COUNCIL FOR DEVELOPMENT AND RECONSTRUCTION (CDR)

ENVIRONMENTAL IMPACT ASSESSMENT FOR DAOURA-BURJ HAMMOUD WASTEWATER TREATMENT PLANT

EIA REPORT

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LIST OF ACRONYMS

AOX	Absorbable Organic Halides
BMLWE	Beirut and Mount Lebanon Water Establishment
BOD	Biological Oxygen Demand
BTEX	Benzene, Toluene, Ethylbenzene and Xylene
CAS	Central Administration of Statistics
CDR	Council for Development and Reconstruction
CDW	Construction and Demolition Waste
CEMP	Construction Environmental Management Plan
COD	Chemical Oxygen Demand
DGA	Directorate General of Antiquities
DGUP	Directorate General of Urban Planning
EBRD	European Bank for Reconstruction and Development
EBS	Environmental Baseline Surveys
EDL	Electricite du Liban
EIA	Environmental Impact Assessment
EIB	European Investment Bank
ELARD	Earth Link and Advanced Resources Development
ELV	Environmental Limit Values
EMP	Environmental Management Plan
EPA	Environmental Protection Agency
ESIA	Environmental and Social Impact Assessment
FC	Fecal Coliform
GAC	Granular Activated Carbon Filter
GBNA	Greater Beirut Northern Area
GHG	Greenhouse Gases
GRM	Grievance Redress Mechanism
HSE	Health, Safety and Environment

IEE	Initial Environmental Examination
IFC	International Finance Corporation
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
NA	Not Available
NGO	Non-governmental organization
NSEQ	National Standards for Environmental Quality
OCU	Oder Control Unit
PAH	Poly Aromatic Hydrocarbons
PE	Population Equivalent
PM	Particulate Matter
PPE	Personal Protective Equipment
TOC	Total Organic Carbon
TSS	Total Suspended Solids
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
USGS	United States Geological Survey
WAS	Waste Activated Sludge
WHO	World Health Organization
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

Brief Project Description

The construction of the Daoura-Burj Hammoud wastewater treatment plant (WWTP) is part of the overall Greater Beirut Northern Area (GBNA) Wastewater Project and will complement the existing Al - Ghadir wastewater pretreatment plant by serving the northern sections of the city of Beirut, parts of the Baabda Caza, and the Metn Caza (up to an elevation of 800 m asl as per the general master plan devised by MoEW). The approximate coordinates of the proposed site are 33.902187°N and 35.544602°E.

The project will be built over two phases: (1) Phase 1 - the pretreatment headworks to be initiated in 2020, and (2) Phase 2 - primary and secondary wastewater and sludge treatment to be initiated in 2022.

The proposed WWTP is located on a reclaimed land with a total area of 65,000 m^2 (19,000 m^2 for Phase 1 and remaining for Phase 2).

The pretreatment headworks plant is planned to include the following components with a capacity to handle 227,500 m^3 of wastewater per day for the year 2020 and which is expected to increase to 325,000 m^3 per day in 2050:

- Inlet screens;
- Inlet pumping station;
- Coarse screens;
- Fine screens;
- Aerated grit and grease removal tanks;
- Effluent pumping stations and outfall pipes; and
- Odor control unit.

The Phase 2 treatment plant will include the following components:

- Primary Treatment
- Secondary treatment
- Sludge Treatment
- Odor Control from sludge treatment

The treated wastewater is discharged with a sea outfall with a length of 1,777 m and around 61.5 m below sea level. Treated wastewater would also be discharged through an emergency outfall when the main outfall would not be available for maintenance reasons or during emergency situations. The emergency outfall has a length of 620 m at around 7.8 m below seawater level and is expected to be used a few times per year at most.

Brief Policy, Legal and Administrative Framework

In reference to the planned Project, a license for use of the public maritime domain (Decision No. 1) was issued in March 2016 by the Council of Ministers (Appendix F2). The license is subject to approval of an EIA by MoE related to the construction and operation of the Wastewater treatment plant to ensure that any potential negative impacts are properly controlled and managed.

A legal review is conducted to ensure compliance not only with the Lebanese environmental laws and regulations, but also with relevant international agreements of which Lebanon is signatory. Compliance with International lenders Environmental and Social requirements is also sought where applicable.

Various governmental and public institutions play a role in the permitting and supervision of the GBNA. These include the Ministries of Environment (MoE), Energy and Water (MoEW), Public Health (MoPH), Ministry of Public Works and Transport (MoPWT), Ministry of Interior and Municipalities (MoIM), the Council for Development and Reconstruction (CDR), in addition to the Beirut and Mount Lebanon Water Establishment (BMLWE), the Municipality of Burj Hammoud, and the Municipality of Beirut.

In addition to the above-mentioned public stakeholders, several local stakeholders play a role in the management of natural resources and livelihood strategies within the Project area. These include NGOs, inhabitants, fishermen and industries (in the adjacent industrial area) that will potentially be affected by the project (or could affect the project).

Brief Public Consultation

During the Scoping phase, a public announcement was posted in the Burj Hammoud Municipality board for 2 weeks to allow citizens to express their comments and concerns relating to the project, and to invite them to a scoping public consultation. No written or oral comments were received from the Municipality or from citizens regarding the Project during that period. The scoping public consultation meeting was held on August 19, 2019 at the premises of the United Armenian College of Burj Hammoud.

The public authorities invited were the Ministry of Environment (MoE), Ministry of Energy and Water (MoEW), Ministry of Public Works and Transport (MoPWT), Ministry of Interior (MoI), Ministry of Public Health (MoPH), Ministry of Culture (MoC), Ministry of Agriculture (MoA), Ministry of Finance (MoF), General Directorate of Urban Planning, Governor of Mount Lebanon, Governor of Beirut, Kaymakam Al Metn, Municipality of Burj Hammoud, Municipality of Beirut, Union of municipalities of Metn, and BMLWE.

The Municipality of Burj Hammoud further publicized the event and invited Members of Parliament and numerous influential personalities in the area to attend the meeting. As such the meeting was attended by over 100 participants.

In general, the attendees highlighted the importance of the project while emphasizing on the need to mitigate any possible negative impacts from the WWTP particularly odors generation and sea water contamination. Some questions were raised also about the implications of splitting the project in two phases and whether financial resources were available for construction of both phases and their operation to ensure the sustainability of the plant.

A public consultation for the EIA phase will be held, to share the details of the whole project and its components with the public and particularly with directly affected population.

Brief Environmental Baseline

The area where the project is to be constructed is highly industrial in nature. Uses of the maritime environment surrounding the plant are mostly related to ports and industrial activities. The closest bathing beaches to the proposed project site are the area near la Marina Dbayeh (6 km) to the North, and the AUB Beach (5.7 km) to the West. The nearest residential area is 940 m South of the plant. The site itself is a reclaimed land with limited ecological value. The marine environment is also likely to be a degraded one also with limited ecological value.

The Municipality of Burj Hammoud plans to use the land adjacent to the plant within the reclaimed area. This future development will become the nearest sensitive receptor to the project.

Potential Impacts

The following tables present a summary of the main impacts of the project and their significance before and after implementation of mitigation measures for both the construction and operation phases.

The two potentially significant impacts during phase 1 are those related to potential odor generation and deterioration of the marine environment from discharge of pre-treated wastewater during the operation phase. Both impacts were quantitatively assessed using appropriate tools and methods. Several improvements to the proposed design of the OCU were proposed in this EIA to enhance the performance of the OCU and minimize potential for odor generation and nuisance from the plant. It was found that when implemented, odor impacts from the plant, even at the adjacent future development would be of minor significance.

During phase 1 the dilution of pre-treated wastewater through the main sea outfall was found to be adequate and is unlikely to have any significant impacts on the marine environment or the nearest sensitive receptor. Dilution from the emergency outfall is however significantly less and dilution thresholds would not be met at nearest receptors. However significance of the impact is considered low given the low frequency of these emergency discharges and the low sensitivity of the surrounding receptors. Additional mitigation measures focus on ensuring the reliability of the plant operation leading to further reducing the frequency of emergency discharges.

Phase 1 also presents many environmental benefits by halting the uncontrolled discharge of untreated wastewater in the coastal areas and groundwater. It is expected to lead to improvement to the coastal marine environment within the study area and overall improvements in health conditions in the area.

During phase 2, the main positive impacts to be considered is the impact generated from the treated wastewater on the marine biology which will be improved as compared to the discharge of pre-treated wastewater. Once Phase 2 is completed, full compliance of Lebanon's international commitments towards the Barcelona convention will be achieved. Phase 2 will generate an additional source of odor from sludge dewatering; an additional OCU will be added to minimize odor emissions while ensuring that cumulative impacts with the odor sources from the pre-treatment plant are acceptable. Phase 2 will also lead to the generation of sludge. Sludge can be effectively managed after dewatering through either landfilling or on-site incineration. The latter might however be a preferable option to avoid posing additional pressure on scarce landfill infrastructure, unless the sludge can be effectively used as soil cover.

Summary of Environmental Impact Assessment (Before and After Mitigation) during the Construction Phase

Environmental Aspect	Potential Impact		Nature	Magnitude	Extent	Timing	Duration	Reversibility	Consequence	Likelihood	Significance
Emissions											
Air Emissions	• Change in air quality due to combustion and exhaust emissions from vehicular transport, generators, and operation of construction equipment; • Change in air quality from airborne particulates from land excavation and clearance.	Before Mitigation	N/D	M	L	S	C	R	3. Moderate	3. High	9. Medium
		After Mitigation	N/D	L	L	S	C	R	1. Negligible	3. High	3. Low
Noise	• Increase in noise levels from mobilization and operation of equipment; excavation and construction activities, vehicles movement (especially trucks); and operation of generators.	Before Mitigation	N/D	M	L	M	C	R	3. Moderate	3. High	9. Medium
		After Mitigation	N/D	L	L	S	C	R	1. Negligible	3. High	3. Low
Wastewater Generation	• Soil and water contamination from inadequate handling and disposal of sewage and liquid wastes	Before Mitigation	N/D	M	L	L	C	R	3. Moderate	3. High	9. Medium
		After Mitigation	N/D	L	L	S	C	R	1. Negligible	1. Low	1. Low
	• Dewatering Activities	Before Mitigation	N/D	M	L	S	C	R	3. Moderate	2. Medium	6. Medium
		After Mitigation	N/D	L	L	S	C	R	1. Negligible	1. Low	1. Low
Solid Waste	• Soil and water contamination from inadequate handling and disposal of construction and domestic solid waste	Before Mitigation	N/D	M	L	M	C	R	3. Moderate	2. Medium	6. Medium
		After Mitigation	N/D	L	L	M	C	R	2. Minor	1. Low	2. Low

Environmental Aspect	Potential Impact		Nature	Magnitude	Extent	Timing	Duration	Reversibility	Consequence	Likelihood	Significance
Accidental Releases	• Soil and water contamination from accidental Spills of Fuel, Oil and Chemicals	Before Mitigation	N/D	M	L	L	C	R	3. Moderate	3. High	9. Medium
		After Mitigation	N/D	L	L	S	C	R	1. Negligible	1. Low	1. Low
Depletion of Resources											
Energy Resources	• Electricity consumption and diesel consumption for generators, vehicles and equipment operation	Before Mitigation	N/D	L	L	M	C	R	2. Minor	3. High	6. Medium
		After Mitigation	N/D	L	L	S	C	R	1. Negligible	3. High	3. Low
Water Resources	• Water Consumption for domestic or construction purposes	Before Mitigation	N/D	L	L	M	C	R	2. Minor	3. High	6. Medium
		After Mitigation	N/D	L	L	S	C	R	1. Negligible	3. High	3. Low
Land Resources	• Temporary or permanent change in topography, soil permeability, erosion and collapse from grading, trenching, or excavation	Before Mitigation	N/D	L	L	M	C	R	2. Minor	2. Medium	4. Medium
		After Mitigation	N/D	L	L	S	C	R	1. Negligible	2. Medium	2. Low
Biological Resources	• Impacts associated with rehabilitation of the outfall/overflow pipes	Before Mitigation	N/D	L	L	M	C	R	2. Minor	3. High	6. Medium
		After Mitigation	N/D	L	L	M	C	R	2. Minor	1. Low	4. Low
Other Impacts											
Socio-economic	• Increased pressure on infrastructure	Before Mitigation	N/D	M	L	S	C	R	3. Moderate	3. High	9. Medium
		After Mitigation	N/D	L	L	S	C	R	1. Negligible	3. High	3. Low
	• Disturbances from traffic, noise and air emissions and dust generation	Before Mitigation	N/D	M	L	S	C	R	3. Moderate	3. High	9. Medium
		After Mitigation	N/D	L	L	S	C	R	1. Negligible	2. Medium	2. Low

Environmental Aspect	Potential Impact		Nature	Magnitude	Extent	Timing	Duration	Reversibility	Consequence	Likelihood	Significance
	• Job creation • Creation of opportunities for local businesses in the supply of goods and services	Before Mitigation	P/D	-	-	-	-	-	B. Beneficial	3. High	+++ Beneficial
		After Mitigation	P/D	-	-	-	-	-	B. Beneficial	3. High	+++ Beneficial
Traffic	• Increase in traffic volumes	Before Mitigation	N/D	M	L	S	C	R	3. Moderate	3. High	9. Medium
		After Mitigation	N/D	L	L	S	C	R	1. Negligible	2. Medium	2. Low
Health & Safety	• Physical Injuries • Exposure to dust and noise	Before Mitigation	N/D	M	L	M	C	R	3. Moderate	2. Medium	6. Medium
		After Mitigation	N/D	L	L	S	C	R	1. Negligible	1. Low	1. Low

Summary of Environmental Impact Assessment (Before and After Mitigation) during the Operation Phase

Environmental Aspects	Potential Impact	Mitigation	Nature	Magnitude	Extent	Timing	Duration	Reversibility	Consequence	Likelihood	Significance
Emissions											
Air Emissions	• Nuisance due to odor emissions from the plant	Before Mitigation	N/D	H	L	L	O	R	4. Major	3. High	12. High
		After Mitigation	N/D	L	L	L	O	R	3. Moderate	1. Low	3. Low
	• Change in air quality from air emissions from generators and equipment	Before Mitigation	N/D	M	L	S	O	R	3. Moderate	3. High	9. Medium
		After Mitigation	N/D	L	L	S	O	R	1.Negligible	3. High	3. Low
Noise	• Change in noise levels from normal operation and maintenance activities	Before Mitigation	N/D	L	L	M	O	R	2. Minor	2. Medium	4. Medium
		After Mitigation	N/D	L	L	S	O	R	1.Negligible	1. Low	1. Low
Wastewater	• Deterioration of seawater water quality due to discharge of pre-treated wastewater from the sea outfall pipe during Phase 1	Before Mitigation	N/D	L	L	M	O	R	2. Minor	1. Low	2. Low
		After Mitigation	N/D	L	L	S	O	R	1.Negligible	1. Low	1. Low
	• Discharge of treated effluent from the sea outfall pipe during Phase 2	Before Mitigation	N/D	L	L	S	O	R	1.Negligible	1. Low	1. Low
		After Mitigation	N/D	L	L	S	O	R	1.Negligible	1. Low	1. Low
	• Dewatering of grit and sludge	Before Mitigation	N/D	M	L	S	O	R	3. Moderate	2. Medium	6. Medium
		After Mitigation	N/D	L	L	S	O	R	3. Moderate	1. Low	3. Low
Solid Waste	• Soil and water pollution from inadequate disposal of wastes generated from pretreatment units	Before Mitigation	N/D	H	L	L	O	R	4. Major	2. Medium	8. Medium
		After Mitigation	N/D	L	L	S	O	R	2. Minor	1. Low	2. Low

Environmental Aspects	Potential Impact	Mitigation	Nature	Magnitude	Extent	Timing	Duration	Reversibility	Consequence	Likelihood	Significance
	• Soil and water pollution from inadequate disposal of sludge from treatment units	Before Mitigation	N/D	M	L	M	O	R	3. Moderate	2. Medium	6. Medium
		After Mitigation	N/D	L	L	S	O	R	2. Minor	1. Low	2. Low
	• Soil and water pollution from inadequate disposal of domestic solid waste generated by the workers	Before Mitigation	N/D	L	L	M	O	R	2. Minor	1. Low	2. Low
		After Mitigation	N/D	L	L	S	O	R	1.Negligible	1. Low	1. Low
Accidental Releases	• Deterioration of seawater quality due to discharge of pretreated wastewater from the emergency outfall pipe during Phase 1	Before Mitigation	N/D	H	G	L	O	R	1. Minor	3. High	3. Low
		After Mitigation	N/D	M	L	S	O	R	2. Minor	1. Low	2. Low
	• Soil and water pollution from accidental Spills of Fuel, Oil and Chemicals	Before Mitigation	N/D	M	L	L	O	R	3. Moderate	2. Medium	6. Medium
		After Mitigation	N/D	L	L	S	O	R	2. Minor	1. Low	2. Low
Depletion of Resources											
Energy Resources	• Electricity consumption	Before Mitigation	N/D	M	L	L	O	R	3. Moderate	3. High	9. Medium
		After Mitigation	N/D	L	L	M	O	R	2. Minor	3. High	6. Medium
Water Resources	• Water consumption	Before Mitigation	N/D	M	L	M	O	R	3. Moderate	1. Low	3. Low
		After Mitigation	N/D	L	L	M	O	R	2. Minor	1. Low	2. Low
Land Resources	• Possible impact on land depreciation and land use change of adjacent plots	Before Mitigation	N/D	L	L	L	O	R	2. Minor	1. Low	2. Low
		After Mitigation	N/D	L	L	L	O	R	1. Negligible	1. Low	1. Low
Biological Resources	• Normal operation: discharge of preliminary treated wastewater during Phase 1	Before Mitigation	N/D	L	L	L	O	R	2. Minor	1. Low	2. Low
		After Mitigation	N/D	L	L	L	O	R	1. Negligible	1. Low	1. Low

Environmental Aspects	Potential Impact	Mitigation	Nature	Magnitude	Extent	Timing	Duration	Reversibility	Consequence	Likelihood	Significance
	• Normal operation: discharge of treated wastewater during Phase 2	Before Mitigation	N/D	L	L	S	O	R	1.Negligible	1. Low	1. Low
		After Mitigation	N/D	L	L	S	O	R	1.Negligible	1. Low	1. Low
Other Impacts											
Socio-economic	• Land value depreciation	Before Mitigation	N/D	L	L	L	O	R	2. Minor	1. Low	2. Low
		After Mitigation	N/D	L	L	L	O	R	1. Negligible	1. Low	1. Low
	• Improvement in coastal water quality	Before Mitigation	P/D	-	-	-	-	-	B. Beneficial	3. High	+++ Beneficial
		After Mitigation	P/D	-	-	-	-	-	B. Beneficial	3. High	+++ Beneficial
Health & Safety	• Increased health and safety risks to workers.	Before Mitigation	N/D	H	L	L	O	R	4. Major	3. High	12. High
		After Mitigation	N/D	L	L	L	O	R	2. Minor	2. Medium	4. Medium

Brief Analysis of Alternatives

As part of the analysis of alternatives, a comparison based on environmental and socioeconomic parameters was performed for the following alternatives: 1) No Project, 2) Project design alternative for the odor control unit, 3) Project design alternative for the sea outfall diffusers, 4) Alternative pre-treatment waste management 5) Alternative sludge management. The results of the analysis led to the identification of preferred options for the handling of certain waste streams during operation, particularly grit and grease that could be sent for recycling. Preferred design for the Odor control Unit is the Granulated Activated Carbon (GAC) possibly combined with a biological filter. The current design is based on chemical scrubbing using highly corrosive and toxic chemicals posing threats to health, safety and environment in case of mishandling. During Phase 2, preferred disposal options for generated sludge from primary and secondary treatment after dewatering are either disposal as soil cover in landfills or on-site incineration. Both options are acceptable from an environmental point of view if adequate mitigation measures are followed.

Environmental Management Plan

The proposed environmental management plan (EMP) to be implemented during the construction and operation phases are shown in the tables below.

Environmental Mitigation Plan for the Construction Phase

Environmental Aspect	Project Activities	Impacts before Mitigation	Mitigation Measures	Impacts after Mitigation	Responsibility	Cost Estimate
Emissions						
Air Emissions	• Combustion and exhaust emissions from vehicular transport, generators, and operation of construction equipment; • Airborne particulates from land excavation and clearance.	Medium	• Ensure the contractor uses properly maintained and operated equipment/vehicles. Precautionary control measures for emissions reduction could include proper engine fuel mixtures and regularly serviced exhaust emission systems, suitable engine tuning, and use of low sulfur content diesel; • Avoid idling vehicles and equipment engines that are left running unnecessarily; • Inspect the presence of black smoke from vehicles and engines and undertake remedial maintenance when it is observed to improve engine efficiency; • Promote collective transportation and carpooling for workers when applicable; • Schedule deliveries of raw material and products efficiently and enforce appropriate speed limits; • Ensure that generator emissions are in line with national standards (MoE Decision 8/1, dated 2001) during operation through regular monitoring of CO, NO_X, SO_2, O_2, flue gas temperature, combustion efficiency, and total dust; • Ensure that an effective maintenance plan and schedule is in place for the generator • Keep the project footprint, and thus areas to be excavated, at a minimum; • Provide wet suppression of areas during excavation and of roads where trucks will circulate; • Cover stockpiles and maintain them at minimum heights and form them into the optimum shape to reduce wind erosion; • Install wind breaks to reduce wind speed; • Cover all incoming and outgoing trucks from the site; and • Inform nearby receptors of the construction works, especially for dusty activities.	Low	Contractor and Supervision Consultant	No separate costs estimation - Included in Contractor's scope of works and fees. Part of construction costs.
Noise	• Mobilization and operation of equipment; • Excavation and construction activities; • Vehicles movement (especially trucks); • Operation of generators.	Medium	• Ensure fencing of the construction site before initiation of works; • Fit all machinery and vehicles with effective exhaust silencers as applicable; • Maintain all machinery and vehicles in good condition and avoid leaving equipment idling unnecessarily; • Material stockpiles and other structures should be effectively utilized to reduce noise from on-site activities, where feasible; • Inform nearby residents of the construction plans, including expected duration, prior to initiating the works; • Establish a procedure to respond to noise complaints which can improve relationships with neighbors and help identify sources of noise for future incidents; • Schedule noisy activities, to the extent possible between 7:00 am and 6:00 pm, to minimize nuisance to neighboring receptors; • Limit work hours as much as possible and avoid noisy activities on Sundays and holidays; and • Conduct regular noise monitoring at the nearest receptors to ensure that noise emissions are compliant with national standards (Decision 52/1); and • Provide workers with noise protection equipment when operating noisy equipment, and enforce their use.	Low	Contractor and Supervision Consultant	Part of construction costs. Noise monitoring: $300/ day. Cost of Ear muffs: USD 26/unit

Environmental Aspect	Project Activities	Impacts before Mitigation	Mitigation Measures	Impacts after Mitigation	Responsibility	Cost Estimate
Wastewater Generation	• Inadequate Storage and Disposal of Wastewater and Sewage • Washing of vehicles on site, without containing the wastewater	Medium	• Provide fully impermeable septic/ holding tanks; • Empty septic/ holding tanks frequently; • Regular inspection of septic/ holding tanks; • Obtain a permit from the Municipality of the relevant Water Establishment to transport and discharge the wastewater and sludge to authorized facilities/ sites; and • Vehicle washing shall only take place in contained maintenance areas offsite or onsite with impermeable concrete pavement and proper drainage.	Low	Contractor, Supervision Consultant and Municipality of Burj Hammoud	No separate costs estimation - Included in Contractor's scope of works and fees
	• Dewatering Activities	Medium	• Prepare a Dewatering Management Plan for approval prior to commencement of Construction works; and • Analyze groundwater quality prior to discharge	Low	Contractor, Supervision Consultant and Municipality of Burj Hammoud	No separate costs estimation - Included in Contractor's scope of works and fees
Solid Waste	• Construction and domestic solid waste generation	Medium	• Segregate at source recyclable domestic waste, construction waste that can be reused/recycled, construction waste to be disposed of, etc. o Domestic waste (paper, cardboard, organic, etc.): ▪ All construction workers and personnel shall be responsible for ensuring that standards of "good housekeeping" are maintained. This will include clearance of all rubbish and work associated debris; ▪ Sorting at source of domestic and general waste is proposed to be implemented. Waste should be sorted into combustible (paper, cardboard, food, and wood) and non-combustible waste (metals, glass, rubble, in addition to plastics) streams by means of suitably labeled containers for safe collection, segregation and handling of all waste streams generated; and ▪ Organic waste should not exceed a 24-hour storage time to avoid attraction of pests and flies. o Hazardous Waste (waste oil, solvents, etc.) ▪ Hazardous waste such as solvents, used batteries, used generator oil and filters, and empty paints' containers should be stored in safe labeled containers and sold to one of the facilities listed in MoE Circular 7/1 of 2017 o Construction Waste: ▪ Excavation waste should be used for levelling/ backfilling activities to the extent possible, transported in trucks on days with low wind activity, and covered with green mesh in order to avoid their release into the environment. • Reuse part of the excavation waste in backfilling; additional unneeded construction waste must be disposed of in an approved Construction and Demolition Waste (CDW) dumpsite in coordination with the Municipality and in agreement with MoE; • Avoid over-ordering of construction materials; • Establish a recording system for the amount of waste generated, recycled, and landfilled; • Progressively carry out rehabilitation of disturbed areas following completion of work in each area (rehabilitation will include reinstatement of soil, surface leveling, re-vegetation and mulching where applicable); • Ensure that standards of "good housekeeping" are maintained (i.e., avoiding littering, preventing storage of combustible waste for more than 24 hours to prevent attraction of pests and flies, continuous clearing of the site from all kinds of waste); and	Low	Contractor, Supervision Consultant and Municipality of Burj Hammoud	No separate costs estimation - Included in Contractor's scope of works and fees

Environmental Aspect	Project Activities	Impacts before Mitigation	Mitigation Measures	Impacts after Mitigation	Responsibility	Cost Estimate
			• Cover and contain construction waste stockpiles to avoid them being transported by wind and rain.			
Accidental Releases	• Accidental Spills of Fuel, Oil and Chemicals	Medium	• Any type of chemical, oil, fuels and lubricants must be stored and handled within containment facilities (e.g. bounded areas, leak proof trays) designed to prevent the release of spills/leaks to the soil and groundwater environment; • Maintenance schedules shall be put in place as part of the inspection procedures of all equipment/generators/machinery for risk minimization; • Maintenance of machines and equipment shall take place off-site or onsite in a contained area with impermeable concrete pavement and drainage for vehicle washing and maintenance; • Oil spill response kits shall be available wherever oils are being used/stored; • Promote awareness among workers on how to handle oil/lubricants; • Train workers on how to clean up small scale spills; • Promote good housekeeping practices during construction; • Ensure drip trays are present when re-fuelling; • Prepare a Spill Emergency Plan specific for the project; • In case of a spill: o Stop the source of spill (close valve, seal pipe, seal hole or as appropriate); o Immediately notify the EHS manager and construction manager who will in turn notify the project proponent and MoE in accordance with the Spill Emergency Plan; o Check for hazards, flammable matters on site; o Clean the spill by removing affected top soil layer by trained employees (they should be wearing appropriate PPE); o Treat the removed layer as hazardous waste and store them on impermeable and solvent resistant plastic sheets such as heavy gauge polyethylene plastic sheets before coordinating with MoE on the recommended disposal/treatment option; and o Adopt as much as possible dry cleaning techniques to decrease resulting wastewater, and to avoid flushing of spills to the aquifer (Sannine Formation – C4).	Low	Contractor and Supervision Consultant	Cost of spill Response Kit: 80 USD Cost of Drip Trays: 60 USD
Depletion of Resources						
Energy Resources	• Electricity consumption and diesel consumption for generator, vehicles and equipment operation	Medium	• Use equipment and vehicles with higher fuel efficiency; • Report and monitor monthly fuel and energy consumption in records to keep track of consumption levels and identify overuse; • Avoid unnecessary idling of vehicles and equipment engines; and • Ensure that an effective Maintenance Plan and Schedule is in place for the generator and equipment.	Low	Contractor and Supervision Consultant	No separate costs estimation - Included in Contractor's scope of works and fees
Water Resources	• Water consumption for construction activities and domestic purposes	Medium	• Adopt water saving techniques and raise construction workers' awareness on the matter so as to avoid over-consumption	Low	Contractor and Supervision Consultant	No separate costs estimation - Included in Contractor's scope of works and fees
Land Resources	• Temporary or permanent change in topography, soil permeability, erosion and collapse from grading, trenching, or excavation	Medium	• Ensure international (ASTM) standards are met during excavation works, compaction and grading activities, in order to minimize expected disturbance during the construction phase; • Manage fixed routes for equipment movement and avoid multiple routes;	Low	Contractor and Supervision Consultant	No separate costs estimation - Included in

Environmental Aspect	Project Activities	Impacts before Mitigation	Mitigation Measures	Impacts after Mitigation	Responsibility	Cost Estimate
			• Contain and cover all stockpiles to avoid runoff water transporting suspended solids as a result during precipitation events; • Sort excavated material based on reusable agricultural soil and other excavation waste; • Secure transportation and reuse of excavated arable soil in agriculture; and • Reuse excavated/cut low agricultural quality materials as general fill where considered suitable.			Contractor's scope of works and fees
Biological Resources	• Rehabilitation of existing sea outfall/overflow pipes	Medium	• Limit activities along the extension area of the pipes only and prevent any disturbances to surrounding marine areas. • Properly remove and dispose of generated construction waste; • Transport and use lubricants and fuel in the sea to the construction site in the appropriate containers to prevent any spills;	Low	Contractor and Supervision Consultant	No separate costs estimation - Included in Contractor's scope of works and fees
Other Impacts						
Socio-economic	• Increased pressure on infrastructure	Medium	• All construction workers and personnel shall be responsible for ensuring that standards of "good housekeeping" are maintained. This will include: o Clear all rubbish and work associated debris; o Sort domestic and general waste into combustible (paper, food, cardboard, and wood) and non-combustible waste (metals, glass, rubble) streams at source by means of suitably labeled containers for safe collection, segregation and handling of all waste streams generated; and o Avoid storage of combustible waste for more than 24 hours to prevent attraction of pests and flies. • Sort and collect hazardous wastes separately from domestic waste. All hazardous waste bags/ containers should be properly labeled so as to prevent occupational health hazards; • Compile details of hazardous wastes, including type, amount and disposal method, to track final destinations and identify opportunities for improvement; • Transport excavation and construction wastes in covered/closed trucks; and • Promote water conservation and energy efficiency during construction.	Low	Contractor and Supervision Consultant	No separate costs estimation - Included in Contractor's scope of works and fees
	• Disturbances from traffic, noise, air emissions and dust generation	Medium	• Implement the dust and noise emissions' and traffic mitigation measures proposed.	Low	Contractor and Supervision Consultant	No separate costs estimation - Included in Contractor's scope of works and fees
Traffic	• Increase in traffic volumes	Medium	• Limit speed on the construction sites to 20 km/h unless otherwise advised, and adopt careful logistical and route planning; • Position any necessary traffic diversion signs and devices correctly. Signs and devices should be clearly displayed in the Arabic and English languages. Temporary traffic signals and signs should be employed to warn of hazards and provide directions, especially on narrow one-lane roads; • Coordinate with Burj Hammoud municipality with respect to the planned road blockages, detours or diversions, and the scheduling of the construction works including material delivery, waste transfer, truck movement and other machinery operations in order to limit the disruption to the neighborhood from traffic inconveniences and traffic flow and to minimize noise and dust generation; • Follow a specific schedule for transport to avoid interference with peak traffic hours and minimize disturbance/delay to commuters at rush hours on the roads leading to the Project construction sites.	Low	Contractor and Supervision Consultant and Municipality of Burj Hammoud	No separate costs estimation - Included in Contractor's scope of works and fees

