affected communities (if any) prior to expropriation procedures and ensuring proper compensation as per the Lebanese expropriation law;
- Developing a Traffic Management Plan (TMP);
- Continuously liaising with local and the governmental authorities; and
- Allowing only certified and trained drivers to carry out transportation related activities.

By applying the above recommended measures, the impacts are reduced to a **minor** level of significance with **low** likelihood of occurrence **(2A)**.

7.9.2 OPERATION PHASE

The project is expected to bring overall **benefits** to the public through ensuring better public health conditions, reduced impacts on cultural heritage, and the creation of job opportunities.

It is to be noted that the government has already started imposing a minimal tariff in fully served areas, which paves the way to the introduction of wastewater tariffs on top of the current water tariffs. These additional tariffs have been designed on the basis of numerous studies conducted to assess the ability to pay of the population served, the costs that need to be covered and the benefits that will be realised for the general public.

7.9.2.1 IMPACT ON LOCAL PUBLIC HEALTH

It is expected that the project will result in the following positive impacts during its operation:

- Reduction in uncontrolled wastewater discharges, thus reducing risks of microbiological and organic contamination;
- The provision of proper sanitary services to the area;
- An overall improvement in environmental conditions resulting in improved health conditions; and
- Properly treatment of discharged effluents, decreasing seawater pollution levels and odours thus ensuring an added value to the neighboring resorts.





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The Project's impact on local public health is thus considered as **beneficial**, of **long-term** nature, and with **high** likelihood of occurrence **(6C)**.

7.9.2.2 IMPACT FROM JOB CREATION

Another direct **positive** impact which can be anticipated from the WWTP's operation consists in employment of skilled technicians and professionals needed for the daily operation of the upgraded WWTP in addition to impacts on cultural heritage and socio-cultural sites, public health, and land use as described below.

The Project's impact on the local economy is thus considered as **beneficial**, of **long-term** nature, and with **high** likelihood of occurrence (6C).



7.10 IMPACTS ON OCCUPATIONAL HEALTH AND SAFETY

7.10.1 CONSTRUCTION PHASE

Networks Construction

The main sources of impact on occupational health and safety are from the site preparation and construction phase of the Project.

Working on a construction project entails several health and safety risk factors that need to be addressed ahead of the influx of the construction workers. The main sources of health and safety risks include physical injuries (potentially leading to fatalities, if not properly prevented and mitigated) and exposure to dust and noise.

With no mitigation measures in place, the impacts on the occupational health and safety from the construction phase are of **short term**, **reversible** nature, **moderate** effect and **medium** likelihood of occurrence (3B).

In order to avoid adverse impacts on workers' health and safety, the following measures are recommended:

- Identification and provision of appropriate PPE that offers adequate protection to the workers (goggles, dust masks, helmets, hearing protection equipment, proper clothing, safety boots...);
- Proper maintenance of PPE, including cleaning when dirty and replacement when damaged or worn out. Proper use of PPE should be part of the recurrent training programs for employees;
- Warning of staff about potential construction hazards during regular toolbox meetings;
- Availability of adequate loading and off-loading space;
- Prohibition of smoking as well as litter or weed build up in the area;
- A fire protection and prevention program approved by the Government is in place;
- Fire-fighting equipment is available within the premises;
- Inspection and maintenance of portable fire protection equipment;
- Investigation of fire incidents;
- Emergency action plan and fire hazard inspection procedures are available on-site at all times for all employees;
- The contractor should ensure that qualified first-aid can be provided at all times.
 Appropriately equipped first-aid stations should be easily accessible throughout the place of work; and
- Adequate signs should be posted throughout the Construction Area, especially at visible locations, indicating type of operation and other information and appropriate medical / emergency action response;
- Staff training about the fundamentals of occupational health and safety procedures, and about handling hazardous material containers and related wastes;
- CDR guidelines for health and safety should be properly implemented;
- Implementation of speed limits for trucks arriving to and leaving the site.



By adopting the above proposed mitigation measures, impacts on occupational health and safety are predicted to become **minor** with **low** likelihood of occurrence (2A).

WWTP Construction

Impacts on occupational health and safety during WWTP construction, as well as mitigation measures proposed to reduce them, are in all ways similar to those identified for the Networks' construction.