Environmental Aspect	Project Activities	Impacts before Mitigation	Mitigation Measures	Impacts after Mitigation	Responsibility	Cost Estimate
Health & Safety	• Physical injuries and exposure to dust and noise	Medium	• Prepare and implement an HSE plan for the project; • Train workers on working safely and on identifying work hazards and associated risks. • Provide sufficient lighting and fencing of the facility to prevent animals and humans from entering the site; • Provide warning signs at the entrance of the site to prohibit public access; • Establish of buffering areas around the site; • Make sure ground/floor openings and trenches are fenced or covered; • Keep machinery and vehicles passages clear; • Post adequate signs throughout the Construction Area, especially at visible locations, indicating type of operation, potential hazards, and appropriate medical / emergency action response. • Ensure that no employee is exposed to a noise level greater than 85 dB (A) for a duration of more than 8 hours per day without hearing protection. In addition, no unprotected ear should be exposed to a peak sound pressure level (instantaneous) of more than 140 dB(A); • Identify and provide appropriate PPEs that offers adequate protection to the worker (goggles, dust masks, helmets, hearing protection equipment, proper clothing…) and enforce their use; • Maintain the PPE (cleaning when dirty and replacement when damaged or worn out); • Ensure the availability of adequate loading and unloading space; • Prohibit smoking and littering; • Ensure adequate portable fire-fighting equipment is available and regularly maintained; • Provide an emergency action plan and fire hazard inspection procedures; • Ensure that first-aid can be provided at all times. Appropriately equipped first-aid stations should be easily accessible throughout the place of work. • Ensure proper housekeeping on site. • Provide induction to visitors on HSE issues at the site. • Ensure full compliance with CDR HSE procedures.	Low	Contractor and Supervision Consultant	No separate costs estimation - Included in Contractor's scope of works and fees

Environmental Mitigation Plan for the Operation Phase

Media	Project Activities	Impacts before mitigation	Mitigation Measures	Impacts after Mitigation	Responsibility	Cost Estimate
Air Emissions	• Odor Emissions from the plant	High	• During detailed design, target for a hydrogen sulfide concentration of 0.25 ppm at the outlet of the OCU stack; such an outlet concentration could correspond to reducing the dynamic hydrogen sulfide concentration to 25 ppm. In addition, the OCU removal efficiency would have to be 99%. With this target met, the calculations reveal that the hydrogen sulfide threshold of 7 □g/m3 would not be exceeded at 40 meters from the outlet stack. • Consider an ambient static hydrogen sulfide concentration would be on average 500 ppm. • Include a chemical dosing station to increase the pH of the influent wastewater to the Daoura WWTP. This would result in an increase of the wastewater pH which in turn would lower the hydrogen sulfide gas emissions. Accordingly, the ambient static hydrogen sulfide gas concentration would be reduced. Chemicals used for this purpose include lime [Ca(OH)2], caustic soda (NaOH) or magnesium hydroxide. The handling and preparation of either lime or caustic soda would be easier than magnesium hydroxide. • Cover the tanks pro provide a building enclosure to the aerated grit chambers. The OCU capacity must be adequate to accommodate the air flow from the aerated grit chambers. • Do not exceed an OCU capacity of 90,000 Nm3/h because an additional increase would result in higher emitted hydrogen sulfide mass flux. • Install an OCU stack of at least 6 meters high from the ground level. Additional height is recommended, if possible, subject to applicable building codes and structural stability considerations. • Plant trees along the boundaries of the proposed plant with a maximum spacing of 3 meters; besides the positive visual impacts, the trees would help absorb odors emissions and would act as a natural barrier for odors emissions containment. • Ensure continuous monitoring on a daily basis of hydrogen sulfide emissions at the emission sources and within the plant boundaries. Measured values are to be compared to the threshold concentrations. Corrective measures and action would be required in case the measured values exceed the threshold concentrations. • Ensure the design of the sludge dewatering OCU during Phase 2 considers the cumulative impacts with the pre-treatment works so the overall cumulative impact is below the threshold at the nearest receptors.	Low	CDR to include the odor control unit design change and landscaping in the final design and scope of work of Contractor Contractor to design and build the OCU as per revised design BMLWE is responsible to maintain the OCU during operation	Additional costs related to: - Measures to achieve the target sulfide concentration of 0.25 ppm - Chemical dosing for pH increase of influent wastewater - Covering the aerated grit chamber tanks or enclosing the building - Tree planting around the plant Maintenance costs during operation
	• Combustion and exhaust emissions and greenhouse gas emissions	Medium	• Install energy saving lighting fixtures (e.g. LED) instead of regular light bulbs; • Ensure that the specifications of the generators are in line with national standards (Decision 8/1 dated 2001) in terms of air pollutant emissions through regular monitoring; • Regular maintenance of the generators;	Low	Contractor for construction BMLWE for operation	No separate costs estimation - Included in Operator's scope of works and fees
Noise	• Operation of on-site generators and pumps • Maintenance activities	Medium	• Construct the treatment facility with proper sound isolation to reduce noise levels from the pumps; • Ensure regular maintenance of generators and pumps • Ensure that generators are fitted with residential grade noise mufflers and soundproof casing as per the set design of the pumping stations; • Avoid conducting maintenance works on Sundays and holidays and limit them to daytime hours (7:00 am to 5:00 pm); • Establish a grievance mechanism and implement timely and effective actions to minimize impacts from noise in the case of complaints from any of the inhabitants/ nearby receptors; • Conduct noise monitoring near sensitive receptors to ensure that noise levels are compliant with national standards (Decision 52/1).	Low	Contractor for construction BMLWE for operation	Cost of sound isolation for pumps if required Noise monitoring cost: $300/ day.

Media	Project Activities	Impacts before mitigation	Mitigation Measures	Impacts after Mitigation	Responsibility	Cost Estimate
Wastewater	• Discharge of preliminary-treated wastewater from the outfall pipe	Low	• Ensuring the raw wastewater is always undergoing preliminary treatment before the effluent is conveyed to the Daoura Sea Outfall. This would ensure that the sea outfall pipe would not become clogged with grit, sand and debris • The Operation and Maintenance contract for the preliminary treatment works should stipulate the requirements to collect and test seawater for fecal coliforms counts. Such data would help optimize the dispersion modeling parameters for the Daoura Sea Outfall.	Low	BMLWE	Sampling and testing of seawater
	• Discharge of treated effluent from the sea outfall pipe during Phase 2	Low	• Ensuring the wastewater is always undergoing primary and secondary treatment before the effluent is conveyed to the Daoura Sea Outfall. • The Operation and Maintenance contract for the primary and secondary treatment works should stipulate the requirements to collect and test seawater for BOD and fecal coliforms counts. • Municipalities within the catchment area of the plant should ensure that industrial wastewater is not discharged into the sewer networks without pre-treatment to avoid causing upsets to the biological treatment plant.	Low	BMLWE	-
	• Dewatering of grit and sludge	Medium	• Prepare a Dewatering Management Plan for approval prior to commencement of operation works; and • Analyze seawater quality prior to discharge	Low	Contractor, Supervision Consultant and Municipality of Burj Hammoud	No separate costs estimation - Included in Contractor's scope of works and fees
Solid Waste	• Collected pretreatment process waste	Medium	• Clean screens regularly and drain screenings on a platform. Drained screenings should be properly disposed at the nearest waste management/ disposal facility. This can be done by hiring a specialized contractor to transport and dispose the contaminated coarse materials; • Ensure that all collected wastes are disposed of in authorized landfills. • Reuse grit if it has adequate characteristics. • Oil and grit should be sent to a certified facility for recycling;	Low	BMLWE	No separate costs estimation - Included in Operator's scope of works
	• Disposal of Generated Sludge	Medium	• Ensure that all collected wastes are disposed of in authorized landfills. • Ensure that sludge is treated and dewatered properly and according to standards	Low	BMLWE	No separate costs estimation - Included in Operator's scope of works
	• Domestic Solid Waste	Low	• Minimize waste generation; • Provide waste storage area with sorting and signs for the various types of waste; • Segregate, collect and store solid waste.	Low	BMLWE	No separate costs estimation - Included in Operator's scope of works

Media	Project Activities	Impacts before mitigation	Mitigation Measures	Impacts after Mitigation	Responsibility	Cost Estimate
Accidental Releases	• Discharge of preliminary-treated wastewater from the emergency outfall pipe	Low	The following additional mitigation measures are recommended to reduce potential impacts further more: • The land reclamation activities, over the Daoura Oveflow Pipe, may have resulted in the burial of about six diffusers. As part of the foreseen rehabilitation works, the overflow pipe needs to be inspected further by divers. If, some of the diffusers have become buried, rehabilitation activities to completely close and disconnect these diffusers would be needed. This would be to ensure that no debris get into the pipe and no wastewater flows get out of these diffusers lifting up the reclaimed sediments above. • There could be a need to extend the overflow pipe further into the sea in light of the fact that its marine section has now become substantially reduced. This would require desk studies to evaluate the extension length taking into account hydraulics, available water heads upstream, economics and plume dispersion. • For proper performance, the raw wastewater must always undergo preliminary treatment before the effluent is conveyed to the Daoura Overflow Pipe. This would ensure that the overflow pipe would not become clogged with grit, sand and debris. • The diversion of the wastewater flow to the Daoura Overflow Pipe should not be practiced randomly. The diversion of wastewater flows to the overflow pipe should only take place when the Daoura Sea Outfall must be put out of service for maintenance or repairs. It would be most suitable to schedule any maintenance or repair activities for the sea outfall during the winter season. • Control discharge of non-municipal wastes and industrial wastes into the sewer network with the help of the Municipality	Low	CDR for overflow design change Contractor for outfall rehabilitation works BMLWE for operation Collaboration with the Municipality	Cost of additional rehabilitation measures
	• Accidental Spills of Fuel, Oil and Chemicals	Medium	• No storage tank should be used for the storage of fuel, oil or chemicals unless its material and construction are compatible with the type of materials to be stored and storage conditions (e.g. pressure and temperature); • All fuel and chemical tanks should be contained in either a double skin tank over concrete floor or inside a concrete bund of at least 110% the capacity of the largest tank. • Drip trays should be installed underneath equipment such as diesel generators and transformers to contain leakage, and when using chemicals; • Keep records of all fuel, oil, chemicals, and diesel; • Reduce the frequency of refueling activity by filling the tanks to the maximal capacity during each refueling operation; • Ensure that the maintenance schedule and checklist already prepared is being efficiently used; • Check tank levels prior to delivery to prevent overfilling through side glass or manually by dipstick logs; • Have a Spill Response Plan in place. • Ensure a supply of suitable absorbent materials is available at re-fuelling points for use in dealing with minor spills. If a leak or spill occurs during loading or offloading operations, the operations must be stopped and the spill must be contained, cleaned up and collected based on the Spill Response Plan. • Ensure that personnel assigned to handle chemicals/oil/fuel are well aware of the requirements. They should be trained prior to commencing their duties.	Low	CDR to modify design to consider mitigation measures Contractor for construction BMLWE for operations	Costs of concrete bunds Cost of drip tray: $200/piece
			Depletion of Resources			
Energy Resources	• Electricity consumption	Medium	• Regular maintenance of equipment; • Install energy saving lighting fixtures (e.g. LED) instead of regular light bulbs.	Medium	BMLWE	
Land Resources	• Change in land use • Possible impact on land depreciation and land use change of adjacent plots	Low	• Ensure no odors are generated from the plant by applying identified mitigation measures, particularly for the OCU; • Plant trees along the fence of the pumping stations to reduce its visibility from adjacent plots and improve the aesthetics of the area.	Low	CDR for design and construction BMLWE for operations and maintenance	Specified under odor control measures above

Media	Project Activities	Impacts before mitigation	Mitigation Measures	Impacts after Mitigation	Responsibility	Cost Estimate
Biological Resources	• Normal operation: discharge of preliminary treated wastewater during Phase 1	Low	• Ensure applying identified mitigation measures to prevent the occurrence of overflows. • Prevent any blockage at the outlet end or malfunction that could lead to flooding or overflow through continuous maintenance of the facility. • Proper management and maintenance of the facility to prevent wastewater overflow and contamination of the soil.	Low	BMLWE	No separate costs estimation - Included in Operator's scope of works and fees
	• Normal operation: discharge of treated wastewater during Phase 2	Low	• Ensuring the wastewater is always undergoing primary and secondary treatment before the effluent is conveyed to the Daoura Sea Outfall. • The Operation and Maintenance contract for the primary and secondary treatment works should stipulate the requirements to collect and test seawater for BOD and fecal coliforms counts. • Municipalities within the catchment area of the plant should ensure that industrial wastewater is not discharged into the sewer networks without pre-treatment to avoid causing upsets to the biological treatment plant.	Low	BMLWE	No separate costs estimation - Included in Operator's scope of works and fees
Other Impacts						
Socio-economic	• Disturbances from odor emissions	High	• Implement the mitigation measures relating to odor generation proposed above	Low	CDR to include the odor control units and landscaping in the final design and scope of work of Contractor Contractor for detailed design and construction of OCU BMLWE for operations and maintenance	Specified under odor control measures above
	• Land value depreciation	Low	• Plant trees at the plant surrounding to have an acceptable landscape and barrier; • Install an appropriate odor control unit to reduce the spread of odors;	Low		
	• Improvement in seawater quality	Beneficial	-	Beneficial	-	-
Health and Safety	• Increased health and safety risks	High	• An alternative OCU needs to be investigated and proposed. The most commonly adopted system is the Granular Activated Carbon (GAC) filter. This system consists of inert material (GAC) placed in a casing to form a filter. There are no hazards whatsoever associated with the handling, storage and use of GAC. • Provide information about exposure to hydrogen sulfide for the operating staff of the Daoura WWTP. The workers doing regular cleaning, maintenance and operational tasks near the plant works should always wear at least disposable protective masks. • Enforce the wearing of masks for operators, workers and/or visitors who intend to be near the plant works for prolonged periods of time. • Comply with the local Health and Safety Requirements, especially the Decree No. 7964/2012 related to the general conditions of public safety in buildings; • Provide appropriate safety equipment, PPE, firefighting equipment and first aid stations; • Emphasize safety education and training for staff and enforce adherence to safety procedures set in and around the facilities; • Ensure proper maintenance of all systems (firefighting, mechanical, electrical, etc.); • Warning of staff about potential hazards during operation and maintenance; • An emergency response plan must be available on site.	Medium	BMLWE	Cost of PPE (boots, gloves, coverall): 102 USD Cost of First Aid Kit: 175 USD Cost of Fire Extinguisher(Powder-6 kg): 55 USD

Proposed Environmental Monitoring Plan

Impacts	Parameters to Monitor	Frequency[1]	Monitoring Location[2]	Standards/Guidelines National/International[3]	Institutional Responsibility	MoE Ref.
Construction						
Air Emissions	• Color and odor of fumes from equipment and construction generators • PM ambient levels • Generator's emissions: PM, NOx, SO_2, CO	• Color and odor of fumes from equipment: weekly • Ambient PM levels: during excavation and earth moving activities • Generator's emissions: once at the start of the works; and in case of complaints from nearby receptors	• Color and odor of fumes from equipment: equipment and generators' exhaust • Ambient PM levels: inside construction site, at nearest receptors • Emissions from generator's stack	• TSP ambient levels: 120 µg/m^3 • Generator emissions: o SO_X Maximum Allowable Value: 500 mg/m^3 o NO_X Maximum Allowable Value: 500 mg/m^3	Contractor/Supervision consultant	• Ambient Air Quality standards Annex 14 of Decision 52/1 dated 1996 • The general maximum allowable limit values for air pollutants from generators of capacity below 0.5 MW according to Annex 1 of Decision 8/1 dated 2001.
Noise	Leq, Lmax, Lmin, L90 dB(A)	• Three times daily during grading and excavation; • Once daily during concrete pouring, and construction activities; • Once during electricity shortage periods (near generator) • In case of complaints from nearby receptors	• Nearest sensitive receptor and next to generator	• Limit for Ambient Noise Level in Urban Residential Areas with construction sites and near a main road: 50-60 dB	Contractor/Supervision consultant	• Annex 10 of MoE Decision 52/1 dated 1996

[1] Frequency of monitoring can be Daily/ Weekly/ Monthly/ Quarterly/ etc.
[2] Monitoring location is where testing/ sampling will take place; linked directly with most sensitive receptors with highest impact
[3] Standard/ Guidelines: for each mitigation measure, criteria and targets must be identified to indicate acceptable levels/ conditions e.g. ambient air and water guidelines, emission limit values, energy consumption limit values, etc.

Impacts	Parameters to Monitor	Frequency[1]	Monitoring Location[2]	Standards/Guidelines National/International[3]	Institutional Responsibility	MoE Ref.
Solid Waste	• Waste types • Waste generation rates (kg or tons/day) • Waste reused • Waste transported for offsite reuse/recycle • Waste disposed of • Method of disposal	Daily	Construction site	-	Contractor/Supervision consultant	Law 80/2018
Wastewater Generation	• Leakages	Daily	Wastewater pipes, septic tank	-	Contractor/Supervision consultant	Decree No. 2761of 1933 (Provides guidelines related to wastewater management and disposal; related to the pollution caused by the discharge of liquid waste, emphasizes the prohibition of direct or indirect wastewater discharges and waste disposal into water streams)
Energy Resources	• Electricity bills • Fuel bills and fuel quantities consumption follow up	Monthly	Construction site	-	Contractor/Supervision consultant	-

Impacts	Parameters to Monitor	Frequency[1]	Monitoring Location[2]	Standards/Guidelines National/International[3]	Institutional Responsibility	MoE Ref.
Water Resources	• Water consumption (m^3/day)	• Daily records • Monthly report/ water bills	Construction site	-	Contractor/Supervision consultant	-
Socio-economic	• Number/ percentage of local workers	Before commencement of construction works and during construction	-	-	Contractor/Supervision consultant	-
	• GRM records (check Appendix I)	Continuous	-	-	MoEW/ BMLWE	-
Health & Safety	• Proper PPE use • Good housekeeping practices	Continuous	Construction site	-	Contractor/Supervision consultant	
Operation						
Odor Emissions	• H_2S threshold • H_2S outlet concentration • Grievances based on grievance mechanism	• Monthly or based on complaints	At adjacent plot that will be developed by Municipality At nearest sensitive receptor(s) Outlet concentration measured in OCU stack	• H_2S threshold concentration of 7 µg/m³ at nearest receptors • 0.25 ppm for H_2S outlet concentration for OCU stack	BMLWE	WHO standard

Impacts	Parameters to Monitor	Frequency[1]	Monitoring Location[2]	Standards/Guidelines National/International[3]	Institutional Responsibility	MoE Ref.
Air Emissions	• Generator's emissions: PM, NOx, SO_2, CO • Grievances based on grievance mechanism	• Daily • Generator's emissions: Annually • Continuous	Pretreatment Plant and Nearby communities	-	BMLWE	-
Noise	• Leq, Lmax, Lmin, L90 dB(A) • Grievances based on grievance mechanism	Annually	Near sensitive receptors and generators	Limit for Ambient Noise Level in Urban Residential Areas with construction sites and near a main road : 50-60 dB	BMLWE	Annex 10 of MoE Decision 52/1 dated 1996
Sea water	Fecal coliforms	Pre-commissioning baseline to be established by Contractor prior to operation of pretreatment plant Every 3 months during operation	300-m from coastline and near sensitive receptors/bathing locations	100 parts/100 mL	BMLWE	MAP/MEDPOL UNEP WHO
	PH, Temperature, dissolved Oxygen, Suspended solids	Daily during the operation of phase 2	Outfall pipe	Table 2-4 Environmental Limit Values (ELV) for Wastewater to be Discharged	BMLWE	Decision 8/1 of 2001
	BOD, COD, Ammonia, Phosphate, Nitrate, Cyanides, Tannins, Surfactant, Phenols, Alkalinity	• Every 3 months during operation of phase 1, and monthly during the operation of phase 2 • 24 samples per year for BOD testing	Discharged effluent at the Outfall pipe	Table 2-4 Environmental Limit Values (ELV) for Wastewater to be Discharged	BMLWE	Decision 8/1 of 2001 IG 19/7

Impacts	Parameters to Monitor	Frequency[1]	Monitoring Location[2]	Standards/Guidelines National/International[3]	Institutional Responsibility	MoE Ref.
	Metals: Al, Bo, Cd, Cr, Cu, Fe, Pb, K, Si, Mn, Mo, Ni, Se, Va, Zn, Hg	Every 6 months during operation of phase 2	Discharged effluent at the Outfall pipe	Table 2-4 Environmental Limit Values (ELV) for Wastewater to be Discharged	BMLWE	Decision 8/1 of 2001
Accidental Leaks	Visually inspect the pumps and pipes for any blockage of the outlet end to prevent flood and overflow. Visually	Monthly	Pumping stations	-	MoEW/ BMLWE	-
Energy Resources	• Electricity bills • Fuel bills and fuel quantities consumption follow up	Monthly	Pumping Stations MBBR	-	BMLWE	-
Socio-economic	GRM (check Appendix I)	Continuous	-	-	MoEW/ BMLWE	
Health & Safety	• Use of PPE by staff • Accidental Releases • Records of Training • Incidence and cause of Incidents and action taken	Records, accidental releases: monthly and upon incidents occurrence	Pumping stations	-	MoEW/ BMLWE	-

1. INTRODUCTION

1.1 SHORT DESCRIPTION OF PROJECT

As part of the overall Greater Beirut Northern Area (GBNA) Wastewater Project is the construction of the Daoura-Burj Hammoud Wastewater Treatment Plant (WWTP), which will complement the existing Al - Ghadir wastewater pretreatment plant by serving the northern sections of the city of Beirut, parts of the Baabda Caza, and the Metn Caza (up to an elevation of 800 m asl as per the general master plan devised by MoEW). The approximate coordinates of the proposed site are 33.902187°N and 35.544602°E.

The project will be built over two phases, the first being the pretreatment headworks, and the second phase adding primary and secondary wastewater and sludge treatment. The scope of this EIA study cover both phases but with more focus on the first phase of the project for which the design was finalized and which will be constructed over an area of 19,000 m^2 and is expected once operational to provide a pretreatment capacity of around 227,500 m^3 of wastewater per day.

1.2 PROJECT PROPONENT

The Council for Development and Reconstruction (CDR) was established through Decree No. 5 dated 31st January 1977. The responsibilities of the CDR were defined into three main tasks: 1) developing and implementing a plan and a time schedule for the resumption of reconstruction and of development, 2) guaranteeing the funding of presented projects, and 3) supervising their execution and utilization by contributing to the process of rehabilitation of public institutions; thus enabling it to assume responsibility for the execution of a number of projects under the supervision of the Council of Ministers.

The CDR has been working since 1992 in the wastewater management field and developed a strategy to address the problem of pollution and wastewater disposal throughout the country, as the Lebanese Government has been working on completing and organizing the public service in the wastewater sector.

The Contract (#20375) was signed on December 31st, 2018; this contract entails conducting and EIA study for the project to be submitted to MoE for approval in the process of project licensing and prior to its commencement.

On the other hand, the Beirut and Mount Lebanon Water Establishment (BMLWE), which is the project beneficiary, shall be responsible for the operation and maintenance of the project once commissioned by CDR.

1.3 EIA PRACTITIONER: ELARD

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, 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 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, Africa, and beyond. With established offices in Lebanon, Syria, the Emirates, Libya and Iraq, field offices are opened on an as-needed basis, as was the case in Pakistan for an extensive groundwater resource assessment project.

ELARD has accumulated hands-on experience in preparing Environmental Impact Assessments (EIAs) and Environmental Baseline Surveys (EBS) related to the development/construction sector, the industrial sector, infrastructure including wastewater treatment plants 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.

1.4 CONTACT DETAILS

Contact details of the proponent and environmental consultant of the project are presented in Table1-1.

Table1-1 Contact Details

Project Proponent	The Council for Development and Reconstruction (CDR) Tallet Al Serail, Riad El Solh, Beirut – Lebanon +961-1-980096
Environment Consultant	ELARD Amaret Chalhoub – Zalka Highway

	Fallas Building - 3rd Floor - Lebanon Ricardo Khoury – Project Director +961-1-888 305, Fax : +961-1-896 793 Email: rkhoury@elard-group.com

1.5 EIA OBJECTIVE

The objectives of this EIA study are to:

- Identify all applicable Lebanese national legislation, policies, standards and international treaties, agreements, standards and guidelines and regulatory environmental requirements for the Project;
- Provide a detailed description of all project activities;
- Describe the existing environmental baseline conditions of the study area covering the physical, biological, and socio-economic elements likely to be affected by the proposed Project activities;
- Identify the nature and extent of any significant potential environmental and social impacts of project activities, be they positive (beneficial) or negative (adverse), temporary or permanent. This shall include routine (planned) operations and non routine/ accidental (unplanned) events;
- Identify any significant cumulative impacts related to the Project;
- Propose appropriate mitigation measures to minimize the significance of the identified negative impacts and enhance positive impacts;
- Identify any residual impacts following the application of mitigation measures; and
- Identify, assess and specify methods, measures and standards to be included in the detailed design, operation and handover of the Project, which are necessary to mitigate these impacts and reduce them to acceptable levels.

1.6 BRIEF DESCRIPTION OF STUDY METHODOLOGY

In this section, the main topics that were developed as part of the EIA process are introduced. In each sub-section (representing main chapters in the ensuing EIA report), available information is first presented followed by proposed methods to fill information gaps. Main impact categories to be assessed are also listed, along with the proposed assessment methodologies and potential mitigation measures. Project alternatives to be analyzed are finally proposed and briefly discussed.

In preparing this report, the following methodology was followed:

- Consideration of key regulatory documents, including the EIA decree and relevant national and international environmental standards;

- A site reconnaissance visit to the Project Area;
- Initial research on potential impacts of key features of the project;
- Identification of sensitive receptors around the Project Site;
- Undertaking public hearing sessions with affected stakeholders; and
- Acquisition of zoning maps and land/plot ownership certificates related to the Project.

1.7 REFERENCE TO OUTCOMES OF THE SCOPING PROCESS WITH MOE

The scoping report was submitted to MoE on August 28, 2019 and registered under MoE No. 3998/B^{2019} and CDR No. 3958/1.

The EIA report took into consideration the comments provided by the MoE during the Scoping phase; MoE's feedback on the project's Scoping report can be found in Appendix A1. The concerns of MoE are addressed in the EIA report as per Table 1-2.

Table 1-2 Clarifications relating to the MoE's Comments on the Scoping Report

Section	Required for completion	Justification	Response/Clarification
MoE comments dated 30/09/2019			
Objectives	The EIA report should include the assessment of all phases of the project (sludge treatment from the primary and secondary treatment) to ensure the compliance of the treated effluent with national standards and regulations	Page 8 of the report states that the EIA will cover Phase 1 of the project only and will not cover Phase 2 due to its construction funding constraints.	This EIA has focused on the impacts of operating the pre-treatment plant which is the worst case scenario; once the secondary treatment is operated, a secondary treated effluent will be discharged into the outfalls which will significantly improve the performance of the plant and further reduce environmental impacts; the OCU and odor assessment (Appendix H in the EIA Report) is already considered for the full plant (OCU operating at full capacity); additional aspects would be related mostly to sludge generation and energy consumption/air emissions; identification of best alternative for sludge management will be assessed in the feasibility study and EIA currently being conducted. Nevertheless this EIA study covers both phases of the project.
Regulatory and Institutional Framework	• Clearly specify the legal articles and regulations that are directly relevant to the project, specifically those relating to environmental standards and requirements. • Specify the absent legal regulations on a national scale, and specify the regional and international regulations that will be referred to based on a scientific comparison.	The report generally specifies the legal texts relevant to the project.	Please refer to Section 2 of the EIA report which includes information of the following: - Relevant national environmental legislations to the project (Subsection 2.3.1) - Relevant national environmental standards relating to wastewater discharge, air emissions, and noise (Subsection 2.3.2) - International treaties and agreements signed and ratified by Lebanon for the protection of the environment, specifically the Barcelona Convention (Subsection 2.4.1) - Relevant international standards and guidelines which are absent in Lebanon and that control the generation of odors (WHO and US EPA), as well as thresholds for safe bathing waters as per the Mediterranean Action Plan (MAP)/MEDPOL/UNEP/WHO (Subsection 2.4.2)

Section	Required for completion	Justification	Response/Clarification
Public Participation	• Clarify this issue and conduct a public participation during the EIA phase	• The report mentioned that the public participation was attended by the Union of Municipalities of Bcharreh, while no attendees represented the MoE, the Caza of Aley or Baaba (or municipalities from those cazas)	The announcement of the public consultation meeting was advertised on two national newspapers, and thus can get the attention of interested parties from all over Lebanon. On the other hand, the Qaemmaqam of El Metn, the Union of municipalities of El Metn, Municipality of Burj Hammoud, Municipality of Beirut, and the Governor of Beirut which are the direct stakeholders affected by the project since the wastewater to be conveyed to the proposed treatment plant will primarily originate from these localities. Parts of the Baabda Caza will only be connected to the proposed pretreatment plant, while the Aley Caza will not. However, the Governor of Mount Lebanon was invited to the consultation meeting.
Description of the Proposed Project	• Specify the coverage area of the project (including served population and cadastral zones) using a map and a clear table, while also identifying the current areas served.	• Page 9 of the report mentioned that the proposed project will treat 227,500 m^3 of wastewater per day.	Please refer to Section 4
	• State the specifications of the outfall/overflow pipes and the rehabilitation activities to be conducted in the EIA report and compare them to relevant references based on relevant scientific criteria	• Page 9 of the report mentioned conveying the wastewater effluent to the existing sea outfalls	Please refer to the Subsections 4.4.7 and 4.5.1 in the EIA report for information about the sea outfalls and planned activities for their rehabilitation. Appendix K in the EIA report also includes further information about the current status of the existing sea outfalls.
	• Consider the location and area of the proposed project in Phase 1 and 2. (including sludge treatment)	• Page 11 of the report mentioned the location and area of the proposed project.	The proposed pretreatment headworks plant will be constructed on a reclaimed land after the removal of the Burj Hammoud dumpsite. The pretreatment headworks plant will be constructed over an area of 19,000 m^2, however the total area required for the

Section	Required for completion	Justification	Response/Clarification
			construction of complete WWTP (phase 1 and 2 combined) is 65,000 m^2 as presented in Subsection 4.3 of the EIA Report.
	• Include the specifications of the proposed odor control unit, including a map that shows its concentrations	• Page 15 of the report mentioned that the pumping station will be equipped with an odor control unit.	Please refer to Subsection 4.4.8 and Appendix H of the EIA Report.
	• It is important to select one specific option for the management of solid waste generated from the proposed project during Phase 1 and 2 including an analysis of alternatives. Additionally specify the mechanism of implementation within and beyond the project.	• Page 15 of the report mentioned the option of treating the generated solid waste from Phase 1, in addition to pumping the treated effluent to the sea outfall in case the flow rate does not exceed 5.2 m^3/s.	During phase 1 of the project no sludge will be generated. Solid waste generated during this phase will mainly include process waste from screens and from grit/grease removal. The management practices for such collected waste are mentioned in Section 8 of the EIA Report. As for the waste that will be generated as part of Phase 2, the feasibility study and EIA being prepared will definitely take into consideration assessing alternatives for implementing the best waste management option. This EIA identifies two environmentally feasible options for the disposal of dewatered sludge: disposal as soil cover in landfills and on-site incineration.
	• Identify the specifications of each generator to be utilized for the project.	• Page 17 of the report mentioned the total capacity of the generators.	For Phase 1, four generators will be used during the operation phase, each with a capacity of 1,600 KVA.
Description of the Environment	• State the scientific references used for the description of the surrounding environment (e.g. marine environment), including specifying the quality of sea water using data	• The report mentioned the surrounding environment of the project	Please refer to Section 10

Section	Required for completion	Justification	Response/Clarification
	published by the National Center for Marine Sciences		
Potential Environmental And Social Impacts	• Explain the reasoning behind excluding certain aspects from the study. • Assess qualitatively and quantitatively the environmental impacts of the project • Consider the potential environmental impacts of the project in all its phases,	Page 42 of the report mentioned the aspects that will be excluded from the study.	• The following aspects were excluded from the study: - Soil and Groundwater Quality: Although the overall project will improve and protect the soil and groundwater quality in the areas covered, however the construction and operation of the proposed project will not affect the soil and groundwater is situated over a reclaimed land on the shoreline of the Mediterranean Sea, and there are no down gradient wells. - Terrestrial Ecology: The project will be located over a reclaimed land that is environmentally deteriorated with very low biodiversity and minimal terrestrial ecological value. - Archeology: the study area is located on a recently reclaimed land. • Please refer to Section 6, Appendix G and H of the EIA Report that present a detailed qualitative and quantitative impact assessment of the project. • The feasibility study and EIA being prepared will take into consideration assessing the potential impact arising from Phase 2 of the project.
Analysis of Alternatives	• Include a detailed comparison table between the different options and the selected one based on scientific references.	The report generally mentioned the analysis of alternatives for odor control, sea outfall, and waste management.	• Please refer to Section 7 of the EIA report for the analysis of alternatives of the project.

Section	Required for completion	Justification	Response/Clarification
	• Consider the alternatives available for all phases on the proposed project • Analyze the alternative options for sludge management		
Environmental Management Plan	• It is important to develop a detailed and comprehensive EMP that considers all phases of the project including sea outfall rehabilitation activities and sludge treatment.	The report included a general EMP.	• Please refer to Section 8 of the EIA report for the EMP for Phase 1 of the project.

1.8 REFERENCE TO OUTCOMES OF THE EIA PROCESS WITH MOE

The EIA report was submitted to MoE on September 24, 2019 and registered under MoE No. 3998/B2019.

This final EIA report took into consideration the comments provided by the MoE during the EIA phase; MoE's feedback on the project's EIA report can be found in Appendix A2. The concerns of MoE are addressed in the EIA report as per Table 1-3.

Table 1-3 Clarifications relating to the MoE's Comments on the EIA Report

Section	Required for completion	Justification	Response/Clarification
MoE comments dated 12/11/2019			
Executive Summary	Reformulate the Executive summary based on the below comments	The report including all its sections needs to be modified	Please refer to the revised Executive Summary
Introduction	Define the master plan results based on the project scope and the villages that will be connected to the WWTP, and the coverage percentage of the Sewage network	In page 1 of the report, it is stated that the project will be implemented in accordance with the general master plan devised by MoEW	Please refer to Section 4 which presents the coverage area map and the administrative areas that will be connected to the WWTP.
	Comply with the principles of Barcelona Convention on the required treatment level for residential areas that include more than 2,000 people	In page 3 of the report, it is stated that several legislations, national, and international standards have been adopted in the report preparation	One of the main outcomes of this project is to assist Lebanon in conforming with the requirements of the Barcelona Convention with regards to reducing land based pollution sources (urban municipal sewage) reaching the Mediterranean Sea. As such, Phase 1 of the project will party reduce sea pollution from municipal sewage by discharging pretreated wastewater into the sea via the outfall (for diffusion). Phase 2 on the other hand should comply with the requirements of the Barcelona Convention since the wastewater will undergo secondary treatment before discharge, greatly reducing sea pollution from this point source.
Regulatory and institutional framework	Include this Decree	Table 2-2 did not include the Hazardous waste management Decree	Please refer to the revised Table 2-2 Summary of Relevant Environmental Legislations

Section	Required for completion	Justification	Response/Clarification
	Comply with the content of Decision IG 19/7 about the required treatment level for residential areas with more than 2,000 people	In page 14 of the report, the Barcelona Convention is mentioned as one of the relevant treaties	Regulates the amount of BOD5 in wastewater discharged in the seawater. Stipulates that all cities having a population greater than 2,000 must have their wastewater collected and undergo secondary treatment before discharged into the environment. Sets the guidelines for monitoring WWTP effluent discharges to verify compliance.
	Clarify the used standard and why it was adopted, while taking into consideration other parameters (e.g. VOCs)	Page 15 of the report includes the concentrations of H_2S, and Ammonia	It is sufficient to control hydrogen sulfide since other constituents would be at much lesser concentrations and that is why hydrogen sulfide is targeted for control during Phase 1 of the project. NH_3 has also been assessed and found not to be a limiting factor too.
	Include Seawater quality standards in the report, (for all relevant parameters) by relying on international standards.	The report included the Coliform parameter only for seawater quality	The coliform parameter was used since it is an important parameter that indicates seawater pollution with regards to safe recreational water environments. The standards used are meant to support the dispersion modeling shown in Appendix G.
	Use environmental standards for generators with capacities more than 500 KVA which are mentioned in MoE Decision 8/1 -2001	Page 33 of the report states the capacity of the four generators is 1,600 KVA, while in page 12 the standards are for generators with a capacity of 500 mg/m^3	Please refer to the revised standards in 2.3.2.2
Public consultation	Clarify how this number was calculated, and commit the design of the plant to fit this size	Page 19 of the report states that the plant is to treat 227,500 m^3	There are no available field data concerning wastewater production (flows) from the catchment area and the characteristics of the wastewater, which have been derived by a consistent sampling and analysis program.

Section	Required for completion	Justification	Response/Clarification
			For the purpose of this study, an estimate for the population served as well as typical wastewater characteristics for the area have been provided by the Ministry of Energy and Water Master Plan (MoEW). The water consumption by 1PE is considered to be around 200 m^3/d/PE. The wastewater flow produced by 1PE is estimated to be 162.5 m^3/d/PE. When these figures are multiplied by the population, we get the average flow rates (Qin) shown in Table 4-1 in Section 4.4.
	Hold public consultation to inform the public on all project components, in accordance with Decree 8633/2012	In the report it is stated that the public consultation was only for the scoping phase, and that the report will be discussed with the relevant stakeholders, particularly the mayor of Burj Hammoud Municipality	ELARD is currently in contact with the Municipality of Burj Hammoud to set a date for a second public consultation session. This is being complicated by the current situation in the country. As soon as the consultation is held, a separate public consultation report will be submitted to MoE.
	Adopted options should be set in accordance with the current situation	Page 20 of the report states the possibility of reusing treated water	This issue was noted as part of the discussion that was raised during the scoping phase public consultation meeting. The EIA report studied the feasible options that can be applied in the current situation.
Description of proposed project	Respond to the comments in the adjusted EIA report	The executive committee report, dated 30,9,2019, issued comments that should be added within the EIA report	Please refer to Table 1-2 that lists the responses to comments issued by MoE on the scoping report.
	Generally clarify each component of the layout	Page 27 of the report includes the project layout	Please refer to the information presented in Section 4.4

Section	Required for completion	Justification	Response/Clarification
	Clearly identify the timeline for the implementation and operation of the 2 project phases including all it components (Including the rehabilitation of the pumping stations, and outfalls, and network construction…..), and it is important to include all relevant legal documents, and the estimated cost for the construction of the different components	In the report it is stated that the project will be implemented over two phases	Please refer to Section 4
	Show how efficient are the outfall pipes, and how compatible they are with the suggested plant and daily flow, with reliance on scientific references	The report states that two outfalls are available for the wastewater discharge	Section 4.4.1.7 presents a brief summary of the existing sea outfalls and the rehabilitation works needed for each. The full report by EDTO regarding the assessment and rehabilitation works needed for the sea outfalls is presented in Appendix K.
Description of the surrounding Environment	Specify the references and data used to determine the seawater quality with the project scope (For example, data from the National Centre for Marine Sciences)	It was stated on page 54 that the biological environment surrounding the environment was deteriorated	The existing industries in the project area and the untreated wastewater that is currently being discharged to the seawater are the main causes of the deteriorated seawater quality. In addition, information about the biological marine environment were taken from the EIA for the Daoura Burj Hammoud WWTP that was developed in 2003. Part of the Information was also based on data presented in the CANA-CNRS Report 2015.
	Specify the current situation of the Burj Hammoud- Jdaideh Landfill for the remaining operation phase and closing date of the landfill	Page 55 of the report states that the solid waste management is operated by RAMCO where the waste is sorted at the Karentina facility and landfilled in the Burj Hammoud- Jdaideh Landfill	As per information provided by CDR, the Burj Hammoud landfill has already reached its maximum capacity and at this stage the landfill is being capped. At the time being collected waste is currently disposed of at the Jdeideh landfill. Expanding the capacity of the Burj Hammoud-Jdeideh landfill is possible by reclaiming land situated between the two

Section	Required for completion	Justification	Response/Clarification
			landfills (if approved by the Council of Ministers).
	To be clarified	The report did not include how industrial waste and waste generated from health related facilities are being managed, which can have a direct impact on the project	A mitigation measure to be adopted is for municipalities and MoE to play an important role in monitoring industrial and healthcare establishments within their juridical boundaries. Such establishment must not discharge non-municipal wastewater into the sewage network unless pretreated onsite first and the effluent discharge has to comply with the requirements of ministerial decision No. 539/1-2015 and decision No. 540-1/2015, related to compliance deadlines. Additionally Odor control must also be mitigated from these sources to reduce the cumulative impacts.
Potential Environmental Impacts of the Project	• Use unified measurement units for H_2S, and it is important to include the used reference to determine the standards in comparison to the standards from MoE Decision 8/1-2001 • Analyze the impact of other gases that are generated from the operation of the project on the surrounding environment (VOC, Ammonia, ….)	Pages 64-68 of the report include an analysis of H_2S gas on the surrounding environment	• The threshold H2S concentration that was used in odor generation modelling study was based on WHO Standards as presented in Section 2.4.2. • It is sufficient to control hydrogen sulfide since other constituents would be at much lesser concentrations and that is why hydrogen sulfide is targeted for control during Phase 1 of the project. NH_3 has also been assessed and given the nature of the influent wastewater NH_3 will not be a major source of odors from the WWTP.
	Clearly state the location of the landfill	In the report it is stated that solid waste generated from the operation of the project will be treated and disposed on at the nearest sanitary certified landfill	The landfill to be used is the Burj Hammoud-Jdeideh Landfill
	Include in the report the environmental impacts that are caused by grit removal throughout the report (when necessary)	The report includes grit removal activities	Collected grit from the WWTP shall be washed then dewatered, and shall be classified for reuse or disposal based on its characteristics. If

Section	Required for completion	Justification	Response/Clarification
			not handled and classified properly, the collected poor-quality grit can lead to additional surface water, groundwater, and soil pollution.
	Reconsider this section to include the environmental impacts from the various phases and components of the project	The report includes analysis of environmental impact assessment from the first phase of the project (pre-treatment)	Please refer to the revised Impact assessment of the project which includes the major impacts caused by the operation of Phase 2 of the WWTP in addition to the detailed impacts assessment of Phase 1.
Analysis of alternatives	Specify the used reference in the analysis of technologies	Page 92 of the report includes a table that compare the different technologies used for the control of odors that are generated from the project	Please refer to Section 10 for the references used in the EIA report.
	Identify alternatives for the management of sludge, taking into consideration the CDR's Guidelines dated 2003	Not included in the report	Please refer to Section 7.5
	Identify alternatives for solid waste disposal, including all types of solid waste, and adopt solutions that can be implemented	Refer to page 94 of the report about waste disposal	Please refer to Section 7.4
Environmental Management Plant	It is important to enlist a detailed inclusive, specific, and comprehensive EMP, which can be monitored and measured, and which should include details for all necessary and required measurements. The EMP should consider all the project phases, the rehabilitation of the outfalls, sludge treatment, and all the previous notes	The report included a general EMP, and it was noticed that some general measures were included, while measures will be prepared and developed at a later stage	Please refer to Section 8.2 for the revised EMP for Phase 1 and Phase 2 of the project.

1.9 REFERRAL TO COMMITMENT LETTER BY PROJECT OWNER/LEGAL REPRESENTATIVE

The project proponent will sign a commitment letter as required in MoE Decision No. 261/1 dated 12/06/2015 to abide by all measures proposed in the EIA. A copy of the signed commitment letter will be provided once the EIA report is approved by the MoE.

2. REGULATORY AND INSTITUTIONAL FRAMEWORK

2.1 INTRODUCTION

This chapter presents an overview of public and private institutional stakeholders concerned with the project, as well as applicable legislation, policies, standards and international treaties and agreements setting the regulatory environmental requirements associated with the project.

The objective is to ensure compliance not only with the Lebanese environmental laws and regulations, but also with the relevant international agreements of which Lebanon is signatory and to observe non-statutory corporate standards and good practice guidance.

2.2 INSTITUTIONAL FRAMEWORK RELEVANT TO THE PROTECTION OF THE ENVIRONMENT

Table 2-1 lists the main institutions concerned with the protection of the environment with relevance to the project implementation.

Table 2-1 Public Administrations Concerned with the Protection of the Environment and the Project's Implementation

Public Administration	Prerogatives
Ministry of Environment (MoE)	MoE is the national competent authority responsible for the protection of the environment in Lebanon. MoE is responsible for reviewing the Environmental Impact Assessment report and for issuing the conditions for approval of the Project. Upon approval of the EIA, MoE is responsible to enforce and supervise the implementation of the EMP.
Ministry of Energy and Water (MoEW)	MoEW monitors surface and groundwater quality. It also estimates water needs and uses in all regions, and identifies the conditions and systems needed for surface and groundwater exploitation. It then develops the schemes for distribution of water (drinking and irrigation). MoEW is also responsible for the design and execution of wastewater networks, treatment plants, outfalls, etc.; giving opinion on wastewater treatment projects executed by municipalities; and organizing the subcontracting operation, specifications and expropriation procedures in cooperation with the Service of Expropriation and Water Rights.
Ministry of Public Works and Transport (MoPWT)	MoPWT is responsible for the public maritime domain
Ministry of Public Health (MoPH)	MoPH is responsible for safeguarding and improving public health through setting allowable levels for contaminants in water, inspecting and protecting water resources, especially groundwater reservoirs.
Ministry of Interior and Municipalities (MoIM)	MoIM stops all kinds of infractions and violations, and oversees local authorities' affairs and operations.
Council for Reconstruction and Development (CDR)	The CDR is engaged in all phases of project implementation from planning, feasibility analysis, detailed design, bidding, expropriation, execution, operation and maintenance of most public facilities and projects.
Beirut and Mount Lebanon Water Establishment (BMLWE)	It is a semi-autonomous public institution having the responsibility of exploitation of both the network and the equipment for providing drinking water and those for wastewater collection, as well as for their maintenance and renewal. Will be responsible for the operation of the wastewater treatment plant.

Public Administration	Prerogatives
Municipality of Burj Hammoud, and the Union of Municipalities of Metn	Municipalities represent the level of local government with legal status, financial and administrative independence, which exercises powers and responsibilities over the territory it is granted by law. The municipality manages complaints from local residents and may be involved if complaints are received during Project implementation. It is also in charge of roads, parks and public places, local urban planning (in coordination with DGUP), as well as solid waste management within its jurisdictions.

At a regional level, the Governorate of Mount Lebanon and the Qaemmaqam of Matn Caza have direct responsibilities relating to the project and to its environment.

In addition to the above-mentioned public stakeholders, several local stakeholders are affected by and play a role in the construction and/or operation of the project. These include:

- Owners of the nearby land parcels;
- Owners and operators of adjacent industries; and
- The local community and NGOs;

2.3 RELEVANT REGULATIONS AND STANDARDS

2.3.1 National Legislative Framework for Environmental Protection

This section describes the most relevant and pertinent national legislations related to the Environment in general and to the wastewater management sector in Lebanon in particular.

Table 2-2 presents an overview of the main environmental legislations relevant to the project; these legislations are listed in reverse chronological order.

Table 2-2 Summary of Relevant Environmental Legislations

Law / Decree	Year	Reference Entity	Relevant Provisions
Decree 5606	2019	CoM	The decree specifies the principles of management (sorting, storage, transport, and disposal) of hazardous waste
Law 80	2018	Parliament	Integrated Solid Waste Management Law - sets the framework for Integrated Solid Waste Management based on the principles of Law 444/2002.
Law 78	2018	Parliament	Framework law for the protection of air quality, in particular Article 24: Establishments that produce unpleasant or harmful odors shall comply with environmental regulations by applying best available technologies and keeping a set minimum distance away from inhabited areas.
Law 77	2018	Parliament	The new Water Law in Lebanon covers the following: Master plan for water resources and water basins, preserving the quality of water, financial regulations of the water sector, sanitation, compensation for pollution, management of public water utilities, addressing natural hazards that can affect the water sector, and violations and penalties.
Memo 9/1	2017	MoE	Prohibits the discharge of wastewater into bottomless wells
Decree 3989	2016	CoM	Designation of an Environmental Police Department within the Ministry of Environment to regulate environmental crimes and enforce penalties; and specification of their organization and mandates.
Decree 3057	2016	CoM	Defines and regulates the procedures followed by the DGA for the preventive and rescue excavations.
Decision 1	2016	CoM	Allocating reclaimed land to the construction of public facilities (Wastewater Treatment Plant)
Decision 261/1	2015	MoE	Procedures for review of scoping reports and EIA reports
Circular 6/1	2015	MoE	Defining EIA and IEE review fees and bank guarantees.
Law 251	2014	CoM	Establishing an Environmental Prosecutor.
Decree 8157	2012	CoM	Establishing the National Council for the Environment and specifying its mandates and organization.
Decree 8633	2012	CoM	Sets the EIA Procedures. It is under the Framework of the Environmental Law. It stipulates the EIA procedures and regulations related to all development Projects that have a potential impact on the environment.
Decree 8213	2012	CoM	Strategic Environmental Assessment of Policies, Plans and Programs in the public sector.
Decree 2275	2009	CoM	Application Decree on the organization and mandates of the MoE, its divisions and departments.
Law 690	2005	Parliament	Law on the Organization of the Ministry of Environment. The Law gives the Ministry of Environment the prerogative to set the standards and norms for the protection of coastal zone, river beds and different water resources taking into account the protection of the environment and the conservation of its natural resources.

Law / Decree	Year	Reference Entity	Relevant Provisions
Decree 11802	2004	CoM	Provides the general regulations for the prevention of occupational hazards and accidents, and the promotion of health and safety in all enterprises subject to the Labor Law
Law 444	2002	Parliament	Sets the framework for environmental protection. Provides the principles and rules for protecting different environmental matrices (air, water, soil…) from pollution with wastewater, hazardous wastes, chemicals, and noise, etc.; and specifies the penalties for violating environmental laws. • Section 1 (Basic Principles and General Provision) • Section 2 (Organization of Environmental Protection), paragraph 4 (Environmental Monitoring Mechanisms) • Section 3 (Environmental Information System and Participation in Environmental Management and Protection) • Section 4 (Environmental Impact Assessment) • Section 5 (Environmental Protection) • Section 6 (Responsibilities and Sanctions)
Decision 8/1	2001	MoE	National Standards for Environmental Quality (NSEQ) • Provides standards for stack emission levels and air pollutants emissions discharge limits from generators. Appendix 1 (ELVs)- Tables 1 to 3) and Appendix 2-9 (minimum stack height for generators) • Provides ELVs for wastewater discharged into different receiving media (sewerage system, surface water, sea).
Law 221	2000	Parliament	Sets the regulatory framework for the management of the water sector in Lebanon, and specifies the roles and responsibilities of the Ministry of Energy and Water and the water establishments in Lebanon which include the design and execution of wastewater infrastructure projects as well as their operation and maintenance.
Decision 52/1	1996	MoE	Specifying the National Standards for Environmental Quality (NSEQ) and the Environmental Limit Values (ELVs) for air, water, and noise: • Section 10 (Noise Standards) • Section 14 (Ambient Air Quality standards)
Law 58	1991	Parliament	Expropriation law which was modified later on by the Law enacted on 12/08/2006.
Law 64/88	1988	Parliament	Environmental protection against hazardous waste that could harm air, water, biodiversity, soil, and people; states fines for activities that result in pollution and hazards to the environment and public health. • Table 1 (specifies hazardous substances and non-hazardous waste).
Decree-Law 69	1983	CoM	Decree-law on urban planning.
Law 118	1977	Parliament	• Article 74: License for digging roads to extend public water pipes • Article 51: Regulate traffic and public transport

Law / Decree	Year	Reference Entity	Relevant Provisions
Decree 8735	1974	CoM	Protection against pollution from solid and liquid waste (prohibiting the digging of wells for the disposal of raw sewage, banning sewage infiltration from septic tanks and the use of untreated sewage for the irrigation of vegetables and some fruit trees), and assigning solid waste management to municipalities.
Law 973/74	1974	Parliament	Relating to solid waste pollution; followed by application Decree No. 8735.
Decree 2761	1933	CoM	Provides guidelines related to Wastewater Management and Disposal; related to the pollution caused by the discharge of liquid waste, emphasizes the prohibition of direct or indirect wastewater discharges and waste disposal into water streams.
Decree law 16 L	1932	CoM	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.
Decision 320	1926	MoE	Related to the protection and use of water bodies belonging to the public domain.

2.3.2 Relevant National Standards for Environmental Protection

The main legislative texts that stipulate environmental standards in Lebanon are listed in Table2-3. National emission and discharge standards were established by the Ministry of Environment (MoE) in Decision 52/1 dated 1996 and later in the Ministerial Decision 8/1 dated 2001. In case some required standards for the assessment are missing in the national legislation, then international standards will be used, particularly those issued by the International Finance Corporation (IFC) of the World Bank and the World Health Organization (WHO).

Table2-3 Relevant National Environmental Standards

RELEVANT STANDARDS		
Ministerial Decision No. 52/1, MoE	29/7/1996	Environmental Quality Standards & Criteria for Air, Noise, Water and Soil
Ministerial Decision No. 8/1, MoE	30/1/2001	Updates/replaces Decision 52/1 by developing National Standards for Environmental Quality (NSEQ) related to air pollutants and liquid waste emitted from classified establishment into receiving water bodies.

2.3.2.1 Wastewater Discharge

The Environmental Limit Values (ELV) for wastewater to be discharged the sea according to the MoE Decision 8/1 of 2001 are summarized in Table 2-4. These are mostly applicable to Phase 2 of the project.

Table 2-4 Environmental Limit Values (ELV) for Wastewater to be Discharged

SUBSTANCE	MAXIMUM ALLOWABLE LIMITS FOR RECEIVING WATER BODIES
	SEA
Color	none
pH	6-9
Temperature	35°C
BOD (5 day, 20°C)	25 mg/l
COD (dichromate)	125 mg/l
Total Phosphorus	10 mg/l
Total Nitrogen[1]	30 mg/l
Suspended solids	60 mg/l
AOX	5

[1] Sum of Kjeldahl-N(organic N + NH3),NO3-N, NO2-N

SUBSTANCE	MAXIMUM ALLOWABLE LIMITS FOR RECEIVING WATER BODIES
	SEA
Detergents	3 mg/l
Coliform Bacteria 370 C in 100 ml[2]	2,000
Salmonellae	Absence
Hydrocarbons	20 mg/l
Phenol Index	0.3 mg/l
Oil and grease	30 mg/l
Total Organic Carbon (TOC)	75 mg/l
Ammonia (NH_4^+)	10 mg/l
Silver (Ag)	0.1 mg/l
Aluminum (Al)	10 mg/l
Arsenic (As)	0.1 mg/l
Barium (Ba)	2 mg/l
Cadmium (Cd)	0.2 mg/l
Cobalt (Co)	0.5 mg/l
Chromium total (Cr)	2 mg/l
Hexavalent Chromium (Cr^{VI+})	0.2 mg/l
Copper total (Cu)	1.5 mg/l
Iron total (Fe)	5 mg/l
Mercury total (Hg)	0.05 mg/l
Manganese (Mn)	1 mg/l
Nickel total (Ni)	0.5 mg/l
Lead total (Pb)	0.5 mg/l
Antimony (Sb)	0.3mg/l
Tin total (Sn)	2 mg/l
Zinc total (Zn)	5 mg/l
Active (Cl_2)	1 mg/l
Cyanides (CN^-)	0.1mg/l
Fluorides (F)	25 mg/l

[2] For discharges in close distance to bathing water, a stricter environmental limit value could be necessary

SUBSTANCE	MAXIMUM ALLOWABLE LIMITS FOR RECEIVING WATER BODIES
	SEA
Nitrate (NO_3^-)	90 mg/l
Phosphate (PO_4^{3-})	5 mg/l
Sulphate (SO_4^{2-})	1,000 mg/l
Sulphide (S^{2-})	1 mg/l

Source: MoE, Decision 8/1, 2001

2.3.2.2 Air Quality

The general maximum allowable limit values for air pollutants from generators of capacity below 0.5 MW according to Annex 1 of Decision 8/1, Table 3 (Group IV) are presented in Table 2-5.

Table 2-5 Maximum Allowable Limit Values for Generators with a Capacity above 0.5 MW

Pollutant	Maximum Allowable Value
O_2 Correction Factor 5%	
Dust	250 mg/m^3
CO	800 mg/m^3
NO_X	4,000
SO_X	3,000

According to the Decision 8/1, ELVs for a minimum stack height should to be kept for the release of exhaust gases. This method can be used instead of applying the ELVs for generators. This means that an operator of a plant can choose whether he meets the ELVs on one hand or installs a capacity correlated stack height on the other hand to fulfill the demands on the necessary dilution of the emissions. The formula for the determination of the stack height is: $H = h + 0.2\sqrt{KVA}$

Where:

- H = Total stack height in meters
- h = Height of neighboring building in meters (within 50 m radius)
- KVA= Total generator capacity of the set in kVA = kW, i.e. the total capacity which is determined by the maximum fuel (energy) input

The minimum stack height is related to the following conditions:

1) Area of applicability: > 500 total generator capacity (kVA = kWj)

2) Minimum height: 1 m + height of neighboring buildings in [m] (inside 50 m diameter from the stack or the average building height in the neighborhood)
3) Minimum exhaust gas velocity: 15 m/s
4) More than one generator: total capacity
5) < 500 total generator capacity [kVA=kW]: 1 m + height of installation hall

2.3.2.3 *Noise*

The National maximum allowable noise levels according to Decision 52/1 is presented in Table 2-6.

Table 2-6 Permissible Ambient Noise Levels in Selected Regions

Region Type	Limit for Noise Level dB(A)		
	DAY TIME (7 a.m. - 6 p.m.)	EVENING TIME (6 p.m. - 10 p.m.)	NIGHT TIME (10 p.m. - 7a.m.)
Residential areas with some construction sites or commercial activities or located near a road	50-60	45-55	40-50
Industrial areas including heavy industries	60-70	55-65	50-60
Residential areas within a city	45-55	40-50	45-35

2.4 INTERNATIONAL AGREEMENTS, TREATIES, GUIDELINES AND STANDARDS

2.4.1 International Agreements and Treaties

Lebanon has ratified 50 International Conventions (48 actually in force). Those treaties and conventions which are most relevant to the proposed project activities are summarized hereunder in Table 2-7.

Table 2-7 Ratified or Signed International Agreements

Agreement	Objective	Relevance To Project
Convention on Biological Diversity, Rio de Janeiro - 1992 Ratified by Lebanon in 1994	1. To conserve biological diversity; 2. To use biological diversity in a sustainable way; and 3. To share the benefits of biological diversity fairly and equitably.	Aims at the protection and conservation of biodiversity during construction and operation activities
The Framework Convention on Climate Change, or Global Warming Convention (UNFCCC)–1992 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 operation and construction activities

Agreement	Objective	Relevance To Project
The Kyoto Protocol – 1997 Ratified by Lebanon on 13/11/2006	To reduce greenhouse gas emissions in an effort to prevent anthropogenic climate change	
Paris Agreement - Paris Climate Conference (COP21), part of the UNFCC - 2015. Agreement Entered into force on October 2016. Signed by Lebanon in 2016. Not yet Ratified	To reaffirm the goal of limiting global temperature increase well below 2 degrees Celsius; To establish binding commitments by all parties to make "nationally determined contributions" (NDCs), and to pursue domestic measures aimed at achieving them; To commit all countries to report regularly on their emissions and "progress made in implementing and achieving" their NDCs, and to undergo international review; To commit all countries to submit new NDCs every five years, with the clear expectation that they will "represent a progression" beyond previous ones; To extend a mechanism to address "loss and damage" resulting from climate change; and To call for a new mechanism, similar to the Clean Development Mechanism under the Kyoto Protocol, enabling emission reductions in one country to be counted toward another country's NDC.	
Vienna Convention for the Protection of the Ozone Layer – 1985 Montreal Protocol on Ozone-Depleting Substances - 1987 and its amendments Ratified by Lebanon between 1993 and 1999	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	Regulate the use of ODS (ozone depleting substances) during all phases of the Project
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	To ensure protection of the Mediterranean Sea and aquatic species from effluent discharges (solid/liquid waste)	To protect the coastal area from uncontrolled discharge and dumping practices in the study area which pose a threat to the existing water resources

Agreement	Objective	Relevance To Project
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)		
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
UNEP(DEPI)/MED Decision IG 19/7 for the protection of the Marine Environment and the coastal region of the Mediterranean	Regional Plan on the reduction of BOD5 from urban waste water in the framework of the implementation of Article 15 of the LBS Protocol	Regulates the amount of BOD5 in wastewater discharged in the seawater. Stipulates that all cities having a population greater than 2,000 must have their wastewater collected and treated before discharge into the environment. Sets the guidelines for monitoring WWTP effluent discharges to verify compliance.
Integrated Monitoring and Assessment Programme (IMAP) of the Mediterranean Sea and Coast. It is integrated in the MAP and Barcelona convention framework and is in line with the EU Marine Strategic Framework Directive and the decisions of the Convention on Biological Diversity (CBD) regarding the ecosystem approach and the Aichi targets.	Seven-step roadmap for the management of human activities in view of promoting the sustainable use of seas and coasts, and conserving marine ecosystems and their sustainable development.	To ensure the sustainable use of sea and coast and protect them from activities that prohibit their sustainable development.