7.10.2 OPERATION PHASE

Networks Operation

Workers who will be in charge of the maintenance of the network will have to regularly inspect lifting stations where they will be exposed to gases, odors, insufficient ventilation, and microbiological hazards as well as potential fall or injury.

Mitigation measures are similar to those suggested for the WWTP operation below.

WWTP Operation

The WWTP will require 25 operating personnel under Phase I, and 29 under Phase II, in addition to 3 administrative/management personnel.

Wastewater treatment plant operators are typically exposed to a variety of hazardous chemical agents contained within the effluents and the reagents used in the wastewater processing or generated during the wastewaters treatment. These chemical agents may cause acute poisoning, chemical accidents (e.g., skin burns, injury to the eyes, etc.) damage to the respiratory system, allergies, dermatitis and chronic diseases. In addition, operators may be injured by slips, trips and falls on wet floors; falls into treatment ponds, pits, clarifiers or vats or splashes of hazardous liquids; they may also suffer cuts and pricks from sharp tools. Other common hazards include electric shock, explosions, entanglement in moving machinery, etc.

Accordingly, in the absence of mitigation measures at the operation phase, impacts on occupational health and safety can be **significant** in magnitude, and have **medium** likelihood of occurrence (**4B**).

The likelihood of impacts on public and occupational safety operation during operation can be significantly suppressed by the following mitigation measures:

- Restricting unattended public access to the wastewater treatment plants by proper fencing and guarding;
- Controlling movement of equipment and vehicles to and from the site;
- Properly labeling and storing chemicals (Chlorine gas or powder), oils, and fuel to be used on-sites;
- Emphasizing safety education and training for system staff and enforcing adherence to safety procedures set in and around the plant facility;
- Providing appropriate safety equipment, fire protection measures, and monitoring instruments;

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- Providing hand railing at all access corridors above and around all open treatment units (except where sidewalls extend ≥1.1 meters above ground level);
- Properly rating electrical installations and equipment and, where applicable, protecting them for use in flammable atmosphere; and
- Providing sufficient lighting that should comply with zoning requirements.

As a conclusion, proper supervision, high workmanship performance, and provision of adequate safety measures will alleviate public and occupational risks.

By adopting the above proposed mitigation measures, impacts on occupational health and safety during operation are predicted to become **minor** with **medium** likelihood of occurrence (**2B**).



7.11 SUMMARY OF ENVIRONMENTAL IMPACTS BEFORE AND AFTER IMPLEMENTATION OF MITIGATION MEASURES

Identified and ranked impacts are summarized here. The Environmental Impact Assessment Matrix is provided in Table 7.4, under section 7.1.3 (page 166).

7.11.1 SUMMARY OF IMPACTS FROM NETWORKS' CONSTRUCTION AND OPERATION

Table 7.16 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 (incl. sludge)	3B								
Excavation and Trenching						3B			
Job Creation								6C	
Land Expropriation								2C	
Traffic Generation								4A	
Operation Phase									
General Operation	6C		1A			6B	6B		4B
Oil Spills	3B								
Wastewater Leakages	3A								
Public Health								6C	

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Table 7.17 Summary of Networks Construction and Operation Impacts With Mitigation Measures

Impact/Pathway	Water	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						6B	6B		2B
Oil Spills	2A								
Wastewater Leakages	2A								
Public Health								6C	
Cultural Heritage								6C	



7.11.2 SUMMARY OF IMPACTS FROM WWTP'S CONSTRUCTION AND OPERATION

Table 7.18 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									
Operation Phase General Operation (Phase I)	6B		1A				6B		4B
	6B 6C		1A 1A	3C			6B 6B		4B 4B
General Operation (Phase I)				3C					
General Operation (Phase I) General Operation (Phase II)	6C			3C					
General Operation (Phase I) General Operation (Phase II) Plant Failure Conditions	6C 2B			3C					
General Operation (Phase I) General Operation (Phase II) Plant Failure Conditions Water Consumption	6C 2B 3C			3C					
General Operation (Phase I) General Operation (Phase II) Plant Failure Conditions Water Consumption Oil Spills	6C 2B 3C 3A	2В		3C					
General Operation (Phase I) General Operation (Phase II) Plant Failure Conditions Water Consumption Oil Spills Wastewater Leakages	6C 2B 3C 3A	2В		3C		1A			
General Operation (Phase I) General Operation (Phase II) Plant Failure Conditions Water Consumption Oil Spills Wastewater Leakages Odor Generation	6C 2B 3C 3A	2B 3B		3C		1A			
General Operation (Phase I) General Operation (Phase II) Plant Failure Conditions Water Consumption Oil Spills Wastewater Leakages Odor Generation Solid Waste/Sludge Generation	6C 2B 3C 3A			3C		1A		6C	