2.4.2 Relevant International Guidelines and Standards

Odors from WWTPs are considered as a form of nuisance whereby several international standards have been formulated with respect to threshold concentrations for ammonia and hydrogen sulfide (H2S). The threshold concentration is the level at which the odor is detected by the recipients and is considered annoying. Table 2-8 below presents the threshold concentrations as recommended by the US EPA and the WHO. H_2S is considered to be the limiting factor for odor control as it would be generated in much larger concentrations than any other odorous compound.

Table 2-8 International Odor Threshold Concentrations

	Hydrogen Sulfide		Ammonia	
Threshold Concentration	**μg/m³**	**ppm**	**μg/m³**	**ppm**
US EPA	1[4]	0.001[3]	100	0.14
WHO	7[5]	0.005[4]	-	-

On the other hand, maximum thresholds for fecal coliforms in bathing waters established by the Mediterranean Action Plan (MAP)/MEDPOL/UNEP/WHO are used to assess the performance of the outfalls. This threshold is 100 parts/100 ml. If dilution is sufficient to reduce the incoming counts of millions to 100 parts within bathing areas, it is a good indicator to demonstrate the effectiveness of the outfalls and diffusers.

The regional ELV on BoD_5 to be implemented as per the IG 19/7 is shown in Table 2-9.

Table 2-9 BOD Threshold Concentrations

Parameter	Scope/Area	ELV (mg/l O_2)	Comments/ Provision
BOD_5 at 20°C without nitrification	LBS Protocol Area	<=50	Assuming a performance of reduction of the influent load of 70-90 % (secondary treatment)
	LBS Protocol Area <=50 Assuming a performance of reduction of the influent load of 70-90 % (secondary treatment).	<=200	Assuming a performance of reduction of the influent load of 20 % (primary Treatment). These ELVs should only be adopted taking into account local conditions, and provided that total loads do not affect the receiving marine environment.

[4] Reference Concentration (RfC) that is an estimate of a daily inhalation exposure of the human population that is likely to be without an appreciable risk of harmful effects during a lifetime
[5] Should not be allowed to exceed with a 30-minute averaging time

3. PUBLIC CONSULTATION

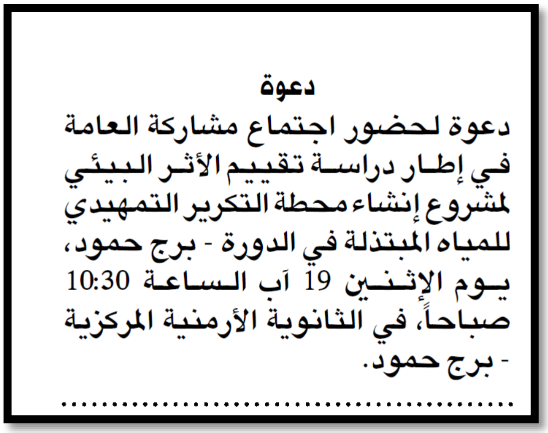
3.1 SCOPING PHASE

According to the existing laws and regulations, international conventions and good practice, the public has the right to be properly and timely informed about any type of project that can cause an impact on the environment and society.

As per local requirements stipulated in Decree 8633/2012 and its implementing decisions, an announcement (Appendix B) was posted on August 1, 2019 at the Municipality of Burj Hammoud premises. The announcement provided basic information about the project and invited members of the public to participate in a consultation meeting to discuss the proposed project and express concerns, if any, regarding environmental or social impacts from the project.

In compliance with the EIA Decree 8633 dated 2012, the announcement was posted 15 days prior to the public participation meeting and a period of one month was given for citizens to express their comments and concerns relating to the project. Moreover, two advertisements were also published in two local newspapers (Addiyar and Al Akhbar) 15 days prior to the meeting.

Figure 3-1 Consultation Meeting Announcement posted at the Municipality of Burj Hammoud



دعوة

دعوة لحضور اجتماع مشاركة العامة
في إطار دراسة تقييم الأثر البيئي
لمشروع إنشاء محطة التكرير التمهيدي
للمياه المبتذلة في الدورة - برج حمود،
يوم الإثنين 19 آب الساعة 10:30
صباحاً، في الثانوية الأرمنية المركزية
- برج حمود.

....

Figure 3-2 Invitation to the Consultation meeting posted in Al Akhbar Newspaper

Invitation letters to the public participation meeting were also sent to the Ministry of Environment (MoE), Ministry of Energy and Water (MoEW), Ministry of Public Works and Transport (MoPWT), Ministry of Interior (MoI), Ministry of Public Health (MoPH), Ministry of Culture (MoC), Ministry of Agriculture (MoA), Ministry of Finance (MoF), The General Directorate of Urban Planning, Qaemmaqam of El Metn, Municipality of Burj Hammoud, Municipality of Beirut, Union of municipalities of Metn, The Governor of Mount Lebanon, The Governor of Beirut, Beirut and Mount Lebanon Water Establishment (BMLWE). The letters can be found in Appendix C.

3.1.1 Public Participation Meeting

A Scoping public participation meeting was held on August 19, 2019 at the premises of the United Armenian College of Burj Hammoud for the purpose of presenting the main components of the project and the components of the EIA study, and to seek comments and possible concerns that need to be addressed during the EIA study. The material presented during the public participation meeting by ELARD can be found in Appendix D.

The number of attendees exceeded 90 persons including MPs and politicians, although due to the large number of attendees not everyone signed up the attendance sheet (Appendix E). The following affiliations were represented in the meeting:

Council for Development and Reconstruction	Ministry of Energy and Water
Directorate General of Antiquities (DGA)	Union of Municipalities of Bcharre
Municipality of Burj Hammoud	Union of municipalities of Al Metn

Municipality of Antelias	Governor of Mount Lebanon Qaemmaqam of El Metn
Municipality of Sin El Fil	Khoury Engineering and Contracting
Municipality of Biakout	Khoury Contracting Company
Municipality of Fanar	G.G. Engineering
Municipality of Mtayleb	D Beirut
Beirut and Mount Lebanon Water Establishment (BMLWE)	Saint Joseph School
Directory of General Urban Planning (DGU)	Syndicate of Fishermen
ELARD	The Associated Consulting Engineers (ACE)

Figure 3-3 Consultation Meeting

The meeting lasted for about two hours; the findings of the scoping phase were presented and a discussion session in which questions, comments and inquiries were received. **Table 3-1** summarizes the main comments raised by the participants as well as the answers provided during the meeting. These inputs will be taken into consideration during the EIA stage. The consultation meeting also included speeches from the Mayor of the Municipality of Burj Hammoud, the governor of Mount Lebanon, CDR Representative and a video was presented about the future development plans of the reclaimed area.

A second public consultation meeting will be held to review the findings of the EIA and the proposed Environmental Management Plan with the stakeholders.

Table 3-1 Consultation Meeting Comments and Responses

Comment	Response
What does the pre-treatment phase include?	Phase one of the WWTP includes mainly the removal of suspended solids and oils.
Why is there a wide time gap between the implementation of Phase 1 and 2?	The funding is currently only available for the pre-treatment phase (phase1). The proposed timeline for the operation of Phase 2 is slightly extended, whereas the design and tendering stages for the second phase will follow soon after phase 1.
The project is being assessed right now for environmental and social impacts, but the final plan for the treatment plant is not yet finalized.	The assessment is only for phase one for which the design is finalized. The objective is to ensure that while Phase 2 is being implemented and before it is operational, that possible negative impacts from Phase 1 are acceptable.
There were concerns about the separation of the storm water drainage system from the wastewater system.	CDR is currently building a network where wastewater is separated from storm water drainage. In addition, the capacity of the treatment plant of 227,500 m^3 is three times the expected amount of wastewater to be received at the treatment plant, so it should be able to handle overflows from rainwater. Additionally, based on the performance of Phase 1, the design of WWTP for Phase 2 can be modified accordingly for optimal performance. This is one major advantage of the staged implementation of the project.
There were concerns about the quality of the effluent discharged from the outfall pipes, and	During the EIA study, a wastewater discharge dispersion modelling study will be conducted to confirm compliance with the Barcelona

Comment	Response
whether it is compliant with the Barcelona convention	convention. If necessary for compliance, the study will make further recommendations for the improvement of the outfall and diffusers design.
There are concerns about the destination of the water from the primary and secondary treatment phase, will it end up in the sea?	The treated wastewater from primary and secondary treatment (Phase 2) will meet very stringent effluent standards. During the feasibility study and EIA (that will be launched in 2019 for a period of 40 weeks), options for the reuse of the treated wastewater will be considered, and if deemed feasible, will be adopted rather than discharging the treated effluent in the sea.
One concern raised is the fact that the sewage will be travelling long distances and will be sceptic; as such there could be odors generated near manholes and parts of the network; a suggestion was made to cover the current wastewater network pipes to avoid this impact.	The CDR agreed to consider this as part of the networks implementation.
What are the areas that will be covered by this wastewater treatment plant?	The WWTP is designed to cover eastern Beirut starting from Damascus road, parts of Baabda Caza, and Metn Caza up to 800 m from sea level.
What is the destination of the solid waste from the wastewater treatment plant?	For phase one, the amount of solid waste produced is very limited, and will be either reused or landfilled, as applicable. These details will be provided in the EIA study. The same applies for Phase 2 whereby waste management options will be analysed and preferred options identified for each waste stream.
There are concerns about the capacity of the treatment plant to serve future populations.	The plant's design horizon is till 2050.
It is important that sufficient financing for operation and maintenance is secured.	The secured construction funding for phase one also covers 2 years of operation and maintenance. For phase two, the government will negotiate further with lenders to increase the O&M period. BMLWE will take control of the project and its funding thereafter.

Comment	Response
How much is the cost of the phase one treatment plant?	The cost of the pre-treatment works amounts to 23 million Euros
Based on experience with the Al-Ghadir wastewater treatment plant, the smell from such facilities can be very unpleasant. There are concerns that this plant will be the same as the Al-Ghadir plant.	The main source of smell in the area near the Al-Ghadir plant is not from the plant itself but from sewage water discharged into the Al-Ghadir river which by-passes the treatment plant to end up in the sea.
In developed countries, where such facilities are built up to standards, they are built within the city, so there are concerns about the reason why the location of this treatment plant is far from residential areas.	There are two important things to consider when choosing the location for such a project: first, the availability of land, and second the cost of land. In this case this reclaimed land was assigned by the government to be used to host the treatment plant. It just happens to be far from residential areas, which is an additional environmental safeguard. The plant is equipped with the necessary odor control equipment to avoid odor nuisance to be generated.
It was noted that Antelias is not connected to the WWTP.	The Collector in Antelias area is not currently working, but should be rehabilitated and operational when the WWTP construction is complete.
Why haven't the project considered building smaller treatment plants in the basin rather than conveying such large volumes of wastewater to be treated at one location downstream?	This option would be very expensive as smaller treatment plants have higher costs per capita. This option would also lead to more requirements for monitoring and supervision at various locations rather than one location. It would also be challenging to find the necessary lands for various treatment plants in such a dense catchment area.
It is important to maintain and expand the fishermen's port in Daoura, because many families depend on it for their livelihood.	Noted
Will there be enough funds to repay the loans?	The project will reduce the costs of environmental degradation, and the consequent health impacts caused by the current activities of haphazard discharge of wastewater along the coast. The government's healthcare bill will be positively impacted by the project.

Comment	Response
There is a need to ensure that BMLWE has the resources and capacity to manage and operate the project later on.	The BMLWE has accumulated experience from managing the Al-Ghadir pre-treatment plant for 16 years. The project includes provision to train the BMLWE staff on the operation and maintenance of the plant.
What are the additional benefits of secondary treatment? Isn't pretreatment with discharge in a long outfall enough?	Phase one of the WWTP does not include biological treatment, only removal of suspended solids and oils. Phase two of the WWTP includes biological treatment, which is considered necessary for the improvement of the quality of seawater and for the conservation of the marine habitat. Nevertheless, the discharged pretreated wastewater will be sufficiently diluted (as demonstrated through modelling) to minimize negative impacts to the marine environment and surrounding areas.

3.2 EIA PHASE

The findings of the EIA will be disclosed to main the stakeholders, particularly the Mayor of Burj Hammound Municipality. The EIA public consultation report will be submitted to MoE once the consultation meeting is conducted.

4. DESCRIPTION OF PROPOSED PROJECT

4.1 PURPOSE AND OBJECTIVES

The wastewater sector in Lebanon suffers from chronic under-investment, combined with a weak institutional and governance structure and an insufficient tariff framework. Untreated wastewater is discharged either into rivers that lead to the Mediterranean Sea or directly into the sea, which can cause environmental harm and health hazards. Parts of the areas of northern Beirut, parts of Baabda, and the Metn district still have their wastewater systems under preparation, thus all the wastewater generated from these areas are haphazardly discharged into the sea without any treatment.

Therefore, the proposed Project to construct a WWTP at Daoura-Burj Hammoud is a crucial component within the overall Greater Beirut Northern Area Wastewater Project to reduce the negative effects of unsanitary disposal of wastewater. The operation of the Daoura-Burj-Hammoud WWTP will eventually reduce marine pollution, protect groundwater aquifers, improve the health conditions of the population directly and indirectly affected by wastewater pollution, and protect the environment and existing diverse ecosystems.

4.2 LOCATION

The proposed pretreatment headworks project as part of the Daoura-Burj Hammoud WWTP will be constructed on a reclaimed land in Burj Hammoud cadastral boundaries in the Metn Caza, in the Governorate of Mount Lebanon. The approximate coordinates of the proposed site are 33.902187 and 35.544602. The project's general location is shown in Figure 4-1 and Figure 4-2.

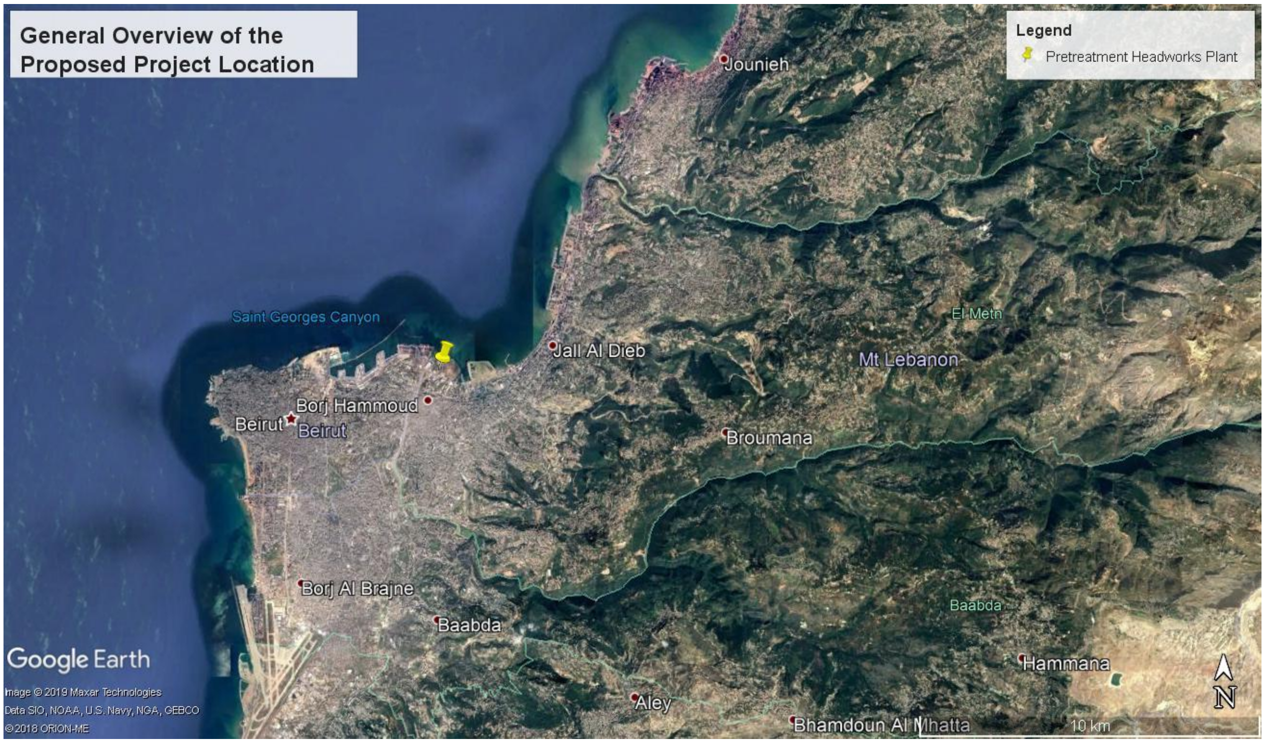


Figure 4-1 General Overview of Proposed Project Location

Figure 4-2 Aerial View of the Location of the Proposed Project Site

4.3 LAND AREA USED/BUILT UP AREA – LANDSCAPE PLANS/MAPS

The proposed pretreatment headworks plant will be constructed on a reclaimed land after the removal of the Burj Hammoud dumpsite, as shown in Figure 4-3, for which a CoM decision 1/2016 was issued in March 2016 (Appendix F2).

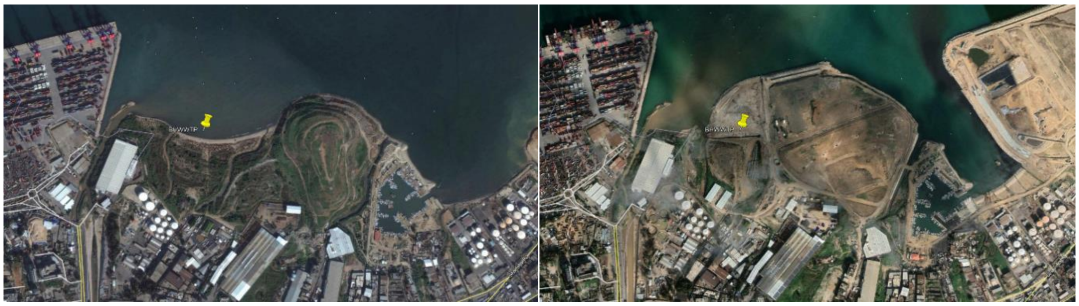


Figure 4-3 Proposed project area in 2015 (left) and 2018 (right)

As part of the Daoura-Burj Hammoud WWTP, the total area required for the construction of the complete WWTP (phase 1 and 2 combined) is 65,000 m^2, including an area of 19,000 m^2 for the pretreatment headworks plant and the remaining area will be used for the second phase treatment. The site location is shown in Figure 4-4 through aerial photographs. The blue section of the site will be the location of phase one (pre-treatment headworks plant), while the red section represents phase two of the project which expands from the edge of the pretreatment plant north till the sea boundary.

Figure 4-4 Aerial Photographs of the proposed site

4.4 COMPONENTS OF PROJECT

The Daoura-Burj Hammoud WWTP will be built over two phases with a planning horizon up to 2050, encompassing a pretreatment headworks plant (Phase 1) and a primary and secondary WWTP (Phase 2). The design of the two phases is based on the following:

- Phase 1: The design of this phase covers the current time (year 2020) where the dry weather peak flow is estimated to be equal to 3.65 m^3/s and the wet weather peak flow to be equal to 4.19m^3/s.
- Phase 2: This design phase covers the future years up to the year 2050, where the estimated dry weather peak flow is equal to 5.21 m^3/s and the wet weather peak flow to be equal to 5.99m^3/s. It's noteworthy to mention that all the facilities that will be built for Phase 1 of the proposed project will be utilized as well for Phase 2.

The data used for the design of the Daoura-Burj Hammoud WWTP was based on population data provided by MoEW as shown in Table 4-1.

Table 4-1 WWTP Design Data

Parameter	Year 2020	Year 2050
Population Equivalent	1,400,000	2,000,000
Flow	227,500 m^3/day	325,000 m^3/day
Dry weather peak flow	3.65 m^3/s	5.21 m^3/s
Wet weather peak flow	4.19m^3/s	5.99m^3/s

Based on the above the WWTP will be capable of treating wastewater generated from the northern sections of the city of Beirut, parts of the Baabda Caza, and the Metn Caza up to an elevation of 800 m asl as per the general master plan devised by MoEW (Figure 4-5). Around 85% of this area is currently covered with a sewage network.

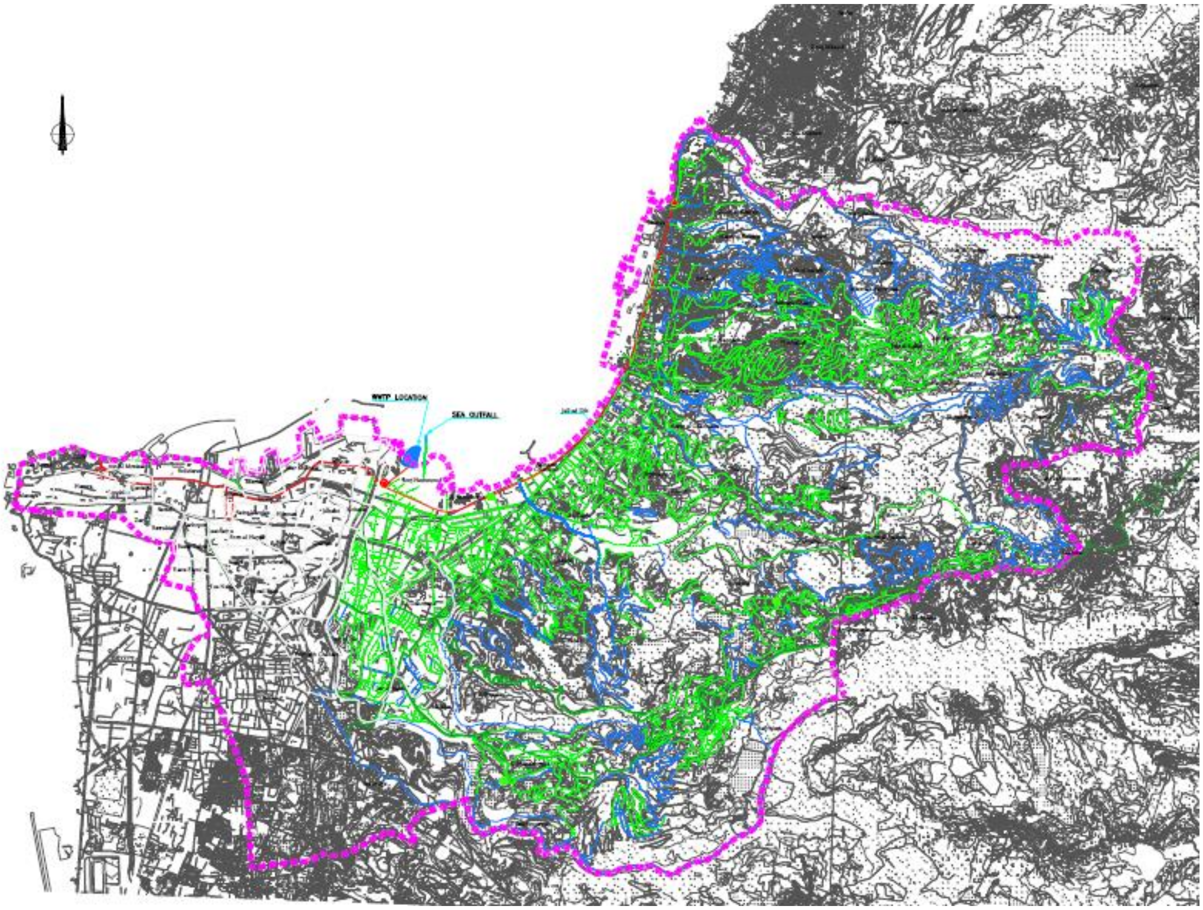


Figure 4-5 Coverage Area of the Daoura-Burj Hammoud WWTP

The coastal area contains a main North Metn wastewater collector originating from Dbaye along the seashore down to Bourj Hammoud and a sewer trunk like connecting Manara (Beirut) sewage collector to Beirut Central District and from Beirut Central District (BCD) to Bourj Hammoud WWTP. The main North Metn sewer collector discharges into pumping stations located in Antelias and at Baouchrieh along the route to the Bourj Hammoud WWTP. Whereas, the main North Beirut sewer collector originating from Manara area discharges into pumping stations located next to Ain-Mraiseh and Zaytouna Bay along the route to the Bourj Hammoud WWTP. The pumping stations have been built along with the collector in 2000. These two trunk lines are still not operational since their execution in awaiting the Bourj Hammoud WWTP construction and operation.

All the existing collectors from different areas are currently discharging wastewater flow into the sea. Moreover, the Northern Metn area, suburbs and parts of Beirut city form one drainage basin that ultimately discharges the sewage into the northern side of the Beirut River.

The existing pumping stations include PS-A2 located in Antelias-Jal el Dib, and PS-3 located in Phoenicia Street. Also, there are three lift stations: LS1-PR located next to Ain-Mraiseh, LS2-PR next to Zaytouna Bay, and LS/A3 situated in Baouchrieh. The latter sewage pumping and lifting stations have odor control units but require further maintenance for proper operation.

Appendix J2 shows the coverage area of the proposed WWTP along with the existing collectors completed and planned sewage networks. Table 4-2 below presents a list of all the administrative areas that will be connected to the Daoura-Burj Hammoud WWTP.

Table 4-2 Administrative areas to be connected to the Daoura-Burj Hammoud WWTP

Metn Caza							
1	Aamaret Chalhoub	16	Borj Hammoud	31	El Majzoub	46	Mazraat Yachouaa
2	Ain Aalaq	17	Bqinnaya	32	El Mansouriyet	47	Mezher
3	Ain Aar	18	Broummane (Partially)	33	El Mtaileb	48	Mkalles
4	Ain Saade	19	Bsalim	34	En Naqqach	49	Mzakke
5	Antelias	20	Chouaya (Partially)	35	Ez Zalqa	50	Nabay
6	Aoukar	21	Dahr el Hossein	36	Haret el Bellane	51	Qannabe
7	Baabdat (Partially)	22	Dbaiye	37	Haret el Ghaouarni	52	Qomet el Hamra (Partially)
8	Beit Chabab (Partially)	23	Dik el Mehdi	38	Hbous	53	Qornet CChahouane
9	Beit ech Chaar	24	Ech Chaouie (Partially)	39	Jall ed Dib	54	Roumie
10	Beit el Kekko	25	Ed Daichouniye	40	Jdaide	55	Saqiet El Misk
11	Beit Meri	26	Ed Dekouane	41	Jisr el Bacha	56	Sinn el Fil
12	Bell Vue	27	El Aatchane	42	Jouret el Ballout	57	Tamich
13	Bhersaf	28	El Baouchriye	43	Mar Aabda	58	Zakrit
14	Biaqout	29	El Fanar	44	Mar Chaaya	59	Zouq el Kharab
15	Bikfaya (Partially)	30	El Fraike (Partially)	45	Mazraat El Hdaira		

Beirut					
1	Achrafieh	16	Hopital Orthodox	31	Mina El Hosn
2	Adlieh	17	Hotel Dieu	32	Nasra
3	Ain El Mreisseh	18	Jeitawi	33	Qoreitem (Partially)
4	Amlieh	19	Jemeizeh	34	Ras Beirut
5	AUB	20	Jisr	35	Ras Nabaa
6	Bachoura	21	Jounblat	36	Rmeil
7	Basta Faouka	22	Kantari	37	Saint Nicolas
8	Basta Tahta	23	Khodr	38	Sanayeh (Partially)
9	Batrakieh	24	Kobeiat	39	Serail
10	Bourj Abouhaidar (Partailly)	25	Manara	40	Sioufi
11	Corniche El Nahr	26	Mar Maroun	41	Snoubra (Partially)
12	Forn el Hayek	27	Mar Mikhael	42	Solidere
13	Ghabeh	28	Mar Mitr	43	Yassoueiya
14	Hamra	29	Marfaa	44	Zarif (Partially)
15	Hikmat	30	Mazraa (Partially)	45	Horch Beirut (Partially)

Baabda Caza					
1	Aaraya	4	El Louaize	7	Hadath (Partially)
2	Baabda (Partiallly)	5	Forn Echbakk	8	Hazmiyeh
3	Chiyah	6	Ghobeiri (Partially)	9	Yarze (Partially)

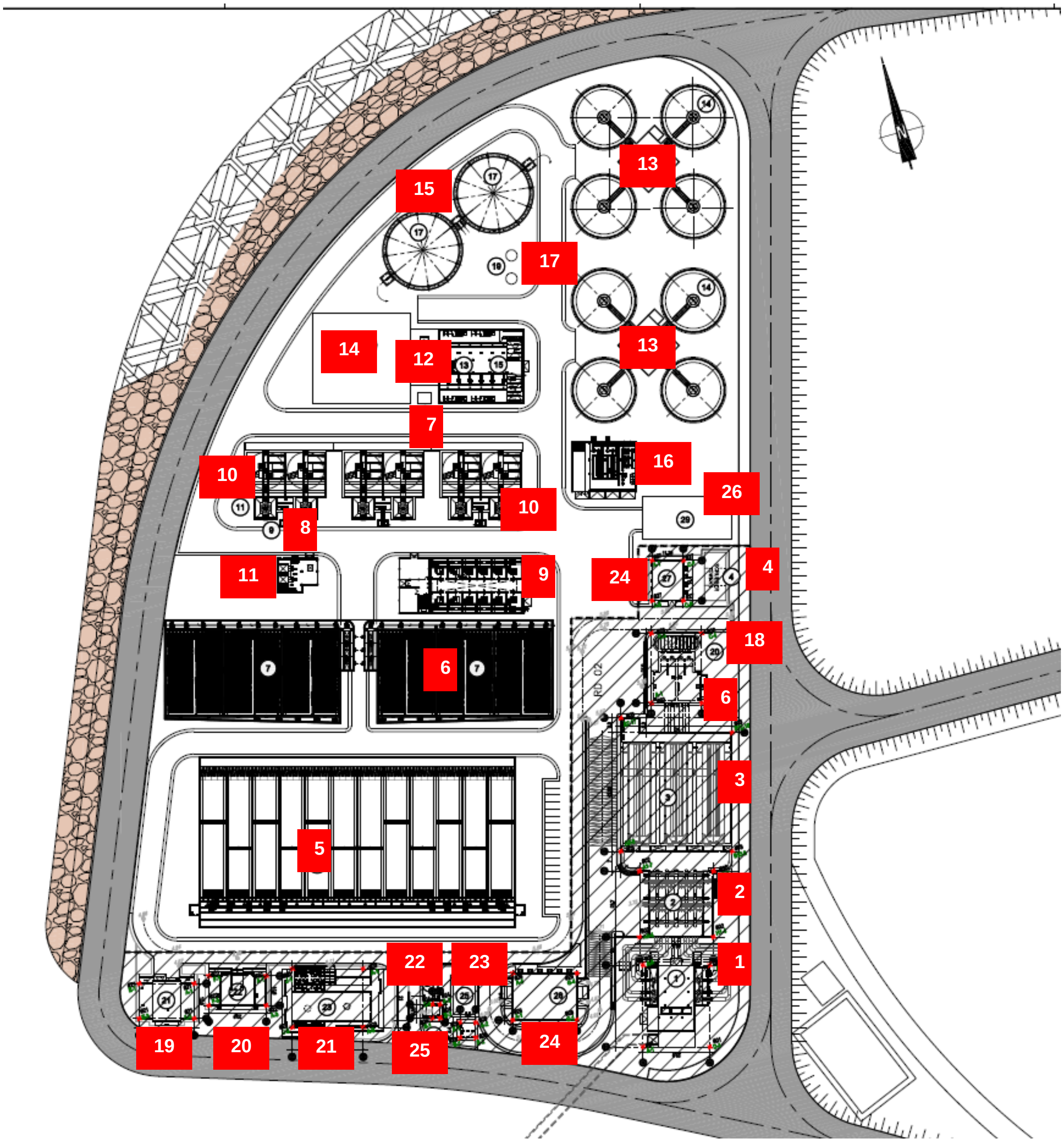
A summary of the headworks staging of the civil construction and equipment for the two phases is presented in Table 4-3.