Table 7.19 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 (incl. sludge)	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)	6C		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	



7.12 POTENTIAL IMPACTS ON THE PROJECT

7.12.1 IMPACTS FROM CLIMATE CHANGE

The Project, especially under Phase II of the WWTP upgrade component, may be impacted by climate change-induced sea level rise. Impacts would mainly relate to interferences with the sea outfalls and increased coastal erosion.

Adaptive measures include structural interventions such as dikes, breakwaters, flap gates, etc.; and the continuous monitoring of the long sea outfall while it is being used.

It is recommended that this impact be more duly analyzed as part of an updated EIA study specific to reclamation activities prior to the start of Phase II.

7.12.2 IMPACTS FROM AIRPORT EXTENSION

As previously mentioned, 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. Nevertheless, the ongoing Feasibility Study has confirmed that this area is not planned for the development of any specific facilities under the official Master Plan for airport extension. Nevertheless, continuous coordination with local authorities and the Civil Aviation Authority is needed to avoid conflicting plans, also when planning for land reclamation.



8 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

This Environmental and Social Management Plan (ESMP) addresses the framework for the mitigation of impacts identified in the Impact Assessment, and proposes the following:

- Mitigation measures to be implemented during the project's construction and operation phases;
- References to control guidelines and standards;
- Responsibilities for the implementation of the plan;
- Verification, monitoring and training requirements;
- Reporting requirements; and
- Overall cost estimates for mitigation measures and monitoring, whenever possible/applicable.

The overall objectives of the ESMP are to ensure Project compliance with environmental legislation, EU standards and proponent's requirements, and to provide the client and the contractors with clear and specific guidelines to undertake the appropriate monitoring activities and compliance inspection programs. The ESMP may be subject to updates and modifications by the project proponent throughout the Project lifetime.

8.1 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

Mitigation measures identified in the impact analysis are summarized in this section. They are presented under separate tables for the Networks Construction (Table 8.1), the WWTP Construction (Table 8.2), the Networks Operation (Table 8.3), and the WWTP Operation (Table 8.4).



Table 8.1 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 TechniquesRaising 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 	Implementation: Contractor	Included in contractor cost
		 Adopting and implementing IFC guidelines for the prevention and control of hydrocarbon / chemical releases 	Supervision: Supervision Consultant	
		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. 		
Air quality	General construction	 Using well designed, well maintained and well operated equipment/vehicles Employing environmentally friendly equipment (higher fuel efficiency, air pollution 	Implementation: Contractor	Included in contractor cost
		control devices).		contractor cost
		 Installing diesel particulate filters on construction equipment 	Supervision: Supervision Consultant	
		 Watering-down work area/s particularly near sensitive receptors 	Supervision consultant	
		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.		

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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	Included in contractor cost
			Supervision: Supervision Consultant	
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 	Implementation: Contractor	Biodiversity assessment: 30,000 USD (assuming 2
		completion of construction works Conducting a biodiversity assessment over the network routes prior to the start of works on networks	Supervision: Supervision Consultant CDR	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 8.2 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 TechniquesRaising Construction Workers' Awareness	Implementation: Contractor	Included in contractor cost
			Supervision: Supervision Consultant	
	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 	Implementation: Contractor	Included in contractor cost
		 Adopting and implementing IFC guidelines for the prevention and control of hydrocarbon / chemical releases (International Finance Corporation's Environmental, Health, and Safety General Guidelines) 	Supervision: Supervision Consultant	
		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. 		
	Dredging activities	 Using Silt Curtains 	Implementation:	Included in
		Reducing velocity of dredging	Contractor	contractor cost
		 Decreasing the time-frame over which the dredging operation is to take place 	Supervision:	
		 Limiting dredging operations to calmer sea states 	Supervision Consultant	
		Ensuring proper disposal of dredged material		



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	Implementation: Contractor	Included in contractor cost
		 Employing environmentally friendly equipment (higher fuel efficiency, air pollution control devices). 	Supervision: Supervision Consultant	
		 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 		
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	Implementation: Contractor	Included in contractor cost
		All vehicles and machinery should be maintained in good repair	Supervision:	
		 Any machinery, which is intermittent in use, should be shut off in periods of non-use 	Supervision Consultant	
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	Included in contractor cost
			Supervision: Supervision Consultant	
Soil and sediments	Land excavation and trenching works, oil	 Adhering to proper waste management practices Keeping all equipment well maintained and adopting a # 	Implementation: Contractor	Included in contractor cost
	spills, and solid and liquid waste generation		Supervision: Supervision Consultant	
	Land reclamation/	Using silt curtains	Implementation:	Included in
	dredging activities	 Reducing velocity of dredging 	Contractor	contractor cost
		 Decreasing the time-frame over which the dredging operation is to take place 	Supervision:	
		 Confining dredging operations to calmer sea states 	Supervision Consultant	



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	Implementation: Contractor	Included in contractor cost
		 Raising the awareness of workers on the respect and preservation of wildlife 	Supervision:	
		 Spreading excavated topsoil containing pollen and roots of the original vegetation upon completion of construction works 	Supervision Consultant	
		 Conducting a biodiversity assessment over the network routes prior to the start of works on networks 		
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 	Contactor Supervision consultant Municipalities	Included in contractor cost
		 Developing an "Archaeological Intervention Plan" in coordination with the DGA 	Local committee	
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)	Implementation: Contractor	Included in contractor cost
		 Warning staff about potential construction hazards 	Supervision:	
		 Ensuring that qualified and accessible first-aid is provided at all times 	Supervision Consultant	
		 Posting signs throughout the construction area 		



Table 8.3 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 8.4 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 	Plant operator(s)	Industrial pollution abatement plan:
		• The preparation, implementation and monitoring of an industrial pollution abatement		Preliminary survey:

Impacted VEC	PROJECT ACTIVITY (Impact/ Pathway)	MITIGATION MEASURES	INSTITUTIONAL RESPONSIBILITIES	COST ESTIMATE
		program in the Al-Ghadir drainage area		~300,000 USD
		 Ensuring redundancy in the WWTP design 		Implementation: to
		 Ensuring adequate training of plant operators 		be determined
	Water consumption	Adopting water saving techniques	Plant operator(s)	Included in
		 Proper training and awareness raising among personnel (especially in maintenance and cleaning) 	(1)	operator cost
	Oil spills	 Same mitigation measures suggested to mitigate the risk of oil spills and leakages during construction 	Plant operator(s)	To be determined
		 Using secondary containment basins for long term storage of lubricants and fuels used on site 		
	Wastewater leakages	 Immediate reporting of leakage to municipal/governmental representative 	Plant operator(s)	Included in
		 Stopping the source of leak (close valve, seal pipe, seal hole or as appropriate) 		operator cost
		 Immediate cleaning of the spill by removing affected topsoil layer by trained employee 		
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 H2S and NH3) remain below threshold values at the nearest receptors 	Plant operator(s)	Odor simulation study: 10,000 USD
		 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 		
	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 (NaOCI, NaHSO₃), oils, and fuel to be used onsites Providing hand railing at all access corridors above and around all open treatment units, (except where sidewalls extend 21.1 meters above ground level); 	Plant operator(s)	Included in operator cost
		 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. 		



8.2 ENVIRONMENTAL AND SOCIAL IMPLEMENTATION PLAN

8.2.1 ROLES AND RESPONSIBILITIES

Specific roles and responsibilities are defined in this section and outlined under an ESMP Implementation Plan (Table 8.5).