The general layout of the Daoura-Burj Hammoud WWTP plant is shown in Figure 4-6 and Appendix J1.

Table 4-3 Civil construction and Installed Equipment for phases one and two

	Civil Construction		**Installed Equipment**	
	Phase One	Phase Two	Phase One	Phase Two
Inlet Pumping Station a. Inlet Screens (50mm) b. Submersible Pumps ($Q=1.5\ m^3/s$, Head= 18m) c. Electromagnetic Flow meters	Full	-	 3 4 4	 - 2 2
Coarse Screens a. Screens (15mm) b. Gates	Full: 2 floor Screens Building	-	 5 5	 1 1
Fine Screens a. Screens (6mm) b. Gates		-	 5 5	 1 1
Grit and Grease Removal Tanks	Full- 6 Tanks	-	4	2
Air Blowers for Grit and Grease Removal	-	-	3	1
Effluent Pumping Station Submersible Pumps ($Q=2\ m^3/s$, Head= 13m)	Full	-	4	-
Substation No. 1 a. Transformers b. Generators	Full	-	 3 4	 3 -
Substation No. 2 (needed for the effluent pumping station) Transformers	Full	-	2	2
Overflow Structure	Full	-	Full	-
Non-Process Buildings (Administrative+ Laboratory+ Workshop..)	Full	-	-	-
Odor Control Building	Full	-	3	-

	Civil Construction		Installed Equipment	
Scrubbers capacity of 30,000 m3/hr.				
Connection of effluent pipe from the effluent P.S. to Existing Sea Outfalls	Full	-	Full	-



Annotation	Description	Annotation	Description
1	Inlet pumping station	**14**	Sludge Dryer (optional)
2	Screening	**15**	Biogas Storage Tanks
3	Grit and grease removal tanks	**16**	Biogas Cogeneration Plant
4	Odor control scrubbers	**17**	Flares
5	Primary Sedimentation Tanks	**18**	Effluent pumping station
6	MBBR Reactors	**19**	Workshop
7	Odor Control Unit	**20**	Laboratory building

Annotation	Description	Annotation	Description
8	Waste Sludge Pumping Station	**21**	Administration building
9	Aeration Blower Station	**22**	Guard house
10	Dense Sludge Pumping Station	**23**	Diesel tanks
11	Chemicals Building	**24**	Substation
12	Sludge thickening and Dewatering Building	**25**	Water tank and pump room
13	Digester and Digesters service Building	**26**	Chlorination Building (Optional)

Figure 4-6 Daoura-Burj Hammoud Wastewater Treatment Plant Layout

4.4.1 Phase One

The final design of the proposed pretreatment headworks plant was issued in February 2019 and will be capable of handling 227,500 m^3 of wastewater per day.

The pretreatment headworks plant is planned to be constructed during phase one and is planned to include the process components and facilities listed below which are further detailed in the following subsections:

- Inlet screens;
- Inlet pumping station;
- Coarse screens;
- Fine screens;
- Aerated grit and grease removal tanks;
- Effluent pumping stations and outfall pipes; and
- Odor control unit.

4.4.1.1 Inlet pumping station coarse screens

The inlet pumping station coarse screens are used to protect equipment in the wastewater treatment plant from damage or clogging caused by large objects. The screen channel's design controls the velocity in a manner that does not allow for major depositing of solids at its bottom and does not allow to drag along solids through the screens openings.

Based on the peak flow rate for phase 2 (2050), which is 5.99 m^3/s, the number and width of the channels was determined. For phase 1, three screen channels, including one standby, shall be fully equipped with 50mm openings.

4.4.1.2 Inlet pumping station

The inlet pumping station to be constructed is designed for the 2 phases of the proposed project simultaneously whereby all the civil works will be executed during phase 1.

For phase 1, the wet weather peak flow rate of wastewater is equal to 4.19 m^3/s thus requiring the deployment of 3 duty pumps and 1 standby pump. Each pump will have a flow rate of 1.5m^3/s. The latter 4 pumps will be installed in a 125 m^2 wet well.

In addition, the pumping station building structure will be equipped with wastewater level sensors, an efficient ventilation system, an H_2S detection system with an alarm, and it will be connected to an odor control unit. Figure 4-7 below shows a schematic diagram of the proposed inlet pumping station.

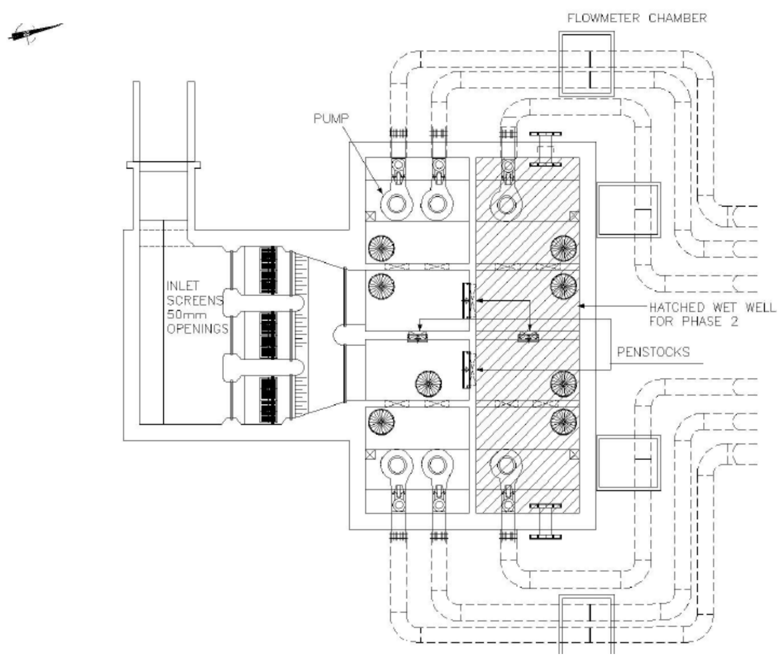


Figure 4-7 Inlet pumping station

4.4.1.3 Coarse screens

The size and number of screens and corresponding channels is based on the wet weather peak flow rate for phase 1 which is estimated at 4.19 m^3/s. Thus, four (4) main duty coarse screens and one (1) additional standby screen with 15 mm openings will be electro-mechanically equipped for phase 1 of the project.

4.4.1.4 Fine screens

Following the coarse screens the wastewater will be conveyed to a finer screening stage whereby 4 main duty fine screens and an additional screen on standby will be installed with 6 mm openings. The collected screening waste from both the coarse and fine screens will be automatically removed to a lower floor in the screens' building structure where they will be washed, dewatered, and then collected in containers for landfilling at the nearest facility.

4.4.1.5 Aerated grit and grease removal tanks

After the 2 stage-screens, the wastewater flow will be conveyed to the grit and grease removal tanks through submersible openings. The latter tanks will be aerated in order to facilitate the separation of the grease and grit from the organic solids that are present in the wastewater inflow. Four grit and grease removal channels shall be used for the first phase of the project, each being 36 m long, 5.8 m wide, having a maximum depth of 5.6 m, and having a volume of 479.5 m3.

Figure 4-8 shows a cross-sectional view of the grit and grease removal tanks.

The estimated quantities of sand and grit that will be removed during the first phase of the project is 103 m^3/day. The collected material will be washed then dewatered, and shall be classified for reuse or disposal based on its characteristics. Grease in the wastewater will be removed using surface scrappers, and the collected scum will be sent for disposal in the nearest landfill.

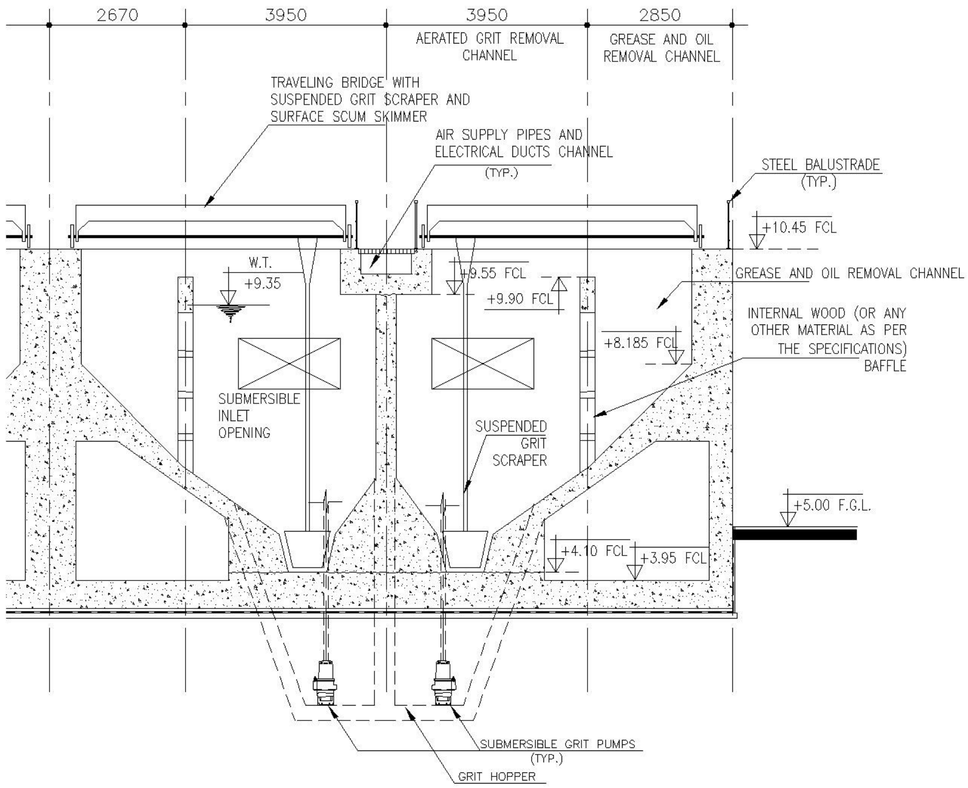


Figure 4-8 Cross section of the grit and grease removal aerated tanks

4.4.1.6 Effluent pumping stations

The effluent from the grit and grease removal tanks shall be conveyed by gravity to effluent pumping station which will eventually discharge the wastewater to the sea outfalls. For the design of phase 1 of the WWTP, the option of discharging the effluent by gravity into the existing sea outfall can be adopted based on design calculations conducted as long as the wet weather peak flow rate does not exceed 5.2 m^3/sec. However, phase 2 of the WWTP will require the installation of pumps in order to convey the wastewater from the pretreatment plant to the secondary treatment facilities.

For phase 1 of the proposed project, the pumping station will be connected to the odor control system and will be equipped with an H_2S detection system with an alarm system for safety purposes.

4.4.1.7 Sea Outfall

Two existing sea outfall pipes (Figure 4-9) are intended to be used for the effluent discharge following the pretreatment stage. The main outfall pipe has a diameter of 1700mm a length of

1,777m, and is around 61.5 m below sea level, while the emergency overflow pipe has a diameter of 2000mm, a length of 620 m, and is around 7.75 m below sea level. The two outfall pipes are made of steel and are protected by a reinforced concrete layer of 210mm and 270mm thickness, respectively.

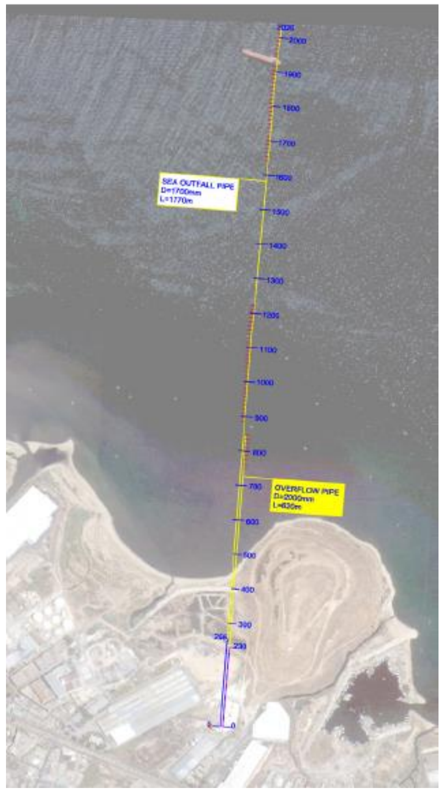


Figure 4-9 Existing Sea Outfalls

The main outfall pipe is equipped with 36 diffusers at its end section, which extends over a length of 350 m and are spaced 10 meters apart from center to center. The internal diameter of the diffusers is approximately 223 mm. The diffusers installed have alternating directions where half are oriented towards the east and the other half are oriented towards the west. It is important to note that the existing sea outfall diffusers extend in the sea beyond the influence of the Beirut harbor.

On the other hand, the emergency overflow pipe is equipped with 26 diffusers at its end section, extending over a length of 125 m, where they are spaced at 5 m apart from center to center. The internal diameter of the diffusers in approximately 407 mm, and were also installed in alternating directions with half of which oriented towards the east and the other half oriented towards the west.

Rehabilitation works for the two pipes should be implemented prior to the commencement of the pretreatment headworks plant construction works as per the report prepared by EDTO, which undertook a study on the conditions of these pipelines as per CDR's request. The recommended actions as per the rehabilitation report by EDTO mainly include the following:

1. Conducting additional investigations through dredging activities in the navigation channel, and using a remotely-operated vehicle (ROV) for surveying purposes after cleaning the debris and sediments form the pipes.

2. Undertaking pipes repair activities including cathodic protection, installation of missing diffusers, temporary closing of diffusers with plates, concrete repair, and protecting the diffusers on the overflow pipe.

4.4.1.8 Odor Control Unit

The odor control unit of the pretreatment plant will be generally based on the process of oxidation/scrubbing (vertical, counter-current, and multiple stage type) to destroy odors by conversion of malodorous contaminants to non-objectionable stable compounds with a removal rate greater than 98%. Sulfuric acid (H_2SO_4), caustic soda (NaOH) and sodium hypochlorite (NaOCl) solutions shall be used for the scrubbing process.

Prior to treatment, the air is estimated to contain a concentration of 25 ppm of H_2S on average, however after treatment this concentration is estimated to be less than 0.2 ppm.

A minimum of 10 air exchanges per hour shall be achieved for areas that are expected to have high odor release including the pumping station, screen area, and grit handling areas, and a minimum of 5 exchanges per hour for non-critical building area like the control room.

4.4.1.9 Other Equipment and Utilities

For phase one, it is estimated that the total electrical demand load will be 4,915 KVA. The electric substations of the pretreatment headworks plant will include 5 transformers, 1250 KVA each. In addition, 4 generators with a capacity of 1600 KVA each, have been allocated to feed the pretreatment area. A spare location for a future generator has been also considered if needed.

In addition, the following non-process buildings will also be included in the proposed project:

- Administrative building;
- Laboratory;
- Workshop;
- Electrical Substations;

- Guardhouse;
- Water tank and pump room; and
- Underground diesel tanks.

4.4.2 *Phase Two*

4.4.2.1 Primary Treatment

The proposed wastewater primary treatment system shall include 12 rectangular conventional primary sedimentation tanks having the following dimensions: each

- Length: 50 m
- Width: 9 m
- Depth: 4 m

The resulting hydraulic residence time will be 1.6 hours. The tanks will also have include settled sludge collection system including travelling bridge scrapers or chain scrapers, hoppers at the inlet, sludge pumps, and floating scum pump collection system. The use of the proposed primary conventional sedimentation tanks is robust, well-established and does not require any major operation skills.

The expected pollutant removal efficiency during the primary treatment stage is presented in Table 4-4.

Table 4-4 Pollutant removal efficiency from primary treatment

Parameter	Removal Efficiency
COD	30 %
BOD	30 %
Suspended Solids	50 %
Total Nitrogen	10 %
Total Phosphorous	10 %

4.4.2.2 Secondary Treatment

The proposed secondary treatment technology is the Moving Bed Biological Reactors (MBBR) which was found to be the most suitable technology at the Daoura-Burj Hammoud Wastewater Treatment Plant. This was based on the sufficient available area to include both the MBBR tanks and the conventional primary sedimentation tanks.

The secondary treatment stage shall include:

- 6 MBBR tanks, each being 30 m long, 20 m wide, and having a depth of 6.95 m. The capacity of each is 6,250 m3. The MBBRs shall also include biofilm plastic carriers which will cover 56-70% of the volume of the tank depending on the required capacity.
- Media Screens to prevent media from exiting the MBBR tanks.
- Aeration system
- 6 dense sludge clarifiers having a total surface area of 1,700 m^2 including tube settler clarification, and mixing-coagulation chambers.
- Chemical dosing system and waste sludge pumping station might be added.

4.4.2.3 Sludge Treatment

The sludge treatment process shall include the following stages:

- Thickening:
  Primary and waste activated sludge (WAS) will be mechanically thickened by 5 centrifuges to achieve approximately 5% dry solids content. The thin sludge is then stored in a sludge buffer tank having a capacity of 1,200 m^3 for a minimum of 5 hours.

- Anaerobic digestion:
  Surplus activated sludge will be digested in 8 anaerobic digesters, each unit having a capacity of 5,900 m^3. The digesters will be equipped with mechanical or gas mixing systems as well as heat exchangers to maintain a temperature between 35-38 ^oC.

- Combined Heat and Power (CHP) Plant:
  The biogas generated from the anaerobic digestion processes will be transferred to two biogas engines (1.2 MW) to produce electrical and thermal energy to ensure 24/7 operation of the WWTP. The electrical energy produced shall cover part of the electrical power needs of the WWTP and the thermal energy shall be used for the heating of the anaerobic digesters.

- Sludge Dewatering:
  The dewatering facility will include five duty and one stand-by centrifuge units with 30 m^3/h capacity each for 16 hours operation per day. Each centrifuge will be fed by a 30 m3/h positive displacement pump. The digested sludge will be dewatered by centrifuges to a solids content of approximately 22-24%.
  An 800 m^3 buffer tank will be constructed for the equalization and storage of digested sludge. The sludge dewatering process will also be equipped with all the necessary equipment needed such polymer preparation and storage units and wash pumps.

4.4.2.4 Odor Control from Sludge Treatment

The engineering firm responsible for the conceptual design of the WWTP recommends that all sludge treatment facilities to be covered in order to contain any odors as a first barrier to control the generation of odors.

Units involved in sludge treatment will be ventilated by introducing fresh air via centrifugal ventilators installed on the side walls, and the foul air shall be extracted by fans to an odor control unit (OCU) for treatment and final release through the stack. Since H_2S concentrations are expected to be low, and relatively high organic sulfide and possibly ammonia and amine concentrations are common in sludge processing units, a bio-scrubber OCU is proposed with a capacity of 90,000 m^3/hr (with 10+ air exchanges per hour).

Natural ventilation shall be preferred over mechanical/electrical ventilation of the sludge storage tanks to reduce any explosion risks since methane is released from the anaerobically digested sludge during storage. Using natural ventilation, the air shall enter or exit the tanks according to the lowering and rising of the sludge level and the exhaust air can be treated using biofilters.

Considering a foul air flow of 1,000 m^3/hr (corresponding to the hourly peak expected sludge flow rate into the sludge holding tanks), and a filter loading rate of 50 m^3/m2/hr, the resulting bed surface area of the biofilter is 20 m^2.

Thermal Hydrolysis Process (THP) and thermal sludge drying could be considered in the future, but only following a detailed analysis of the prevailing conditions and based on sludge disposal options available.

4.5 CONSTRUCTION PHASE

It is expected that the construction works for Phase 1 will require 28 months, while the construction of Phase 2 of the project will require 24 months.

The pretreatment headworks will be the main focus of the Construction phase description, considering that the second phase design and components are not yet fully finalized.

4.5.1 Description of Activities

Construction activities for Phase 1 of the WWTP will the full execution of the civil works required up to the year 2050 and the installation only of the electro-mechanical equipment of the pretreatment headworks required for the Phase 1.

The construction phase will consist of the following main activities:

- Soil Improvement, subsurface and geotechnical investigations;

- Preparation works, including sheet piling, dewatering;
- Earthworks including excavation, backfilling and sub-grade preparation;
- Concrete, architectural, electro-mechanical works for buildings;
- External networks and infrastructures;
- Roads and walkways; and
- Other ancillary and associated works.

As for the rehabilitation works of the two existing sea outfalls, the works will mainly include the following:

- Dredging a limited area to expose both pipes ends;
- Removal of pipes end plates;
- Heavy and large debris removal including provisional use of ROV (Remotely Operated Underwater Vehicle) with a manipulated arm of suitable horsepower;
- ROV Survey of the interior of pipes;
- Reinstatement and installation of pipes end plates at inlets and outlets;
- Cathodic Protection including installation of anodes;
- Installation of missing or damaged diffusers; and
- Provisional concrete repairs including reinforcing steel cleaning, repair and anchoring of new steel.

With regards to Phase 2 of the WWTP the construction activities will include construction of primary and secondary wastewater treatment structures, sludge treatment building and storage tanks, biogas holders, CHP, related odor control units, optional structures for disinfection and sludge drying. The above works shall be accompanied by all necessary support facilities.

4.5.2 Equipment, Machinery, Raw Material and Labor Requirements

The main equipment and machinery that will be deployed on site for the construction phase include excavators, dewatering equipment, soil improvement and shoring equipment, piling equipment, cranes and related lifting equipment. The construction phase will also entail the deployment of power supply machinery and generators (mobile and portable ones).

Regarding the primary raw materials that will be used for construction they include concrete, steel, pipes (DI, HDPE, UPVC, SS, GRP), waterproofing material, finishing material, aggregate base material, coating material, cladding layers, as well as aluminum, stainless steel, and steel structures.

Preliminary information provided by the pretreatment headworks plant design firm estimated that the total number of workers who will employed during the construction phase will range between 60 to 70 workers.

4.5.3 Manpower, Transportation and Security

Preliminary information provided by the pretreatment headworks plant design firm estimated that the total number of workers who will be employed during the construction phase will range between 60 to 70 workers. For Phase Two of the project the number of worker needed in not yet determined.

The Contractor shall provide all necessary temporary sheds, offices, mess halls, sanitary facilities, accommodation and other temporary facilities required for his and subcontractors use. The locations are to be decided on site in compliance with local laws and ordinances. Accommodations shall be provided for 20 workers as well.

4.5.4 Energy Consumption and Power Supply

The project proponent will apply to the Electricité du Liban (EDL) to connect to the grid during the construction phase. Electricity will also be supplied by a backup generator during electricity blackouts. The capacity of the generators is estimated to range between 150-250 KVA.

4.5.5 Water Supply

The Contractor shall provide clean fresh water during the construction phase and make temporary arrangements for storing and distributing water on site. The source of fresh water is via the public supply network and by water cisterns.

During the construction phase, ready mix concrete will be used and as such water will not be required for onsite concrete mixing. Therefore, water will only be needed for domestic use by workers, wetting dusty areas and curing activities. Domestic water consumption by workers is estimated at a maximal rate of 160 l/c/d (MoE, 2010), which is a conservative estimate if workers will reside on site during construction works.

4.5.6 Wastewater Generation

The daily domestic wastewater generation per capita as per MoE Decision 3/1 is 120 L/day, considering approximately an 80% wastewater generation rate out of the domestic water volume consumed (around 120 L/c/d as a conservative estimate). The generated wastewater will have to be discharged into an onsite septic tank to be emptied regularly and discharged into the nearest network (not on site).

4.5.7 Solid Waste

Solid Waste expected to be generated during the construction phase can be divided into two (2) categories:

- General construction waste; and
- Domestic waste.

Construction waste mainly includes excavated soil, concrete and foam works; and remains of piping. Approximately 20,000 m^3 of soil will be excavated for the construction pretreatment headworks plant. Part of the excavated material that is free from debris, stones, and other loose material can be re-used for backfilling, while the remaining quantity and the construction waste will be disposed of in a Construction and Demolition Waste (CDW) dumpsite approved by MoE in coordination with the Municipality. No waste will be left on-site during or after the completion of construction works.

The estimated domestic waste generation in urban areas is 0.95-1.2 kg/c/d (SWEEP-NET, 2014). Domestic waste will be collected by the hired company responsible for solid waste collection in Burj Hammoud.

4.5.8 Construction Cost Estimates

Construction cost estimates of the pretreatment headworks plant is around 23 million Euros. The construction cost of the primary and secondary treatment plant is around 200 million Euros.

4.6 OPERATION PHASE

The operation phase is expected to start within 28 months from the commencement of construction works for the pretreatment headworks. Following the construction of the preliminary treatment headworks, and once the funding has been provided, the second phase construction work will start, and will take around 24 months for the plant to become operational.

4.6.1 Energy Consumption and Power Supply

The project proponent is connected to the Electricité du Liban (EDL) grid, which will be used during the operation phase. Electricity will also be supplied by 4 generators with a capacity of 1600 KVA each. The generators operate on diesel fuel which is stored in two underground steel tanks with a capacity of 70,000 liters each. The tanks will be placed in a concrete sand-filled pit lined with a diesel resistant layer and water proofing layers.

During the operation of Phase Two of the WWTP the pumping station and secondary treatment process of MBBR are predicted to consume the most electricity.

4.6.2 Water Consumption

Water consumption during the operation phase of the project will be limited to domestic use by the workers and for cleaning purposes of the facility.

4.6.3 Wastewater Generation

Wastewater generation usually constitutes between 70% and 90% of water use, and will be generated from the administration building. Based on wastewater production of 75 liters/capita/day from staff working on industrial sites (Metcalf & Eddy, 2004), and given that the facility will have 10 employees during Phase One it is estimated that the facility will be generating an average around 750 liters of wastewater per day. Additional wastewater will be generated from the plant from cleaning activities as well.

This produced wastewater from the plant will be diverted to the pretreatment plant along with the rest of the sewage received from the network by the plant. The treated wastewater will be discharged to the sea through the main outfall pipe.

4.6.4 Solid Waste

The majority of waste generated from the pretreatment headworks plant will be from pretreatment processes, namely the debris and material trapped by the coarse and fine screens, grit, and grease. The estimated annual screenings waste that will be collected is between 7,000-21,000 m^3. As for the estimated quantities of sand and grit that will be removed from the plant is 37,621 m^3/day. Waste generated from the pretreatment plant will be disposed of in the Burj Hammoud-Jdeideh Landfill.

In addition, domestic waste generated by the workers will largely include organic food waste and common office waste such as paper and cardboard waste, which will also be disposed of in the Burj Hammoud-Jdeideh Landfill.

The waste generated from the primary and secondary treatment plant will be namely the sludge, which will be treated and dewatered onsite. Then the dewatered sludge will be collected in storage tanks then sent to the nearest landfilling facility. The estimated quantity of sludge generation is expected to be around 82.55 tons of dry solids/day on average.

5. ENVIRONMENTAL AND SOCIAL BASELINE

5.1 INTRODUCTION

This chapter establishes the baseline environmental conditions within the designated Study Area. Environmental conditions considered mainly cover the physical and biological environments, as well as the socio-economic and cultural contexts.

For this purpose, existing documents were collected, reviewed and analyzed 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, a dilution modeling and consultation meetings with officials and local community representatives.

5.2 PHYSICAL ENVIRONMENT

5.2.1 Site Description

The proposed project is located on an undeveloped land between the Mediterranean Sea (north) and the Daoura-Burj Hammoud industrial area (south) on maritime public property that was reclaimed after the removal of the Burj Hammoud landfill.

The industrial area south of the proposed site location includes several industrial facilities as well as a tank farm for the storage of petroleum products located 120 m southwest from the western boundary of the pretreatment plant. From the west, the Coral Composting facility and the Port of Beirut are located, as well as the Beirut River is distant by 335 m. On the other hand, the reclaimed land gained after the removal of the Burj Hammoud dumpsite east of the proposed project site will host future development projects by the Municipality of Burj Hammoud. The pictures presented Figure 5-1 in portray some of the nearby receptors of the pretreatment headworks plant.

Beirut River and Beirut Port

Future Development Area

Tank Farm

Figure 5-1 Surrounding Receptors to the Pretreatment Headworks Plant

Figure 5-2 shows the major sensitive receptors surrounding the pretreatment headworks project site which also include the following:

- Fishermen's port distant 737 m southeast
- Residential area 940 m south; and a
- Wheat mill 803 m southeast

Figure 5-2 Proposed Project and its Surroundings

5.2.2 Atmospheric Environment

The proposed project area is located in a region that is classified with a typical Mediterranean climate, where the rainy season falls between October and April. Onshore Southwest winds from the adjacent Mediterranean Sea affects the area most of the year.

The meteorological data were retrieved from the Central Administration of Statistics official website (www.cas.gov.lb) and were recorded at the Beirut International Airport station (33.822714, 35.495628).

5.2.2.1 Temperature

The study area is characterized by hot dry summer and relatively mild wet winter. Average minimal and maximal temperatures recorded between January 2017 and December 2018 are represented in Figure 5-3. Monthly temperatures ranged between a minimum of 10.2°C in February 2017, and a maximum of 31°C in August 2017.

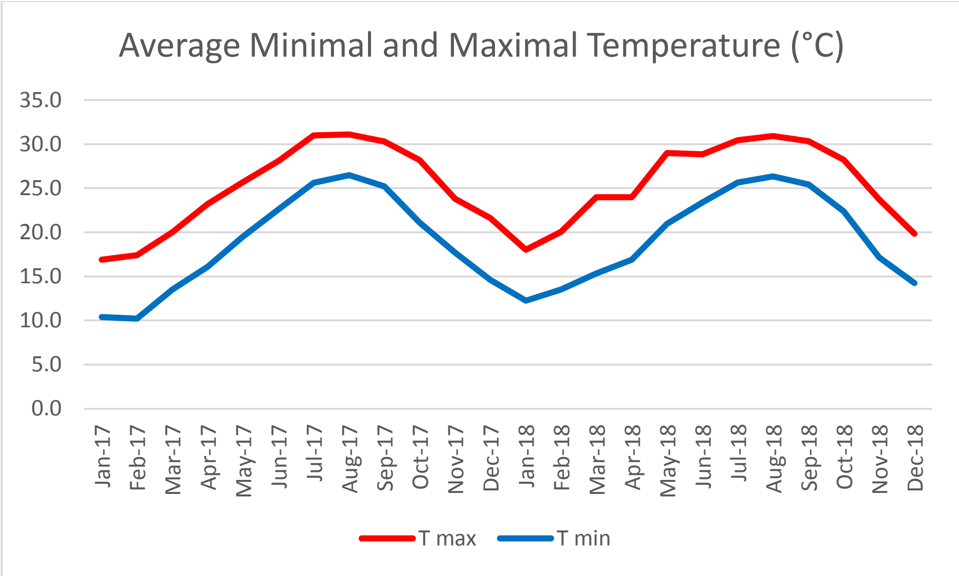


Figure 5-3 Average Maximum and Minimum Temperatures at Beirut Airport Weather Station (Jan-17, Dec-18)
Source: Cas.gov.lb

5.2.2.2 Precipitation

Precipitation Levels are shown in Figure 5-4. Monthly precipitation levels range between a maximum of 232.6 mm in December 2018 and totally dry months in July, August, and September of 2017 and 2018, respectively.

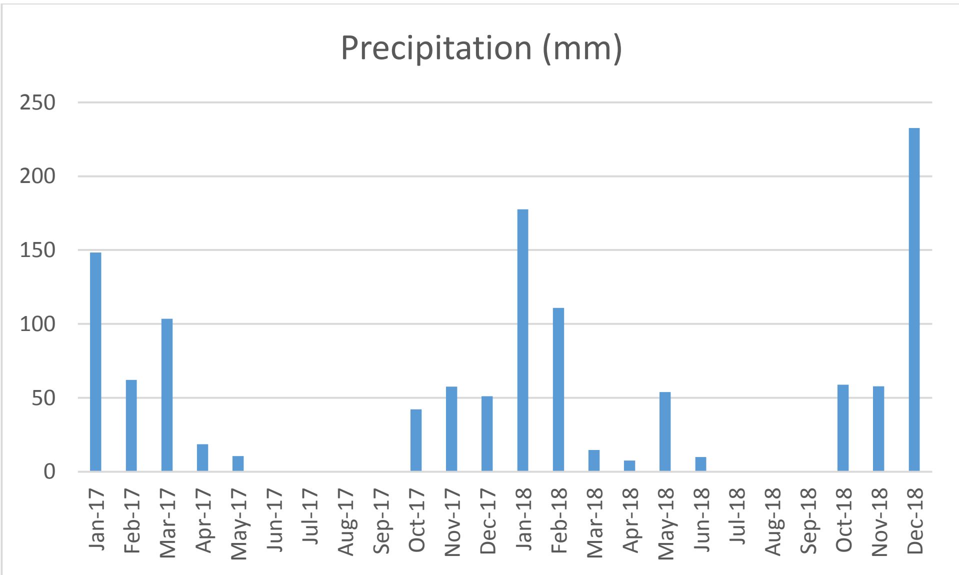


Figure 5-4 Monthly precipitation levels recorded at Beirut Airport Weather Station (Jan-17, Dec-18)

Source: Cas.gov.lb

5.2.2.3 Wind

The maximum recorded wind power in the area of Beirut for the year of 2017 is 11.7 m/second which was recorded in January 2017 as shown in Figure 5-5. The wind is mainly originating from the Southwest and Northeast directions according to the data taken from the Wind Atlas of Lebanon (Figure 5-6)

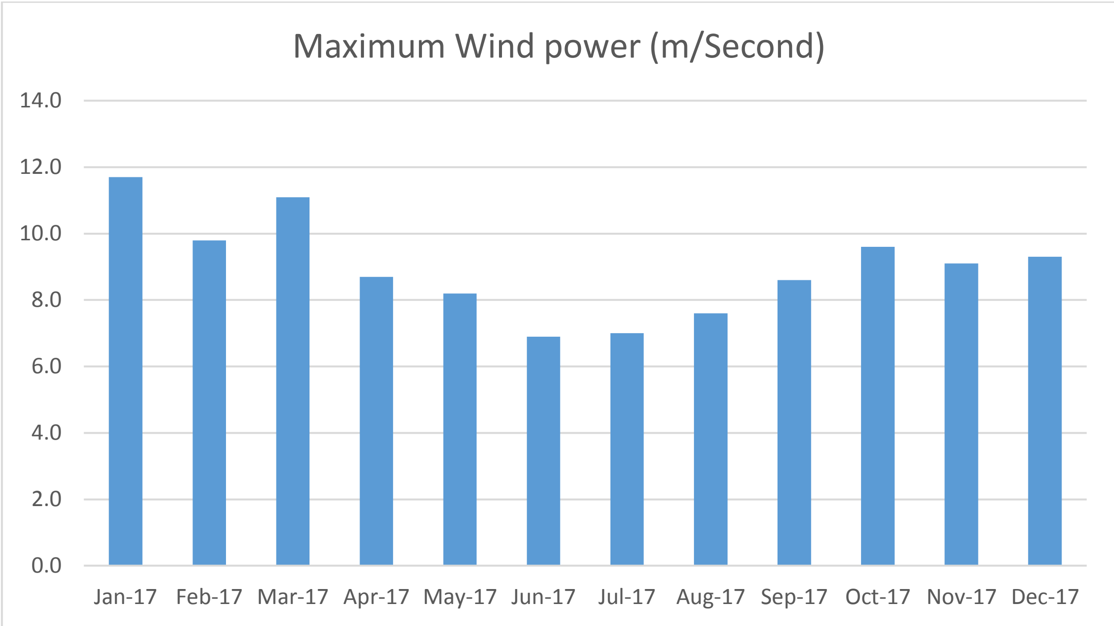


Figure 5-5 Maximum Wind power in the Study Area
Source: Cas.gov.lb

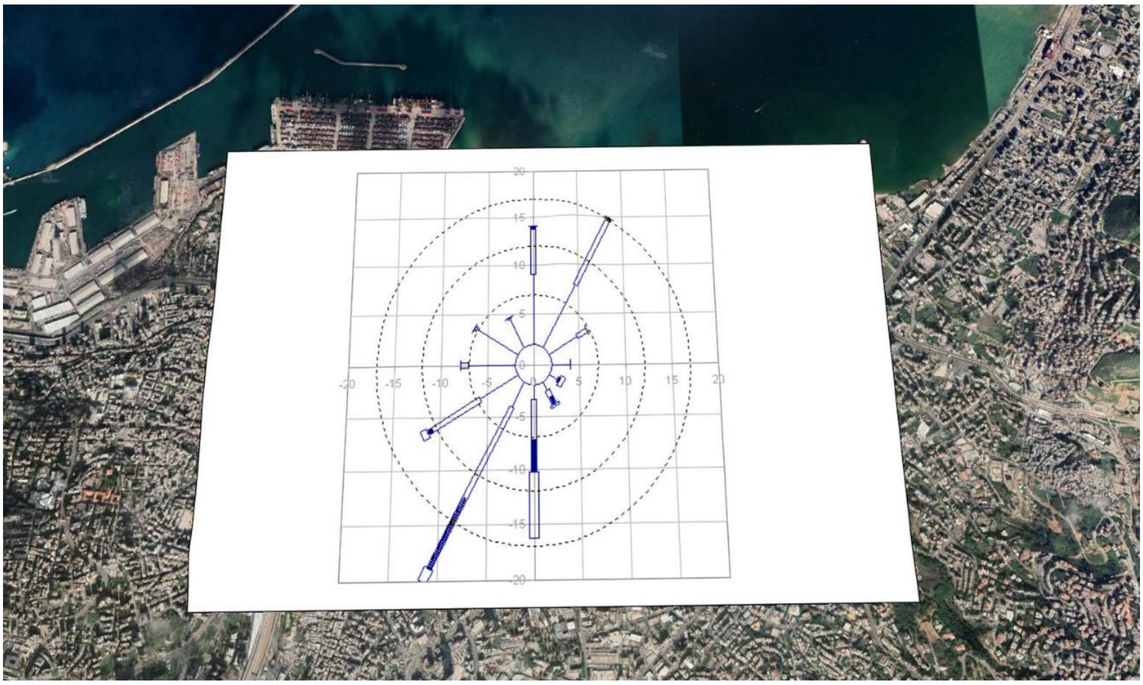


Figure 5-6 Wind Rose for the Project site
(Source: UNDP/CEDRO, 2011)

5.2.3 Acoustic Environment

Noise measurements were recorded using the noise meter Cirrus CR: 800C (Figure 5-7). The Cirrus CR: 800C complies with the latest IEC standards and American National Standards Institute (ANSI) standards. It was factory-calibrated in January 2018. The Noise meter was calibrated before and after each set of measurements according to the manufacturer's guidelines.

The noise metric L90 was used to characterize the baseline noise as it is thought to be more representative of existing conditions than the equivalent sound level or Leq because of the nature of the noise. The L90 is the measured sound pressure level (in A-weighted decibels or dBA) that is exceeded 90 percent of the time during a monitoring event. High noise events, such as a large transport truck passing nearby, or a dog barking near the microphone, tend to be excluded in the L90 metric. The noise metric L90 is generally considered to be representing the background or ambient level of a noise environment. The L10 is the measured sound pressure level (in A-weighted decibels or dBA) that is exceeded 10 percent of the time during a monitoring event.

Figure 5-7 Sound Level Meter and Outdoor Measurement Kit Used in Noise Monitoring

5.2.3.1 Measurements Carried Out

The monitoring locations for the noise measurements were selected to be representative of the proposed site location and away from being influenced by interferences such as wind, impulsive sounds and electromagnetic radiation from high voltage transmissions lines. Three locations were selected for noise measurements: at the project site and two other surrounding locations near the fishermen's port and in the industrial area to the south as shown in **Figure 5-8**. The coordinates of each point are listed in **Table 5-1**.

Table 5-1 Noise Measurements Coordinates

Point	Coordinates	
	Latitude	Longitude
N1	33.904263°	35.543354°
N2	33.899597°	35.550384°
N3	33.899710°	35.540896°

Figure 5-8 Noise Measurements Locations

The measured sound pressure levels were compared to the Lebanese standards for environmental noise as per MoE Decision No. 52/1/1996. A summary of noise monitoring results is provided in Table 5-2, where L90 noise levels at all three locations N1, N2, and N3, did not exceed the standards set out by decision 52/1 for industrial areas. Above standard results, such as LMAX at all locations are due to passing vehicles along the adjacent road.

Table 5-2 Summary of Measured Baseline Sound Levels

Point	Time/Period		Limit For Ambient Noise Levels dB(A) in Selected Regions (Decision 52/1)	Sound Level Values in dB(A)*			
				L_{EQ}	L_{MAX}	L_{10}	L_{90}
N_1	Day Time (07:00-18:00)	9:36	Industrial Area (60-70)	69.3	**90.6**	69.1	59.5
N_2		9:50		62.6	**79.6**	65.4	52.8
N_3		10:05		55.7	**78.7**	56.1	49.9

5.2.4 Geology, Soil, Groundwater, and Seismicity

Table 5-3 Geosciences Baseline of Burj Hammoud Pretreatment Headworks Plant

Topic	Aspect	Situation	Reference Figures/Tables
Topography	-	- **Altitude:** Between 2 and 6 m asl - **Slope:** Naturally Gentle - **Relief:** Flat, coastal area.	- **Figure 5-9**
Surface Hydrology	-	- **Proximity to Surface Water (River, stream, canal, lake, sea/ocean):** o Reclaimed land in the Mediterranean Sea - **Runoff / drainage direction:** Surface runoff is toward northeast into the Mediterranean Sea in the environs of the project. - **Base level for runoff / Receiving water body:** Mediterranean Sea o Distance: 240 m o Perennial/non perennial: Not Applicable o Flow: Not Applicable o Water usage: Not Applicable - **Municipal Storm water presence and discharge location:** Storm water in the area drains into the Mediterranean Sea. - **Key downstream receptors:** Mediterranean Sea and Marine Life	- **Figure 5-9**
Geology/ geomorphology	Conservation	- **Not Applicable**	-
Hydrogeology	Groundwater	- **Aquifer / groundwater depth or downstream distance to aquifer exposure:** o Groundwater is essentially seawater in dredged / fill material making up reclaimed land. - **Groundwater flow direction:** North toward Mediterranean Sea - **Key down gradient receptors (springs, wells):**	- **Figure 5-10** - **Table 5-4** - **Table 5-5**

		Mediterranean Sea and marine life - **Inherent groundwater vulnerability (Low, medium, high):** Not Applicable - **Groundwater Quality:** o Water Quality in Quaternary deposits underneath seafloor according to CGC Geotechnical Report is highly saline and comparable to seawater quality: • Chlorides (Cl^-): 1,585 mg/l • Sulfates (SO_4^{2-}): 100 mg/l • pH: 7.42 - **Groundwater Use:** Not Applicable	
	Springs	- No noteworthy springs (submarine springs) reported down gradient from the Burj Hammoud WWTP proposed location.	- **Figure 5-10**
	Wells	- **Proximity to Wells:** o 990 m northeast of a private well (up gradient) o No reported public wells - **Down gradient wells:** o No reported down gradient wells.	- **Figure 5-10**
Soil Cover	-	- **Availability:** Not Available in the project site because of reclaimed land - **Type:** Not Applicable - **Value (arable):** Not Applicable	- **Figure 5-10**
Natural Hazards	Seismicity (Faults, inherent stability of ground / geology)	- **Proximity to Faults:** o No mapped faults within the study area o Presence of blind faults cannot be refuted o Mount Lebanon Thrust Fault is located about 12 km north of the study area. - **Consolidated/Unconsolidated Ground/Geology:** Based on CGC Geotechnical Report the first 4.5 meters underlying the project site are man-made and composed of fine to medium sand and gravel. The underlying formation is made up of fine, medium, coarse sand and gravel with silt and clay (Q).	- **Figure 5-10** - **Figure 5-11** - **Figure 5-12**

		Seismicity o Several earthquakes have occurred within the study area and their magnitude ranges between 2 and 3.4 o The seafloor underneath the proposed site is composed of unconsolidated Quaternary deposits, which are inherently weak and unstable during earthquakes o According to Huijer et al. (2011), the project area has a 10% probability of exceeding a Peak Ground Acceleration (PGA) value of 0.3 g during a period of 50 years o In accordance with seismic risk, the shoreline is prone to tsunami risk.	
Other / Hazards	-	- **Not Applicable**	

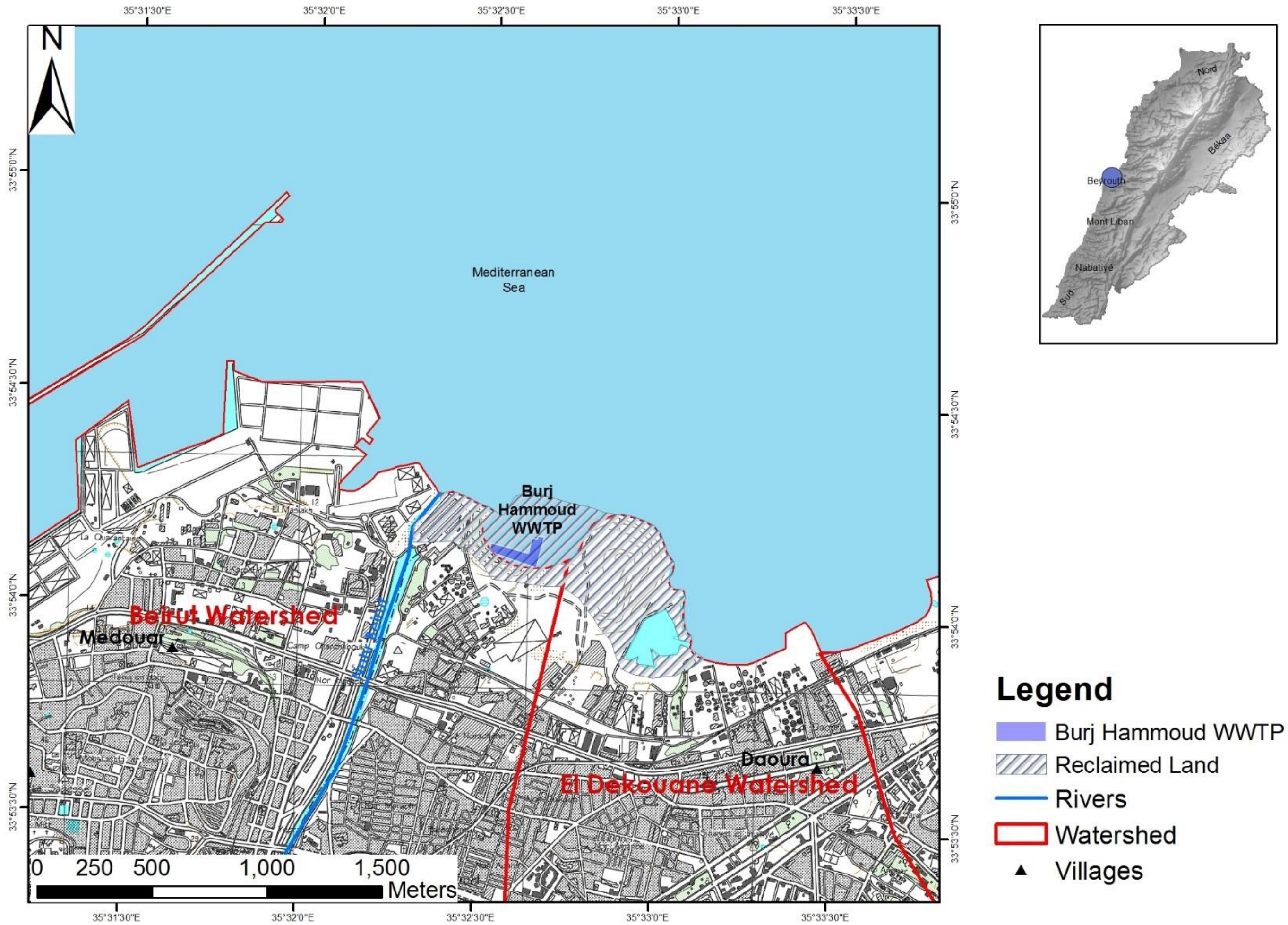


Figure 5-9 Topographic Map of Burj Hammoud WWTP Proposed Site (Geographic Projection)

Topographic map of Beyrouth. 1:20,000 Directorate of Geographic Affairs (Beirut-Lebanon)-2005

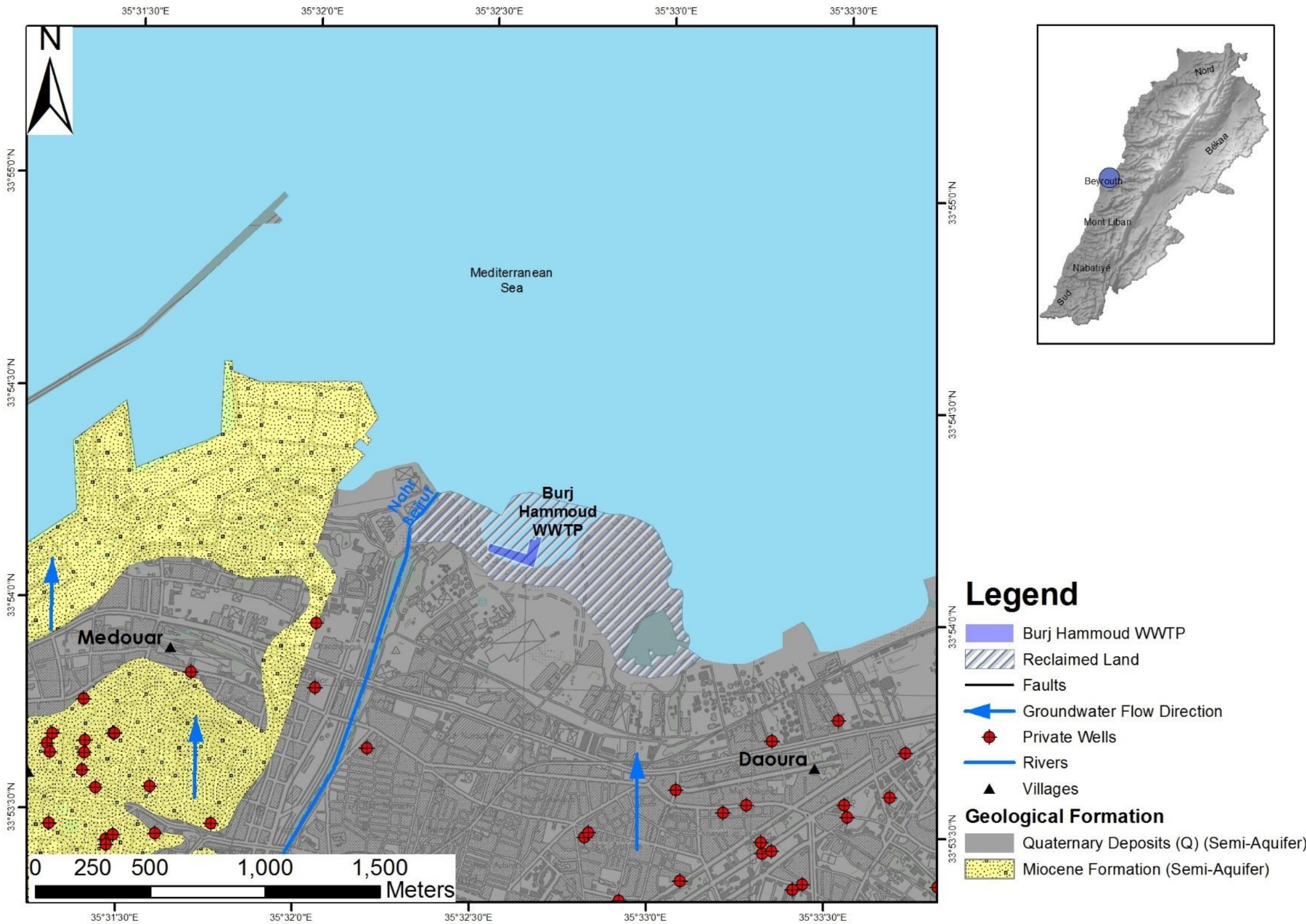


Figure 5-10 Hydrogeological Map of the Study Area, also showing Public and Private Wells

Source: Dubertret, 1953

Table 5-4 Summary of the Stratigraphy and Hydrostratigraphy of the Study Area

Period	Age	Formation / Deposits /Age	Dubertret Alphanumeric Nomenclature	Thickness (m)	Lithostratigraphy	Hydrostratigraphy
Quaternary		Quaternary Deposits	Q	Up to 100 m	Sand, silt, detrital limestone, conglomerates and alluvial deposits	Semi-Aquifer: The Quaternary deposits are with hydraulic connection with Miocene semi-aquifer (mL)
Tertiary	Neogene	Upper to Middle Miocene	mL	150	The lithology varies from reefal limestone near the coast to marly limestone moving inland towards the east	Semi-aquifer

Table 5-5 Soil/Lithology description beneath project site (CGC Geotechnical Report)

Depth Below Ground (m)	Soil Description	Geology
0-4.5	*Backfill consisting of fine to medium sand with gravel*	*Reclaimed Land*
4.5-7.5	Grey fine to medium sand with gravel.	Quaternary Deposits (Q)
7.5-10.5	Grey medium to coarse sand with gravel	
10.5-15	Dark grey fine to medium sand with gravel	
15-20	Dark grey silty clay with sand	

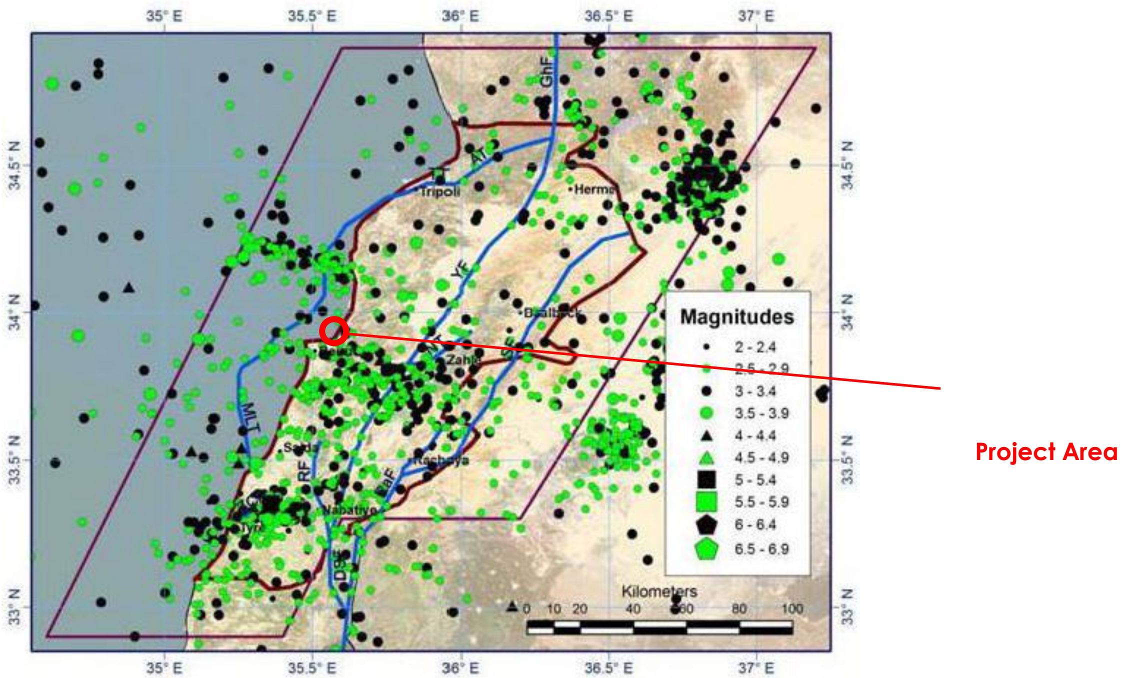


Figure 5-11 Map showing Earthquake Events in and around Lebanon between 1998 and 2009 with Magnitudes ≥ 2 along with the WWTP project area (Adapted from Huijer et al., 2011

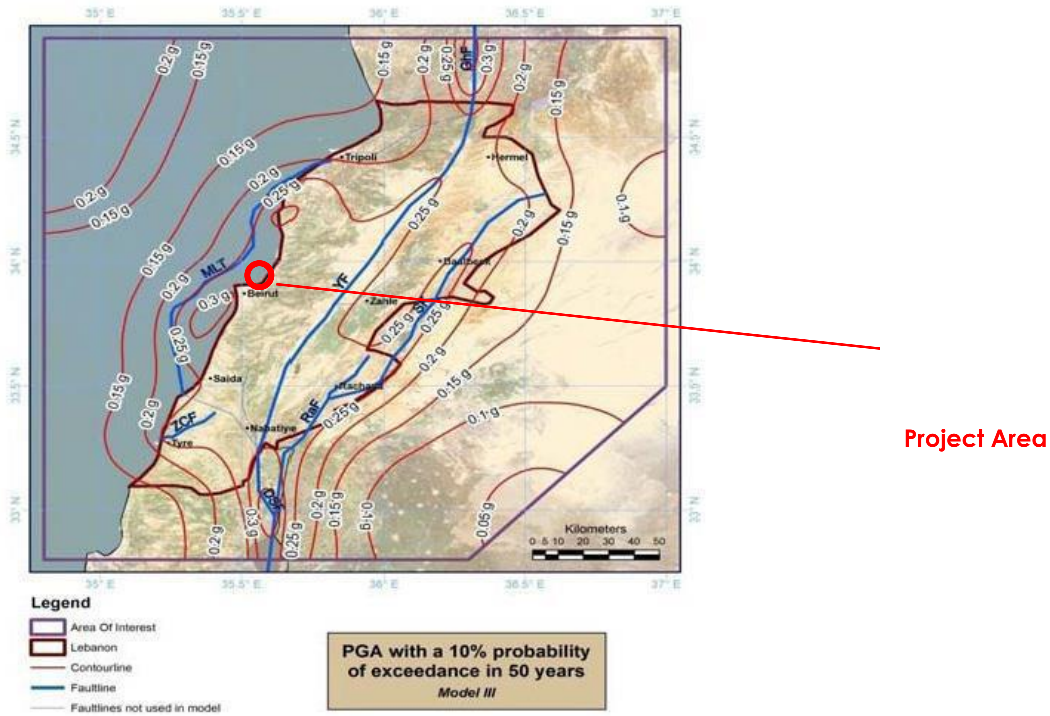


Figure 5-12 Map Showing the Seismic Hazard in Lebanon (contouring of peak ground acceleration with a 10% probability of exceedance in 50 years) along with WWTP project area (Adapted from Huijer et al., 2011)

5.3 BIOLOGICAL ENVIRONMENT

The proposed site for the WWTP is located on the coast of Burj Hammoud, this site is not a natural landscape and was originally part of the sea (Figure 5-13). Since the project area is a reclaimed one and is surrounded by industrial facilities, it can be considered environmentally deteriorated with very low biodiversity and minimal terrestrial ecological value.