Table 8.5 ESMP Implementation Plan

INSTITUTION/BODY	ROLES AND RESPONSIBILITIES
Council for Development and Reconstruction (CDR)	Overall responsibility over the implementation of the EMP during construction
Beirut and Mount Lebanon Water and Wastewater Establishment (BMLWWE)	 Supervision and support in the WWTP operation Ensuring regular monitoring of treated effluent, keeping record of analysis results, and intervening when needed Overall responsibility for the WWTP operation and networks operation
Municipality of Mreijeh - Tahouitat Al Ghadir - Laylakeh and other municipalities within the drainage area	Monitoring of ESMP implementation during construction and operation
Ministry of environment (MoE)	 Ultimately approving EMP reports Informing supervision consultants in case of additional environmental requirements to be followed Conducting site audits as needed to check implementation of EMP
Ministry of Transportation (MoT)	Monitoring and coordinating the implementation of a Traffic Management Plan
Lebanese Civil Aviation Authority (LCAA)	 Ensuring safety procedures are met during construction and operation Coordinating and approving of extension plans
Directorate General of Antiquities (DGA)	Coordinating and supervising "Archaeological Intervention Plan"
Engineering consultant(s)	Ensuring EIA findings and EMP considerations are properly taken into consideration in the detailed engineering design and properly integrated in the tender documents for contractors
Contractor	 Preparing a Construction Environmental Management Plan (CEMP) that details how the contractor shall implement the provisions of the EMP
	 Providing a field HSE officer to ensure implementation of the CEMP Liaising with supervision consultant and regularly reporting on EMP implementation
	 Immediately reporting to supervision consultant in case of accidents, spills or other events which have health, safety or environmental implications
	 In case of incidents, contractors should fill an incident records form, including how the incident is planned to be addressed
Supervision consultant(s)	Supervising the contractor's implementation of the CEMP
	Preparing a checklist to be used to supervise contractor's works
	 Reviewing and approving contractor's CEMP Coordinating with the MoE to ensure appropriate reporting of EMP implementation

INSTITUTION/BODY	ROLES AND RESPONSIBILITIES		
	 Identifying training needs of concerned parties to ensure EMP requirements are well-understood and can be implemented 		
Local committee	Following up on the project implementation		
	 Liaising between the local community and the project proponent (through engineering consultant and/or supervision consultant) regarding EMP implementation 		
	 Following up on any complaints and responding to them/ seeking prompt solutions in coordination with the municipalities and the BMLWWE 		

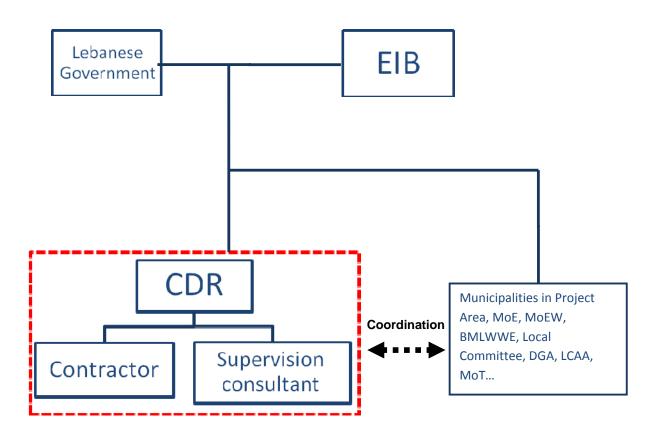


Figure 8–1 Institutional Setup for EMP Implementation



8.2.2 CAPACITY BUILDING NEEDS

8.2.2.1 TRAINING NEEDS DURING THE CONSTRUCTION PHASE

In order to ensure a proper and effective implementation of the CEMP, it is particularly important to undertake a training program for the contractor regarding its preparation and implementation. Training sessions for the contractor should be conducted prior to the commencement of the construction works and shall focus on the following topics:

- Preparation and implementation of CESMP;
- Implementation of CDR's HSE guidelines;
- Air pollution control;
- Control of leakages;
- Water Consumption;
- Solid Waste Management;
- Traffic Management Plan; and
- Emergency plan.

8.2.2.2 TRAINING NEEDS DURING OPERATION PHASE

It is recommended to train the WWTP's operation and maintenance personnel on:

- The WWTP components and operation process;
- Odor control/management;
- Operation and maintenance requirements;
- Types of hazards associated with its operation and measures to be taken;
- How to act in case of Emergency (overflow/ network leakage/ shutdown/ health and security emergencies...);
- Management of solid waste generated (sludge, harvested reeds, and waste from the screen cleaning);
- Oil spill and wastewater leakages prevention and control; and
- Chemicals handling and storage.

8.2.3 ENVIRONMENTAL MONITORING PLAN

The monitoring component is of particular importance in identifying successfulness of mitigation measures formulated for the significant impacts identified. A Construction and Operation Monitoring Plan shall thus be developed to include parameters to be monitored, frequency of monitoring, and responsibilities, in a format similar to that of Table 8.6.