In general, the Lebanese coast is a habitat for several species of Phytoplankton, zooplankton which show abundance during two annual peaks, Zoobenthos mainly *Coris julis* which is a bottom dwelling fish species, and 324 fish species and marine reptiles. However it is to be noted that the marine ecosystem in the vicinity of the proposed project site has highly deteriorated over the years due to anthropogenic causes such as urbanization, industrial developments, and haphazard raw wastewater discharge in the sea and in the nearby Beirut River as such the Beirut River Estuary is currently heavily polluted.

It is an important requirement for the contractor to conduct a pre-commissioning study to establish the baseline levels, to be used as a basis to monitor the project impacts on sea quality.

Figure 5-13 Proposed Construction Site

5.4 SOCIO-ECONOMIC AND CULTURAL CONTEXT

5.4.1 The Town of Burj Hammoud

Burj Hammoud is located along the cost approximately 2 km east of the Lebanese capital Beirut. The town is situated in the greater Beirut area, in the Mount-Lebanon Governorate, Matn Caza, and has an estimated surface area of 2.6 km^2.

5.4.2 Population and Land Use

The current population of Burj Hammoud is around 150,000 inhabitants. And the land use in the vicinity is a mix of residential, Industrial, and commercial.

5.4.3 Education and Employment

Burj Hammoud is home to 24 schools and 4 technical schools providing education for approximately 9,400 student.

5.4.4 Economic Activity

In Burj Hammoud there are over 15,000 commercial units, and the town can be considered as an industrial and commercial center. Burj Hammoud is also known for its popular markets, and it is s also home to a fishermen's port.

5.4.5 HealthCare

There are 6 health, social and medical centers, and 1 hospital located within Burj Hammoud.

5.4.6 Waste Management

Solid waste is managed by RAMCO a private contractor that collects the generated waste and transfers to a sorting facility in Karantina, however most of the waste is then disposed in the Burj Hammoud or Jdeideh landfills. Moreover, solid waste sorting at the source is not generally practiced by the residents.

5.4.7 Water Supply

Water provision in Burj Hammoud depends on a network that pumps water to the Greater Beirut area. The network is managed by the Beirut and Mount Lebanon Water Establishment (BMLWE).

5.4.8 Wastewater Network

Households in Burj Hammoud are connected to the existing sewage network, however given the current situation the generated wastewater is either discharged into the Beirut River and end up in the sea or directly discharged into the sea.

As part of the works of this project the network will be connected to the WWTP and the generated waste will be conveyed to the proposed preliminary treatment plant.

5.4.9 Electricity Supply

Burj Hammoud is connected to EDL's grid for electricity provision. During power outages, the residents depend on communal or private generators for electricity supply.

5.4.10 Archaeology

As the proposed project site is located on a recently reclaimed land, it has no cultural nor archeological values.

6. POTENTIAL ENVIRONMENTAL IMPACTS OF THE PROJECT

This section identifies the main potential impacts that could arise from the construction and operation of the Daoura-Burj Hammoud treatment plant and assesses their significance so that any potentially significant impacts can be properly mitigated.

6.1 IMPACT IDENTIFICATION AND ASSESSMENT METHODOLOGY

6.1.1 Impact Identification

Identification of potential environmental and socio-economic impacts and their severity is facilitated by identifying the main activities at the site, the major impacts, and the environmental media affected. Impacts can be induced during the construction of the constructed wetland, and later during its operation. After identifying the Project impacts, the EIA evaluates their significance and determines mitigation measures to eliminate/minimize these impacts.

6.2 SIGNIFICANCE ASSESSMENT

The environmental and social impacts will be assigned a level of significance (Low, Moderate or High) based on the likelihood (Low, Moderate or High) of the impact and the consequence (Insignificant, Minor, Moderate, Major, Critical and Beneficial) of that impact. A number of considerations are built into the Impact Consequence Criteria including nature, direction, magnitude, geographic extent, timing, duration, reversibility of the impact as per the MoE Decision 261/1. Some basic questions which can be used to address the above considerations are shown below.

Table 6-1 Questions for Addressing Considerations under Impact Consequence Criteria

Issue	Question	Criterion	
Nature of Impact	What is the nature of the impact?	P: Positive N: Negative	D: Direct I: Indirect
Magnitude of the Impact	The magnitude will be assessed for each impact category separately	L: Low M: Medium H: High	
Extent of the impact (geographical scale of the impact)*	Is the extent of the impact localized or confined to a designated area around the project site, or does it extend regionally/ nationally/ globally?	L: Local - Change or effect only within the project site or extends to areas immediately outside G: Global - Regional, national, or international changes or effects.	
Timing of the impact	Is the impact likely to persist for a long or short term?	S: Short term M: Medium term L: Long term	

Issue	Question	Criterion
Duration of the impact	Are the consequences likely to be limited to the construction or operation phase?	D: During decommissioning C: During construction O: During operation
Reversibility of the impacted condition (impacted condition can be changed or reversed)*	Are the consequences likely to be reversible or irreversible?	R: Reversible I: Irreversible.

The consequence assessment criteria table to be included under each component is provided below.

Table 6-2 Consequence Assessment Criteria Template Table

Impact/Source	Nature	Magnitude	Extent	Timing	Duration	Reversibility	Consequence Rating

Consequence criteria are ranked into six levels of significance based on their rating as listed in the hereafter table.

Table 6-3 Consequence Assessment Criteria

Criteria	Consequence Rating
Nature: Negative Magnitude: High Extent: Global (large area of effect that supports sensitive receptors) Timing: Short, medium or long-term Reversibility: Irreversible	5. Critical
Nature: Negative Magnitude: High Extent: Local (area supports a significant proportion of sensitive receptors) Timing: Short, medium or long term Reversibility: Reversible or irreversible	4. Major
Nature: Negative Magnitude: Moderate Extent: Local (area of effect encompasses an area that supports either a moderate or minor proportion of sensitive receptors) or global Timing: Short, medium or long term Reversibility: Reversible	3. Moderate

Criteria	Consequence Rating
Nature: Negative Magnitude: Low Extent: Local (sensitive receptors located in the immediate vicinity of the source or areas immediately outside) Timing: Medium or long-term (1 – 5 years or > 5 years) Reversibility: Reversible	2. Minor
Nature: Negative Magnitude: Low – unlikely to be noticeable Extent: Local (absence or presence of sensitive receptors located in the immediate vicinity of the source) Timing: Short-term Reversibility: Reversible	1. Negligible
Changes that result in a net positive impact to an ecosystem, environment or population.	B. Beneficial

The likelihood of the occurrence of the impact is then rated according to the criteria outlined below.

Table 6-4 Likelihood Categories and Rankings Impacts

Score	Category	Definition
H=3	High	The impact will occur under normal operational conditions
M=2	Moderate	The impact may occur at some time under normal operating conditions
L=1	Low	The impact is very unlikely to occur under normal operating conditions but may occur in exceptional circumstances

Impact significance level is assigned according to the Likelihood of Occurrence cross-tabulated with the Consequence Rating Criteria as shown below.

Table 6-5 Impact Significance Levels

		Consequence Rating					
		Negligible 1	Minor 2	Moderate 3	Major 4	Critical 5	Beneficial B
Likelihood Rating	Low L=1	1	2	3	4	5	+
	Medium M=2	2	4	6	8	10	++
	High H=3	3	6	9	12	15	+++

Legend

Consequence Rating	Likelihood	Significance	
1- Negligible	L- Low (1)	+ to +++	Beneficial
2- Minor	M- Medium (2)	1 to 3	Low
3- Moderate	H- High (3)	4 to 9	Medium
4- Major		10 to 15	High
5- Critical			
B- Beneficial			

6.3 MANAGEMENT OF IMPACTS

Residual impacts will be ranked for significance after all possible mitigation measures are applied. The following apply for the different levels of impact significance:

Low significance — These impacts are considered to be acceptable. Implementation of mitigation and monitoring measures are required to ensure these impacts remain at low significance. Management of these impacts is the responsibility of the project proponent.

Medium Significance — It must be demonstrated that the significance of these impacts cannot be reduced further. These impacts must be managed in a manner defined during the EIA process.

High Significance — These impacts are not tolerable. They are likely not to be acceptable to affected populations even with compensation. Measures to reduce the significance of the impacts to Medium or Low need to be identified. This may involve project re-design, consideration of alternatives meeting the same objectives or any other means to

	reduce the significance of the impact. Final decision on impact acceptability must be made in conjunction with affected stakeholders in a manner defined during the EIA process.
Beneficial	These are positive impacts that should be maintained by the project proponent. Proponent should demonstrate through the implementation of the monitoring plan that these impacts remain positive and to the extent possible, enhance its benefits through complementary measures.

6.4 SOURCES OF CUMULATIVE IMPACTS

Potential cumulative sources of impacts around the Project site include the following:

- Vehicular air and noise emissions along the main and secondary roads (especially the seaside road that endures a lot of traffic during peak hours);
- Air and noise emissions related to the activities in the surrounding industrial area;
- Untreated wastewater discharge from Beirut river outfall.

6.5 EMISSIONS

6.5.1 Air Emissions

6.5.1.1 Construction Phase

Emission of Air Pollutants and Dust Generation

Soil disturbance during clearance, grading, backfilling, trenching, and other construction activities will potentially lead to an increase of atmospheric dust emissions, which may impact local ambient air quality. Under normal meteorological conditions, dust impacts will be limited to within several tens to hundred meters from the disturbance area. The main environmental and health concerns associated with dust generation include:

- Potential nuisance and health impacts on receptors in close vicinity of the proposed site within the surrounding industrial area and the adjacent reclaimed land that is planned for future development, e.g. Asthma and eyes irritation;
- Occupational health risk and irritation to construction workers; and
- Impact on infrastructures in close vicinity of the proposed site, including metal corrosion, and material deterioration.

The duration of main soil disturbance activities (excavation works) is of short duration and of limited extent, such that it is unlikely that the dust emissions will be of major concern.

Combustion emissions from fuel-powered construction equipment and vehicles, such as, Particulate Matter (PM), Sulfur Dioxide (SO_2), Nitrogen Oxides (NO_X), Carbon Dioxide (CO_2) and

Carbon Monoxide (CO), may create a temporary impact on local air quality. Exhaust emissions are inevitable during normal operation of combustion sources. However, lack of maintenance, poor quality fuel, unnecessary idling periods, long operation periods (especially for power generators) and absence of exhaust emission control units will result in the increase of pollutants concentration emissions. Gaseous pollutants' emissions from this project however are expected to be restricted to short duration only (during construction) and of low significance given the limited number of machinery and equipment to be used.

Table 6-6 Environmental and social impacts from air pollutants

Air Pollutants	Environmental and Social Impacts
NOx	NOx contributes to the formation of acidic species, which can be deposited in a dry or wet manner. Also, NO_2 is a toxic gas, even when in low concentrations.
SO_2	SO_2 is a toxic gas and can also contribute to the formation of acidic species. In addition, it can have health effects and cause respiratory diseases.
CO	CO has negative health impacts, it can cause a reduction in the O_2 intake and can lead to serious impacts when inhaled for a period long of time.
CO_2	CO_2 is a greenhouse gas, and contributes to global warming. It also has adverse health effects, it can cause acidosis and is toxic to the heart.
Particulate matter with a diameter of less than 10 µm (PM10)	PM10 is able to penetrate deeply in the lungs. It has been associated with excess short term mortality and morbidity rates.

During the construction phase of the pretreatment headworks plant, the total hourly estimated fuel consumption for a maximum capacity of 250 KVA as per the engineering design would be around 0.881 GJ. The emissions for criteria pollutant are reported therefore in Table 6-7.

Table 6-7 Emissions of criteria pollutant during the construction phase

Pollutant	Emissions (g/h)	Emissions (tons/y)*
CO	81.9	0.2

Pollutant	Emissions (g/h)	Emissions (tons/y)*
NOx	269.6	0.8
SOx	82.8	0.2
NMVOC	17.6	0.1
PM10	18.5	0.05
PM2.5	15.9	0.05

*Assuming operation time is 8 hours per day

In addition to emissions related to combustion processes and during the construction phase, fugitive emissions of PM10 and PM2.5 are expected to be released as a result of excavation works. According to the EIA study conducted in 2003 for the Burj-Hammoud wastewater treatment plant (ESIA, 2003), it is estimated that around 148 g/m2/month of activity of Total PM10 are to be emitted as fugitive emissions. According to the engineering design, the total area of the pre-treatment headworks is around 20000 m^2. Therefore, around 35.52 tons of PM10 are expected to be emitted on a yearly basis. As for PM2.5, and according to Muleski et al., 2005, the ratio of PM10/PM2.5 from construction activities is around 0.52. For instance, around 18.47 tons of PM2.5 are expected to be generated.

The levels obtained on a yearly basis are negligible when compared to the national emission inventory (Waked et al., 2012), suggesting a minor impact related to air quality (Table 3).

Table 6-8 Comparison to the rates obtained from the emissions inventory

Pollutant	Combustion* (tons/y)	Combustion and fugitive emissions* (tons/y)	Emission inventory for a base year of 2010** (tons/year)
CO	4.8	0.2	563000
NOx	15.8	0.8	75000
SOx	4.8	0.2	62000
NMVOC	1.0	0.1	115000

Pollutant	Combustion* (tons/y)	Combustion and fugitive emissions* (tons/y)	Emission inventory for a base year of 2010** (tons/year)
PM10	1.1	35.57	12000
PM2.5	0.9	18.52	9000

*Assuming operation time is 8 hours per day

**(Waked et al., 2012)

6.5.1.2 Operation Phase

Odor Emissions

The main potential source of air pollution during the operation phase is odor generation from the WWTP specifically from:

- Inlet Pumping Station;
- Screening Building;
- Aerated Grit Chambers;
- Effluent Pumping Station; and
- Sludge treatment, dewatering, and sludge storage tanks during Phase 2

Generated odors could lead to nuisance to surrounding communities. Odorous compounds include organic and inorganic gases. The primary inorganic odorous compounds are the Hydrogen Sulfide (H_2S) and Ammonia (NH_3); these tend to be the major odor contributors. On the other hand, the common organic odorous compounds are Methyl Mercaptan (CH_3SH), Dimethyl Sulfide $(CH_3)_2S$ and Indole ($C_6H_4(CH)_2NH$). The modeling of odor dispersion will focus mainly on H_2S, since other constituents would be at much lesser concentrations and that is why hydrogen sulfide is targeted for control.

To assess quantitatively the odors emissions, the Gaussian air dispersion model is adopted. The detailed modeling report for odor generation form the pretreatment headworks plant (phase 1) is provided in Appendix H.

The model permits the calculation of the concentration of an odorous compound at any distance from the emission source knowing the emission rate at the source. The model was designed to study three scenarios for the modelling of H2S emissions from the outlet stack of the OCU defined as follows:

- ***Scenario 1:*** In this scenario, optimum working conditions are assumed with an emitted mean H_2S concentration of 0.5 ppm.

- ***Scenario 2:*** In this scenario, close to optimum working conditions are assumed with an emitted mean H_2S concentration of 0.75 ppm.
- ***Scenario 3:*** In this scenario, average working conditions are assumed. In Scenario 3, taking into account the above mentioned conditions, we would assume an emitted H_2S concentration of 1.0 ppm to represent the mean under variable flow, temperature and removal efficiency conditions. This corresponds to a removal efficiency of: 98 %.
- ***Scenario a:*** Minimum Wind Speed = 2.0 m/s
- ***Scenario b:*** Moderate Wind Speed = 2.5 m/s
- ***Scenario c:*** Average Wind Speed = 3.0 m/s

On the other hand, no odor impacts related to ammonia emissions from the outlet stack of the OCU are expected since the threshold is not exceeded at the inlet to the stack.

As shown in Figure 6-2 the odor dispersion model results show that under favorable operating conditions (case of Scenario 1c), the H_2S emissions would stay below the threshold of 7 $\mu g/m^3$ at a distance of 530 meters from the OCU. At minimum wind speed of 2.0 m/s, the threshold is not exceeded at a distance of 710 meters from the OCU. The H_2S threshold would be exceeded inside the industrial zone under minimum wind speed conditions. The inhabited zone, located at 925 meters from the OCU, would not be negatively impacted by the odor emissions.

Under less favorable operating conditions, but still close to optimum (case of Scenario 2c), the H_2S emissions would stay below the threshold of 7 $\mu g/m^3$ at a distance of 760 meters from the OCU. At minimum wind speed of 2.0 m/s, the threshold is not exceeded at a distance of 990 meters from the OCU. The H_2S threshold would be exceeded inside the industrial zone, the mixed development zone, the Daoura highway and a small portion of the inhabited zone under minimum wind speed conditions. The inhabited zone, located at 925 meters from the OCU, would not be negatively impacted by the odor emissions under average wind speed conditions ranging from 2.5 m/s to 3.0 m/s.

Under average operating conditions (case of Scenario 3c), the H_2S emissions would stay below the threshold of 7 $\mu g/m^3$ at a distance of 950 meters from the OCU. At minimum wind speed of 2.0 m/s, the threshold is not exceeded at a distance of 1,230 meters from the OCU. The H_2S threshold would be exceeded inside the industrial zone, the mixed development zone, the Daoura highway and an appreciable portion of the inhabited zone under minimum wind speed conditions. The inhabited zone, located at 925 meters from the OCU, would be slightly negatively impacted by the odor emissions under average wind speed of 3.0 m/s.

In all the studied scenarios, the H2S emissions threshold of 7 μg/m3 would be exceeded inside the boundaries of the Daoura PTP. This would negatively impact the operators and workers of the plant. A maximum concentration of about 40 μg/m^3 (equivalent to about 0.03 ppm) could be emitted around the location of the odor control building under unfavorable operating conditions.

Based on the summer wind data the sector that would receive the emissions, most of the time, remains the one facing the prevailing wind directions. Figure 6-1 shows the most potential zone that would be affected by odor emissions during the summer period.

Figure 6-1 Area most affected by odor generation

Thus, the assessed odor emissions from the pretreatment headworks plant could be of serious importance due to potential negative impacts under less favorable, or even average operating conditions, and subject to winds incoming from the northern sectors affecting the nearby residential zones. Additionally, odor would impact the adjacent land that is planned for future development by the Municipality of Burj Hammoud, and negatively affect the workers of the plant. This would lead to a high negative environmental impact due to its major consequences and high likelihood of occurrence.

Based on the aforementioned assessment, the following mitigation measures are recommended:

- With reference to the report "Pretreatment Headworks at Daoura WWTP – Final Design Report – February 2019" prepared by the Consultant ACE for the CDR, the cover page of this report shows a 3D view of the proposed Daoura wastewater treatment plant. Looking at the 3D view, we notice the complete absence of trees along the boundaries of the plant. We recommend planting trees along the boundaries of the proposed plant with a maximum spacing of 3 meters. Besides the positive visual impacts, the trees would help absorb odors emissions and would act as a natural barrier for odors emissions containment.

- The release of hydrogen sulfide gas from the liquid wastewater can be minimized by increasing the pH of the wastewater. This EIA strongly recommends the provision of a chemical dosing station to increase the pH of the influent wastewater to the Daoura PTP. This would result in an increase of the wastewater pH which in turn would lower the hydrogen sulfide gas emissions. Accordingly, the ambient static hydrogen sulfide gas concentration would be reduced. Chemicals used for this purpose include lime [Ca(OH)2], caustic soda (NaOH) or magnesium hydroxide. The handling and preparation of either lime or caustic soda would be easier than magnesium hydroxide.
- The odor emissions from the aerated grit chambers must be captured and treated. This would require covering the tanks or providing a building enclosure around the tanks. The OCU capacity must be adequate to accommodate the air flow from the aerated grit chambers.
- The OCU capacity of 90,000 Nm3/h should not be increased further because an additional increase would result in higher emitted hydrogen sulfide mass flux.
- The OCU stack must be at least 6 meters high from the ground level. Additional height is recommended, if possible, subject to applicable building codes and structural stability considerations.
- The tender documents for the pretreatment headworks plant should specify the required outlet H2S concentration from the OCU without necessarily indicating the required removal efficiency. In addition, the tender documents must specify that the ambient static hydrogen sulfide concentration would be on average 500 ppm.
- This EIA recommends that information about exposure to hydrogen sulfide be provided for the operating staff of the Daoura PTP. The workers doing regular cleaning, maintenance and operational tasks near the plant works should always wear at least disposable protective masks.
- A notice is required to warn the wearing of masks for operators, workers and/or visitors who intend to be near the plant works for prolonged periods of time.
- This EIA recommends the continuous monitoring on a daily basis of hydrogen sulfide emissions at the emission sources and within the plant boundaries. Measured values are to be compared to the threshold concentrations. Corrective measures and action would be required in case the measured values exceed the threshold concentrations.

By applying the above recommended mitigation measures, it could be possible to release from the odor control unit outlet stack a hydrogen sulfide concentration of 0.25 ppm. Such an outlet concentration could correspond to reducing the dynamic hydrogen sulfide concentration to 25 ppm through various measures that involve reducing the ambient static hydrogen sulfide concentration. In addition, the OCU removal efficiency would have to be 99%. For the conditions of having the removal efficiency at 99% and the dynamic hydrogen sulfide concentration at 25 ppm, the outlet hydrogen sulfide concentration would be 0.25 ppm. It would not be an easy target to achieve all the time. Nevertheless, with this target met, the calculations reveal that the hydrogen sulfide threshold of 7 g/m^3 would not be exceeded at 40 meters from the outlet stack. Therefore, at an emitted hydrogen sulfide concentration of 0.25 ppm, there would be no adverse impacts from odor emissions.

The residual negative environmental impact will be low due to its moderate consequences and low likelihood of occurrence.

On the other hand, odor generation during Phase 2 of operation of the WWTP is expected to be affected by odors generated from the residual sludge and sludge treatment processes in addition to cumulative odor impacts generated by the pretreatment phase.. For Phase 2, given that insufficient data is currently available and given that it is still under conceptual design odor dispersion modelling will not be accurate.

Nevertheless, the conceptual design of Phase 2 includes a ventilation system for the sludge storage tanks and a bio-scrubber are proposed to be installed as odor control measures to manage foul air generated from sludge treatment. In addition the design recommends that all sludge treatment facilities at the WWTP to be covered.

Given the above mitigation measures proposed in the design of Phase 2 and considering that good operation and maintenance practices are followed the impacts of odor generation from sludge treatment at the WWTP should be low. However, it is strongly recommended to conduct an in-depth odor generation modelling study to accurately assess those impacts in the EIA for Phase 2 considering overall cumulative impacts with the pretreatment works.

Scenario 1c

Scenario 2c

Scenario 3c

Figure 6-2 Odor Dispersion Model Results during Average Wind Speeds

Air Emissions from Generators and Combustion

During the operation of the WWTP a total load for the pre-treatment head-works of around 4,915 KVA would be needed for which four generators of 1,600 KVA each have been allocated. The total load is assumed to be supplied by the four private generators during the pretreatment phase when electricity from EDL is not supplied. Air pollutants emissions such as CO, NOx, SOx, NMVOC, PM10 and PM2.5 are expected to be generated and may have a negative impact on the quality of the air we breathe. In order to evaluate the emitted quantities, estimation of generation rates for CO, NOx, SOx, NMVOC, PM10 and PM2.5 was conducted. Due to the fact that fuel consumption and generators specifications were not provided, we used a rough estimate in order to quantify those emissions. The adopted methodology is described as follows:

• In order to estimate the activity data/fuel consumption on the basis of the demand load, we relied on the study of Shihadeh et al., 2013 where a survey was conducted for 109 diesel generators for the city of Beirut. The total reported diesel fuel consumption rate amounted to 136500 L/month for a total capacity of 15000 KVA and an operating time of 3 hours per day. With a capacity of ~5000 KVA, the estimated fuel consumption is around 45500 liters with an hourly rate of 489 liter of diesel. Having a diesel density of around 0.832 kg/L and a net calorific value for diesel of 43.33 TJ/Kt (IPCC, 2006), the estimated hourly fuel consumption would be around 17.64 GJ.

• In order to estimate the emission factors, the Tier 1 methodology of the EMEP/EEA guide book (i.e. 1.A.4 small combustion) of 2016 (EMEP/EEA, 2016) was used due to the fact that specific emissions factors for Lebanon are not provided.

• Emissions are then calculated by multiplying the activity data by the emission factor for each pollutant. The emissions for criteria pollutants are reported in Table 6-9 on an hourly and annual rates.

Table 6-9 Emissions criteria pollutants during the operation phase

Pollutant	Emissions (g/h)	Emissions (tons/y)*
CO	1640.5	4.8
NOx	5397.8	15.8
SOx	1658.2	4.8
NMVOC	352.8	1.0
PM10	370.4	1.1
PM2.5	317.5	0.9

*Assuming operation time is 8 hours per day

Exhaust emissions from the power generators are inevitable during the operation phase in order to ensure that the collected wastewater at the pumping stations is being regularly conveyed to avoid overflow. However, lack of maintenance, poor quality fuel, and absence of exhaust emission control units will likely result in the increase of pollutants concentration emissions leading to moderately significant environmental impacts on air quality and human health.

During the operation of Phase 2 additional air pollutants will be generated from the proposed flaring system that will be installed to be burn the generated methane gas from the sludge treatment facilities.

6.5.2 Noise

6.5.2.1 Construction Phase

Noise Generation from Construction Activities

Noise generated by project-related construction activities would be a function of the noise levels generated by individual pieces of construction equipment, the type and amount of equipment operating at any given time, the timing and duration of construction activities, the proximity of nearby sensitive receptors, and the presence or absence of shielding at these sensitive receptors. Construction noise levels would vary on a day-to-day basis during each phase of construction depending on the specific task being completed.

Construction phases anticipated with the project would include clearance, grading, trenching, and other construction activities. Each construction phase would require a different combination of construction equipment necessary to complete the task and different usage factors for such equipment.

Construction noise would primarily result from the operation of heavy construction equipment and arrival and departure of heavy-duty trucks.

Given that the area is mainly industrial in nature and has no adjacent residential areas noise impacts from construction works are expected to have minor consequences with a high likelihood for occurrence, thus a medium negative environmental impact. Noise mitigation measures are introduced in the EMP to ensure compliance with MoE Decision 52/1 noise emission standards for industrial areas.

6.5.2.2 Operation Phase

Noise Generation from plant operation

During the operation phase, noise will mainly result from the operation of the pumps and the utilization of the generators; however, their use will not be continuous. Moreover, noise might be generated during maintenance activities, however these are expected to be of short term duration and low significance.

6.5.3 Wastewater Discharge

6.5.3.1 Construction Phase

Wastewater from Construction Activities

Construction workers and site staff will generate sewage that if discharged into the Mediterranean Sea can cause additional deterioration of seawater quality.

In addition, if vehicles are washed onsite and wash down water is not contained and allowed to drain over natural ground or discharged into the Mediterranean Sea then pollutants may further pollute seawater.

Dewatering Activities

The proposed project is situated over a reclaimed land in the Mediterranean. Hence dewatering activities prior to the construction phase will take place since the water table within the site is shallow (between -3.11 m asl and +1.15 m asl as reported by the CGC geotechnical report). Uncontrolled dewatering can be detrimental to the environment as it may potentially cause groundwater depletion, water pollution, ground subsidence, flooding, and structural collapse. Given that the water in the area is highly saline, impacts on surface water and groundwater from dewatering will most probably be negligible. However, the geotechnical impacts of dewatering will be of most concern in the project site.

The geotechnical impacts that may generally result from dewatering are:

- Land subsidence (lowering of the land–surface elevation from changes that take place underground)
- Increased load on foundation soil below the original groundwater table.

6.5.3.2 Operation Phase

Pretreated Wastewater Discharged into the Sea from the Outfall Pipe

Since phase 1 of the proposed project includes the pretreatment of wastewater only, a dilution modeling assessment was conducted to study the dispersion of wastewater from the main outfall pipe which extends 1,777 m into the sea. The detailed modeling report is provided in Appendix G.

Figure 6-3 shows the dispersion plume during the dry season (when bathing might occur), where the sea current is at 20 cm/s and coming from the North-East direction, which occurs during the majority of the dry season. The modeling calculations showed that the safe bathing zone that extends from the shoreline to a distance of 300 m into the sea and the nearest bathing resort would not be negatively affected by fecal coliforms.

Figure 6-3 Dilution Modeling for the Dry Season with Sea Current 20 cm/s towards the North-East

For a particular condition during summer, when the prevailing sea currents direction is reversed, the discharged wastewater plume would disperse in the direction of Beirut harbor (Figure 6-4). The fecal coliforms concentration would be about 200 FC/100ml at the North-Eastern boundary of the Beirut harbor. The marine zone that extends from the northern edge of the plant reclaimed land to Beirut harbor north-eastern boundary is subject to industrial marine activities including large shipping vessels movements, fuel tankers and the like. This zone is not used for bathing, or for recreational activities, especially that there are no shoreline beaches along this zone. Accordingly, this zone cannot be considered sensitive. Therefore, in the event the wastewater plume disperses in the direction of the Beirut harbor, negative environmental impacts on bathing activities are not expected.

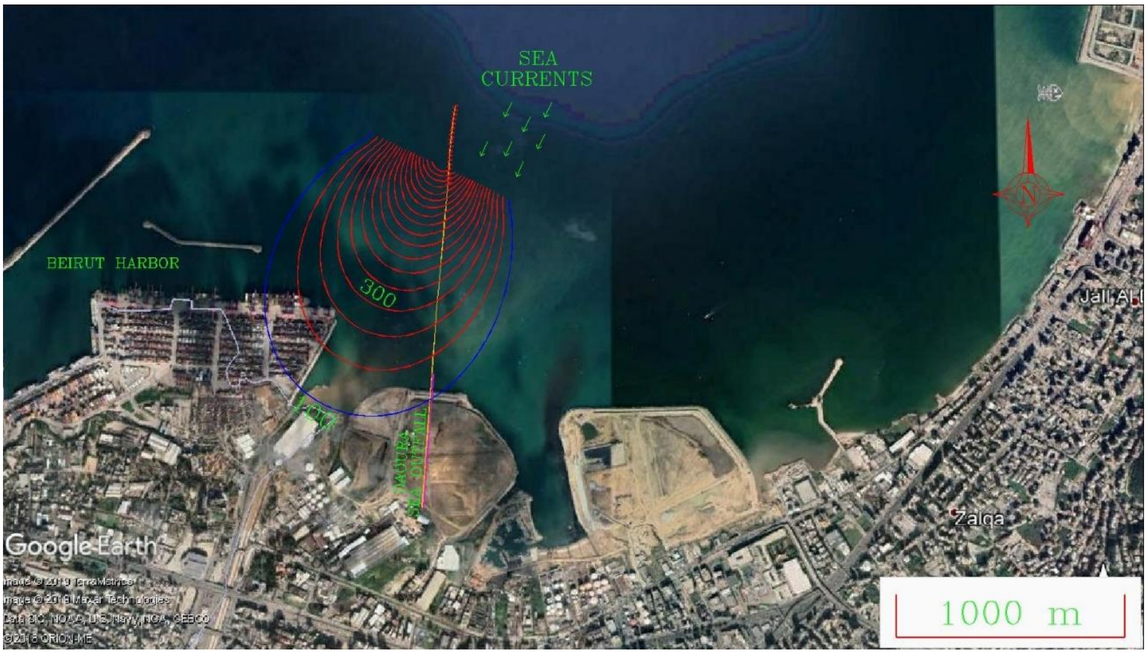


Figure 6-4 Dilution Modeling for the dry season with sea current of 15 cm/s towards the South-West

Pretreated water will be only discharged into the sea until the primary and secondary treatment plant is built, and according to the wastewater dispersion modelling presented above, the impact of pretreated wastewater discharge into the sea from the main outfall pipe is expected to have minor consequences and low likelihood with an overall low environmental impact due to the proper dilution of wastewater away from safe bathing zones.