Table 8.6 Construction and Operation Monitoring Plan

ENVIRONMENTA L COMPONENT	PARAMETERS	FREQUENCY	LOCATION	RESPONSIBILITY	ESTIMATED UNIT COST (USD)	ESTIMATED TOTAL COST(USD)
DURING CONSTRU	JCTION					
Traffic Flow	Number of days of road diversions due to the construction of networks on major and minor roads	Monthly	All roads to be crossed by wastewater networks		N.A.	N.A
Ambient Air Quality	Dust emissions: TSP + PM10 and PM2.5	Continuous	Construction Site	Site HSE officer		Depending on length of construction period
Noise Levels	Leq, Lmax, Lmin (dBA)	Spot monitoring near sensitive receptors, and upon receiving complaints	Construction Site	Site HSE officer	USD 1,250/month	Depending on length of construction period
Solid waste	Waste Type	Daily	Construction Site	Site HSE officer	N.A.	N.A
	Quantity of generated waste (kg/tons)					
	Methods of disposal					
	Waste transported for offsite reuse/recycle					
Health safety	Proper PPE use	Continuous	Construction site	Site HSE officer	N.A.	N.A
environment and Hygiene	Good housekeeping practices					
DURING OPERATION	ON					
Ambient Air	Number of complaints about odors	Daily/monthly	Ghadir area	Local Committee	N.A.	N.A
Quality		during operation	Pumping stations			



ENVIRONMENTA L COMPONENT	PARAMETERS	FREQUENCY	LOCATION	RESPONSIBILITY	ESTIMATED UNIT COST (USD)	ESTIMATED TOTAL COST(USD)
Noise Levels	Leq, Lmax, Lmin (dBA)	Monthly	WWTP area		USD 1,250/month	
Treated Effluent Quality	pH, Temperature, color, Dissolved Oxygen, Suspended Solids	Daily	Treated effluent at the outlet	BMLWWE Plant Operator(s)		Included in operational costs (laboratory on-site)
	COD, BOD, Ammonia, Phosphate, Alkalinity	Weekly	Treated effluent at the outlet	BMLWWE Plant Operator(s)		
	Nitrates, Sulphates, Surfactants, Phenols, Cyanides, Tannins	Monthly	Treated effluent at the outlet	BMLWWE Plant Operator(s)	Included in operational costs (laboratory on-site)	
	E.Coli/100ml Fecal coli/100ml Helminth eggs/l	Twice/month	Treated effluent at the outlet	BMLWWE Plant Operator(s)		
	Metals (Al, Bo, Cd, Cr, Cu, Fe, Pb, K, Si, Mn, Mo, Ni, Se, Va, Zn, Hg)	Twice/year	Treated effluent at the outlet	BMLWWE Plant Operator(s)		
Sludge Quality	Dry and organic matter	Four times/year	Sludge produced at the WWTP	BMLWWE Plant Operator(s)		
	Heavy metals (As, Cd, Cr, Cu, Pb, Hg, Zn)	Four times/year	Sludge produced at the WWTP	BMLWWE Plant Operator(s)		
	Primary nutrients (N, NH4-N, P, K) and secondary nutrients (Ca, Mg, S, Na and oligoelements)	Four times/year	Sludge produced at the WWTP	BMLWWE Plant Operator(s)	Included in operational costs	Included in operational costs
	Organic compounds (AOX, PAH, PCB, PCDD/F)	Yearly	Sludge produced at the WWTP	BMLWWE Plant Operator(s)	(laboratory on-site)	(laboratory on-site)
	Pathogen microorganisms (Fecal coliforms, E. Coli)	Four times/year	Sludge produced at the WWTP			

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10 ANNEXES





ANNEX 1 - MAP OF EXISTING AND PLANNED NETWORKS-IN THE GHADIR DRAINAGE AREA





ANNEX 2 - PROPOSED WWTP LAYOUT





ANNEX 3 - SECTION DRAWING OF RECLAMATION WORKS





ANNEX 4 - PUBLIC CONSULTATION MEETINGS: INVITATION LETTERS AND FLYERS





ANNEX 5 - PUBLIC CONSULTATION MEETINGS - LIST OF INVITEES





ANNEX 6 - PUBLIC CONSULTATION MEETINGS: PRESENTATIONS IN ARABIC AND ENGLISH





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