The wastewater dispersion modeling is mainly focused on bathing considering that it is the most conservative use and the most critical parameter from the discharged pre-treated wastewater is the Fecal Coliform in terms of discharge concentration.

Additional mitigation measures to safeguard that no elevated risks occur include ensuring the raw wastewater is always undergoing preliminary treatment before the effluent is conveyed to the Daoura Sea Outfall. This would ensure that the sea outfall pipe would not become clogged with grit, sand and debris. Additionally, the Operation and Maintenance contract for the preliminary treatment works should stipulate the requirements to collect and test seawater for fecal coliforms counts. Such data would help optimize the dispersion modeling parameters for the Daoura Sea Outfall.

Applying the above will result in a low residual impact with negligible consequences and low likelihood.

Treated Wastewater Effluent Discharge into the Sea from the Outfall Pipe

Although the pre-treated wastewater assessment was mainly focused on the bathing water quality, because the assessment was conservative, the wastewater effluent generated from the full wastewater treatment plant (phase 2) should meet the national ELVs for discharge into the sea water. During the operation of Phase 2 of the WWTP, the wastewater will undergo primary and secondary treatment, thus discharging the treated effluent into the sea will have no negative impacts. On the contrary, this will contribute to improving the sea water quality and eliminating the negative environmental and health impacts of discharging raw or pretreated wastewater in the sea.

Municipalities within the catchment area of the plant should ensure that industrial wastewater is not discharged into the sewer networks without pre-treatment to avoid causing upsets to the biological treatment plant.

Dewatering Activities

Wastewater will be generated from the grit dewatering activities in phase 1, and the sludge dewatering activities in phase 2. This generated wastewater will be discharged along with the influent wastewater for treatment.

Wastewater Generated by the Workers

During operation, domestic wastewater will be generated by the workers from offices, toilets and laboratory. Domestic wastewater includes black water (fecal sewage), grey water (wastewater from sinks, baths, etc.) and starch, grease, oil (wastewater from kitchen) and is categorized as an organic pollutant. The main pollutants are ammonia, nitrate, Ortho-Phosphate, suspended solids, oil and grease, and pathogens such as bacteria and viruses, etc. The generated wastewater will be diverted to the treatment plant along with the rest of the sewage received by the plant.

6.5.4 Solid Waste

6.5.4.1 Construction Phase

Waste Generation from Construction Activities

Waste streams that are likely to be produced during the construction phase of the project include:

- Construction Waste: General construction waste such as cement bags, solvents/oil containers and excavated material (20,000 m^3 of soil from Phase 1) will be generated from the construction of the proposed site. Solvents and other chemicals (such as paints) used during construction and finishing of the stations are considered as hazardous waste and shall be managed accordingly.
- Part of the excavated material will be re-used for backfilling, especially those excavated for the construction of the pressure lines, while the remaining quantity and the construction waste will be disposed of in a Construction and Demolition Waste

(CDW) dumpsite approved by MoE and in coordination with the Municipality of Burj Hammoud. No waste will be left on-site during or after the completion of construction works.

- Domestic Waste: regular domestic solid waste generated by the workers is expected. All domestic solid waste and littering generated by construction workers has to be collected and disposed of in communal bins to be collected by the local waste contractor.

Inappropriate waste handling and disposal practices may potentially result in nearby surface water bodies' contamination due to leachate generation and polluted runoff.

6.5.4.2 Operation Phase

Collected Pretreatment Process Waste

The waste generated from the pretreatment headworks plant will be namely the debris and material trapped by the coarse and fine screens, grit, and grease.. The estimated annual screenings waste that will be collected is between 7,000-21,000 m^3. As for the estimated quantities of sand and grit that will be removed from the plant is 37,621 m^3/day.

The collected screening waste from both the coarse and fine screens will be automatically removed to a lower floor in the screens' building structure where they will be washed, dewatered, and then collected in containers for landfilling at the Burj Hammoud Landfill. As for the collected material from the grit and grease removal units, they will be washed then dewatered, and shall be classified for reuse or disposal based on its characteristics. Grease in the wastewater will be removed using surface scrappers, and the collected scum will be sent for disposal in the Burj Hammoud landfill.

Generated Sludge

The majority of waste generated from the primary and secondary treatment plant will be the treated sludge. The generated sludge might cause off-site negative impacts on soil if not properly handled, stored and transferred. However, since the sludge will be dewatered and treated onsite, its negative impacts are considered low during handling and transportation to the closest landfilling facility for disposal.

Domestic Solid Waste

Domestic waste generated by the workers will largely include organic food waste and common office waste such as paper and cardboard waste. It is expected that the waste will be stored in bins and will be disposed of as part of the municipal waste management system in Burj Hammoud.

6.5.5 *Accidental Releases*

6.5.5.1 Construction Phase

Accidental Spills of Fuel, Oil and Chemicals

The major potential sources of accidental spills in this project include chemicals (paint), diesel supplies, lubricating oil as part of routine equipment and generators operations, and maintenance during the construction phase.

These spills may 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. 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 soil, they tend to adhere and accumulate due to their low evaporation and biodegradability.

There is a high risk of accidental spills during maintenance on site if no precautionary measures are in place.

The site and its surroundings are situated on top of a reclaimed land on the shoreline of the Mediterranean Sea. Direct discharge of chemical spills into the Mediterranean will lead to serious contamination of the seawater. Mitigation measures to reduce the consequence and likelihood of chemical spill are proposed in the EMP.

6.5.5.2 Operation Phase

Wastewater Discharged in the Sea from the Overflow Pipe

The major potential source of overflow and/or flooding is either from excess storm water in the system from heavy rainfall events if rainwater is entering the sewerage, or from malfunction of the WWTP and prolonged power outages. Should overflow/flooding of the WWTP occur then the Mediterranean Sea will most likely be further polluted because the dispersion factor available from the main outfall pipe will not be available. Moreover, the pretreated wastewater is discharged into the sea during the operation phase is only screened for large objects, grit and grease and the wastewater will still be contaminated with biological and chemical contaminants such as fecal coliforms.

Precautionary design measures have been already incorporated in the design of the pretreatment headworks, and those include:

- A standby pump is available to cover the overflow requirements and in case the main ones fail to operate.

- A stand by coarse screen is available to cover the wet weather peak flow.
- A standby air blower is available to supply the air to the aerated grit removal channels.
- 4 generators, 1600 KVA each, are available in case of power outages, plus an additional generator to be added for Phase 2.
- In the emergency case of an overflow, the wastewater is discharged into the sea via the overflow pipe.

In all cases an assessment of the performance of the Daoura Overflow Pipe under variable flow and environmental conditions was conducted by modelling the dispersion of wastewater discharged from the overflow pipe during Phase 1. The results revealed that for the horizon 2020, during the summer season, the wastewater plume dispersion reveals the following would have negative impacts on the marine northern border of the newly reclaimed land east of the Daoura overflow pipe. The fecal coliforms concentration, along the northern edge of the newly reclaimed land, would be 1000 FC/100ml. At the north-western edge, the fecal coliforms concentration would be as high as 3,000 FC/100ml. There is no bathing beach shoreline along the northern border of the newly reclaimed land east of the Daoura overflow pipe. Negative impacts on bathing activities are not expected.

The marine zone extending from north of the plant reclaimed land to the north-west toward the Beirut harbor would have high fecal coliforms concentrations with a maximum of 15,000 FC/100ml. The fecal coliforms concentration reduces to the threshold value of 100 FC/100ml at the eastern edge of the Beirut harbor. This zone is not used for bathing, or for recreational activities, especially that there are no shoreline beaches along this zone. Accordingly, this zone cannot be considered sensitive. Negative environmental impacts on bathing activities are not expected

From the eastern edge of the newly reclaimed land and further downstream toward all the areas to the east, the discharged wastewater would not have negative impacts on the safe bathing zone that extends from shoreline to a distance of 300 meters into the sea.

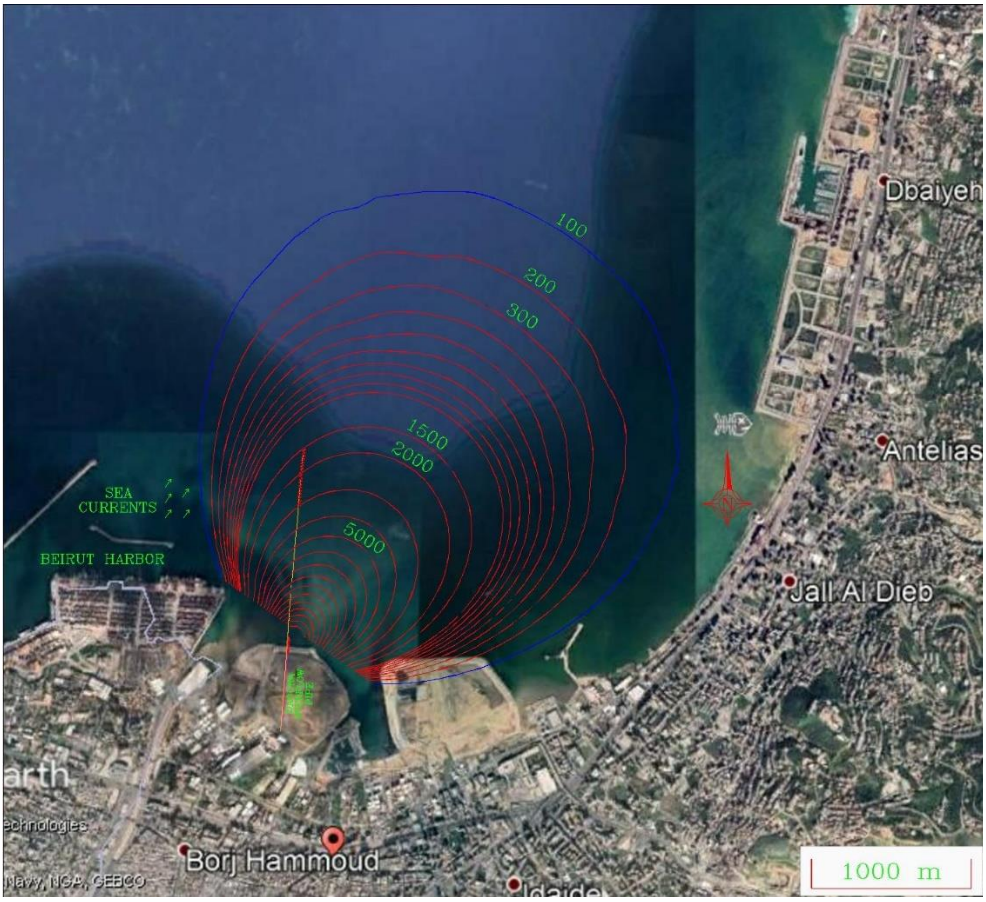


Figure 6-5 Dilution Modeling from the overflow pipe for the Dry Season with Sea Current 20 cm/s towards the North-East

Thus, the impact of pretreated wastewater discharge into the sea from the overflow pipe is expected to have moderate consequences and low likelihood with an overall low environmental impact due to the proper dilution of wastewater away from safe bathing zones.

Some of the recommended mitigation measures to be adopted during the operation phase include:

- The land reclamation activities, over the Daoura Oveflow Pipe, may have resulted in the burial of about six diffusers. As part of the foreseen rehabilitation works, the overflow pipe needs to be inspected further by divers. If, some of the diffusers have become buried, rehabilitation activities to completely close and disconnect these diffusers would be needed. This would be to ensure that no debris get into the pipe and no wastewater flows get out of these diffusers lifting up the reclaimed sediments above.
- There could be a need to extend the overflow pipe further into the sea in light of the fact that its marine section has now become substantially reduced. This would require desk studies to evaluate the extension length taking into account hydraulics, available water heads upstream, economics and plume dispersion.
- For proper performance, the raw wastewater must always undergo preliminary treatment before the effluent is conveyed to the Daoura Overflow Pipe. This would ensure that the overflow pipe would not become clogged with grit, sand and debris.

- The diversion of the wastewater flow to the Daoura Overflow Pipe should not be practiced randomly. The diversion of wastewater flows to the overflow pipe should only take place when the Daoura Sea Outfall must be put out of service for maintenance or repairs. It would be most suitable to schedule any maintenance or repair activities for the sea outfall during the winter season.

Considering the above mitigation measures are fully implemented the residual impact of wastewater discharge from the overflow pipe would be low with minor consequences and low likelihood.

Accidental Spills of Fuel, Oil and Chemicals

The odor control unit proposed for this project consists of scrubber towers that would be using sulfuric acid H_2SO_4 which can lead to major environmental impacts in case of spills. The issues relate to the handling of the hazardous chemical from its origin source, along the travel path, at Beirut harbor when imported, along the Lebanese roadways and inside the plant.

The storage tanks of sulfuric acid need to be contained within concrete curbs in order to curtail any leakage. It would be very dangerous not to foresee containment curbs for the sulfuric acid. For this issue, the documents provided by the client did not mention any details on the containment curb in the description of the proposed odor control unit for the project.

Accidental spills could also occur during refueling of diesel supplies and lubricating oil as part of routine generators operations and maintenance during the operation phase. Leakage / spills from fuel and diesel storage tanks can also occur. Such sources can cause surface water pollution if improperly contained and disposed of.

The occurrence of accidental spills has medium likelihood and could lead to moderate consequences given the location of the site. Further mitigation measures to reduce the risk of chemical and fuel spills are proposed in the EMP.

6.5.6 *Depletion of Resources*

6.5.6.1 Energy Resources

6.5.6.1.1 Construction Phase

During construction, electricity will be sourced from EDL's grid and from private generators during power outage. In addition, fuel will be used for the operation of project equipment and vehicles.

The impacts on energy resources during the construction phase are expected to be moderate given the size and duration of the project.

6.5.6.1.2 Operation Phase

During operation, electricity provided by EDL will be used to operate the pretreatment headworks plant and private generators will be used during power outage. The total demand for the pretreatment area is estimated at 4,915 KVA.

Moreover, the two biogas engines for Phase 2 are proposed for the cogeneration of 24/7 electricity. The electrical energy produced shall cover part of the electrical power needs of the WWTP and the thermal energy shall be used for the heating of the digesters.

The impacts on energy consumption during the operation phase are expected to be moderate.

6.5.6.2 Water Resources

6.5.6.2.1 Construction Phase

Water consumption is expected to reach a maximum of 11,200 L per day considering construction activities of the pretreatment headworks will require 70 workers. The majority of water consumption is expected to come from domestic use since relatively low quantities of water will be used for construction purposes, mainly watering down of working areas for dust suppression.

6.5.6.2.2 Operation Phase

During the operation phase of the pretreatment headworks plant, the average water consumption is estimated to be around 830 liters per day. Therefore, the additional pressure from the project’s operation on water resources is considered relatively low.

6.5.6.3 Land Resources

6.5.6.3.1 Construction Phase

Site clearance, grading and excavation activities are expected to take place over the reclaimed land whereby changes in natural topography and surface drainage are nonexistent.

Excavated and raw material stockpiles such as sand that are neither contained nor covered during rainfall season can be transported by runoff water and reach the nearby Mediterranean Sea.

6.5.6.3.2 Operation Phase

No major impacts are expected to result from the Daoura-Burj Hammoud WWTP on land resources during the operation phase, only negligible changes. Possible impact on land depreciation of adjacent plots that are going to be developed in the future by the

Municipality of Burj Hammoud might occur, however the deteriorated conditions of the area in general makes this unlikely to happen.

6.5.6.4 Biological Resources

6.5.6.4.1 Construction Phase

As observed during the field survey, the proposed site for the project is located on a reclaimed land on the coast of Burj Hammoud in an environmentally deteriorated area. This site is not a natural landscape and was originally part of the sea. Based on that, the project will not lead to significant negative impacts on the terrestrial biodiversity.

The main factors associated with construction activities and having negative impacts are on marine biodiversity mainly caused by the rehabilitation works of the outfall and overflow pipes. Impacts from this activity are mainly due to the mismanagement of generated waste and wastewater, and potential accidental spills of oils and chemicals, as well as disturbances to the marine habitat along the pipes extension area.

6.5.6.4.2 Operation Phase

During operation the impacts on biological resources are considered positive, due to the already deteriorated conditions of the sea water quality in the area, the treated water will stop the discharge of chemical and biological polluters. During the Pre-treatment phase the outfall and overflow pipes' diffusers will aid in diluting the wastewater discharged in the sea. Additionally, the limited impacts on marine biological resources during the pre-treatment phase would be reversible particularly given the nature of the effluent (i.e. sewage).

6.5.7 Socio-economic Impacts

6.5.7.1 Construction Phase

The project is expected to have direct negative impacts on socio-economy due to increased pressure on infrastructure and disturbances from noise and air emissions and dust generation, and increase pressure on traffic in an area that suffers from a lot of traffic during rush hour.

On the other hand, the project is expected to have direct positive impacts on socio-economy. These include:

- The creation of new construction-related job opportunities; and
- The creation of opportunities for local businesses in the supply of goods and services.

6.5.7.2 Operation Phase

During operation the pretreatment headworks plant is expected to have negative impacts on the socio-economic level due to the following reasons:

- Nuisance from odor emissions caused from the pretreatment plant. This will mainly impact the industries south of the proposed project and the future developments planned on the rest of the reclaimed area. In some cases due to a change in regular wind directions, the odor can reach the residential areas south of proposed project in Burj Hammoud worsening the foul odors conditions that the area suffers from already. Nuisance from odors is highly expected in case no design changes to the plant are implemented.
- Land value depreciation in the surroundings, although doubtful considering that the area is already highly environmentally deteriorated due to the nearby landfill, and surrounding industrial area; and

Alternatively, the proposed project will have positive impacts due to:

- Treatment of the wastewater generated from the areas to be connected to the plant, thus eliminating haphazard wastewater discharge into rivers, streams, and direct discharge of wastewater on the shore in some coastal areas.
- Reducing the levels of bathing water contamination in the surrounding areas connected to the treatment plant. As revealed from the dilution modeling for the outfall and overflow pipes the discharge of preliminary treated wastewater during the summer season would not have negative impacts on the safe bathing zone that extends from shoreline to a distance of 300 meters into the sea, along all the areas to the east of the sea outfall. The closest bathing beaches to the proposed project site is the area near la Marina Dbayeh (6 km) to the North, and the AUB Beach (5.7 km) to the West. As for the primary and secondary treatment phase, the quality of the sea water is expected to be improved, as chemical and biological pollutants in the wastewater will be removed and reduced to acceptable concentrations in the treated effluent.

6.5.8 Archaeology and Cultural Resources

Considering that the proposed project will be located on a recently reclaimed land with no impacts on archeology are expected.

6.5.9 Traffic

6.5.9.1 Construction Phase

The construction phase requires the transport of heavy machinery and equipment, construction materials and wastes, in addition to the workforce. Vehicles transporting materials and wastes may need several trips to the construction site per day, which may increase the traffic volume on the roads leading to this site, namely during peak hours (morning and evening time). Areas in the direct vicinity of the Project construction site, already experience heavy traffic during rush hours, will experience an increase in traffic volume due to the deployment of construction vehicles, transport vehicles and equipment. Increased traffic will also lead to an increase in noise levels, air pollutants emissions and the risk of accidents.

6.5.9.2 Operation Phase

No impacts on traffic are anticipated during the operation of the wastewater pretreatment headworks plant.

6.5.10 Health and Safety Hazards

6.5.10.1 Construction Phase

Working on a construction project entails several health and safety risk factors, related to accidents resulting from the improper handling and storage of construction material as well as accidents occurring with the operation of moving equipment and trucks moving on-site. These factors need to be addressed ahead of the influx of the construction workers. The main sources of health and safety risks include physical injuries and exposure to dust and noise. According to the World Health Organization (WHO), prolonged or excessive exposure to noise can cause hearing impairment; similarly, exposure to dust will have respiratory impacts.

6.5.10.2 Operation Phase

During the project's Operation phase, serious negative impacts on the staff's health and safety may occur if no proper hazard identification, elimination, and mitigation measures are implemented. The main sources of health and safety risks during operation are related to exposure to high levels of H_2S gas emitted from the wastewater at several stages of the pretreatment plant. However, as a mitigation measure in the plant design, the plant will be equipped with H_2S detectors and alarm system to warn employees about high H_2S levels in the air.

Another negative impact relates to the handling and storage of strong acidic chemicals (sulfuric acid) to be used in the odor control unit of the pretreatment headworks plant. A non-informed worker just touching or getting splashed with sulfuric acid would have the body part disintegrated. Exposure to sulfuric acid would cause permanent burns and if it touches the eyes immediate blindness would result. Due to potential hazards inherent with the handling, storage and use of sulfuric acid, the EIA study does not recommend the proposed OCU for this project and proposes other safer odor control technologies.

Health and safety hazards from daily routine works and possible exposure to the wastewater also pose a risk.

6.6 SUMMARY OF ENVIRONMENTAL IMPACTS

A summary of environmental impacts before and after implementation of mitigation measures is provided in Table 6-10 and Table 6-11.

Table 6-10 Summary of Environmental Impact Assessment (Before and After Mitigation) during the Construction Phase

Environmental Aspect	Potential Impact		Nature	Magnitude	Extent	Timing	Duration	Reversibility	Consequence	Likelihood	Significance
Emissions											
Air Emissions	• Change in air quality due to combustion and exhaust emissions from vehicular transport, generators, and operation of construction equipment; • Change in air quality from airborne particulates from land excavation and clearance.	Before Mitigation	N/D	M	L	S	C	R	3. Moderate	3. High	9. Medium
		After Mitigation	N/D	L	L	S	C	R	1. Negligible	3. High	3. Low
Noise	• Increase in noise levels from mobilization and operation of equipment; excavation and construction activities, vehicles movement (especially trucks); and operation of generators.	Before Mitigation	N/D	M	L	M	C	R	3. Moderate	3. High	9. Medium
		After Mitigation	N/D	L	L	S	C	R	1. Negligible	3. High	3. Low
Wastewater Generation	• Soil and water contamination from inadequate handling and disposal of sewage and liquid wastes	Before Mitigation	N/D	M	L	L	C	R	3. Moderate	3. High	9. Medium
		After Mitigation	N/D	L	L	S	C	R	1. Negligible	1. Low	1. Low
	• Dewatering Activities	Before Mitigation	N/D	M	L	S	C	R	3. Moderate	2. Medium	6. Medium
		After Mitigation	N/D	L	L	S	C	R	1. Negligible	1. Low	1. Low
Solid Waste		Before Mitigation	N/D	M	L	M	C	R	3. Moderate	2. Medium	6. Medium

Environmental Aspect	Potential Impact		Nature	Magnitude	Extent	Timing	Duration	Reversibility	Consequence	Likelihood	Significance
	• Soil and water contamination from inadequate handling and disposal of construction and domestic solid waste	After Mitigation	N/D	L	L	M	C	R	2. Minor	1. Low	2. Low
Accidental Releases	• Soil and water contamination from accidental Spills of Fuel, Oil and Chemicals	Before Mitigation	N/D	M	L	L	C	R	3. Moderate	3. High	9. Medium
		After Mitigation	N/D	L	L	S	C	R	1. Negligible	1. Low	1. Low
Depletion of Resources											
Energy Resources	• Electricity consumption and diesel consumption for generators, vehicles and equipment operation	Before Mitigation	N/D	L	L	M	C	R	2. Minor	3. High	6. Medium
		After Mitigation	N/D	L	L	S	C	R	1. Negligible	3. High	3. Low
Water Resources	• Water Consumption for domestic or construction purposes	Before Mitigation	N/D	L	L	M	C	R	2. Minor	3. High	6. Medium
		After Mitigation	N/D	L	L	S	C	R	1. Negligible	3. High	3. Low
Land Resources	• Temporary or permanent change in topography, soil permeability, erosion and collapse from grading, trenching, or excavation	Before Mitigation	N/D	L	L	M	C	R	2. Minor	2. Medium	4. Medium
		After Mitigation	N/D	L	L	S	C	R	1. Negligible	2. Medium	2. Low
Biological Resources	• Impacts associated with rehabilitation of the outfall/overflow pipes	Before Mitigation	N/D	L	L	M	C	R	2. Minor	3. High	6. Medium
		After Mitigation	N/D	L	L	M	C	R	2. Minor	1. Low	4. Low
Other Impacts											
Socio-economic	• Increased pressure on infrastructure	Before Mitigation	N/D	M	L	S	C	R	3. Moderate	3. High	9. Medium
		After Mitigation	N/D	L	L	S	C	R	1. Negligible	3. High	3. Low

Environmental Aspect	Potential Impact		Nature	Magnitude	Extent	Timing	Duration	Reversibility	Consequence	Likelihood	Significance
	• Disturbances from traffic, noise and air emissions and dust generation	Before Mitigation	N/D	M	L	S	C	R	3. Moderate	3. High	9. Medium
		After Mitigation	N/D	L	L	S	C	R	1. Negligible	2. Medium	2. Low
	• Job creation • Creation of opportunities for local businesses in the supply of goods and services	Before Mitigation	P/D	-	-	-	-	-	B. Beneficial	3. High	+++ Beneficial
		After Mitigation	P/D	-	-	-	-	-	B. Beneficial	3. High	+++ Beneficial
Traffic	• Increase in traffic volumes	Before Mitigation	N/D	M	L	S	C	R	3. Moderate	3. High	9. Medium
		After Mitigation	N/D	L	L	S	C	R	1. Negligible	2. Medium	2. Low
Health & Safety	• Physical Injuries • Exposure to dust and noise	Before Mitigation	N/D	M	L	M	C	R	3. Moderate	2. Medium	6. Medium
		After Mitigation	N/D	L	L	S	C	R	1. Negligible	1. Low	1. Low

Table 6-11 Summary of Environmental Impact Assessment (Before and After Mitigation) during the Operation Phase

Environmental Aspects	Potential Impact	Mitigation	Nature	Magnitude	Extent	Timing	Duration	Reversibility	Consequence	Likelihood	Significance
Emissions											
Air Emissions	• Nuisance due to odor emissions from the plant	Before Mitigation	N/D	H	L	L	O	R	4. Major	3. High	12. High
		After Mitigation	N/D	L	L	L	O	R	3. Moderate	1. Low	3. Low
	• Change in air quality from air emissions from generators and equipment	Before Mitigation	N/D	M	L	S	O	R	3. Moderate	3. High	9. Medium
		After Mitigation	N/D	L	L	S	O	R	1.Negligible	3. High	3. Low
Noise	• Change in noise levels from normal operation and maintenance activities	Before Mitigation	N/D	L	L	M	O	R	2. Minor	2. Medium	4. Medium
		After Mitigation	N/D	L	L	S	O	R	1.Negligible	1. Low	1. Low
Wastewater	• Deterioration of seawater water quality due to discharge of pre-treated wastewater from the sea outfall pipe during Phase 1	Before Mitigation	N/D	L	L	M	O	R	2. Minor	1. Low	2. Low
		After Mitigation	N/D	L	L	S	O	R	1.Negligible	1. Low	1. Low
	• Discharge of treated effluent from the sea outfall pipe during Phase 2	Before Mitigation	N/D	L	L	S	O	R	1.Negligible	1. Low	1. Low
		After Mitigation	N/D	L	L	S	O	R	1.Negligible	1. Low	1. Low
	• Dewatering of grit and sludge	Before Mitigation	N/D	M	L	S	O	R	3. Moderate	2. Medium	6. Medium
		After Mitigation	N/D	L	L	S	O	R	3. Moderate	1. Low	3. Low
Solid Waste	• Soil and water pollution from inadequate disposal of wastes generated from pretreatment units	Before Mitigation	N/D	H	L	L	O	R	4. Major	2. Medium	8. Medium
		After Mitigation	N/D	L	L	S	O	R	2. Minor	1. Low	2. Low

Environmental Aspects	Potential Impact	Mitigation	Nature	Magnitude	Extent	Timing	Duration	Reversibility	Consequence	Likelihood	Significance
	• Soil and water pollution from inadequate disposal of sludge from treatment units	Before Mitigation	N/D	M	L	M	O	R	3. Moderate	2. Medium	6. Medium
		After Mitigation	N/D	L	L	S	O	R	2. Minor	1. Low	2. Low
	• Soil and water pollution from inadequate disposal of domestic solid waste generated by the workers	Before Mitigation	N/D	L	L	M	O	R	2. Minor	1. Low	2. Low
		After Mitigation	N/D	L	L	S	O	R	1.Negligible	1. Low	1. Low
Accidental Releases	• Deterioration of seawater quality due to discharge of pretreated wastewater from the emergency outfall pipe during Phase 1	Before Mitigation	N/D	H	G	L	O	R	1. Minor	3. High	3. Low
		After Mitigation	N/D	M	L	S	O	R	2. Minor	1. Low	2. Low
	• Soil and water pollution from accidental Spills of Fuel, Oil and Chemicals	Before Mitigation	N/D	M	L	L	O	R	3. Moderate	2. Medium	6. Medium
		After Mitigation	N/D	L	L	S	O	R	2. Minor	1. Low	2. Low
Depletion of Resources											
Energy Resources	• Electricity consumption	Before Mitigation	N/D	M	L	L	O	R	3. Moderate	3. High	9. Medium
		After Mitigation	N/D	L	L	M	O	R	2. Minor	3. High	6. Medium
Water Resources	• Water consumption	Before Mitigation	N/D	M	L	M	O	R	3. Moderate	1. Low	3. Low
		After Mitigation	N/D	L	L	M	O	R	2. Minor	1. Low	2. Low
Land Resources	• Possible impact on land depreciation and land use change of adjacent plots	Before Mitigation	N/D	L	L	L	O	R	2. Minor	1. Low	2. Low
		After Mitigation	N/D	L	L	L	O	R	1. Negligible	1. Low	1. Low
		Before Mitigation	N/D	L	L	L	O	R	2. Minor	1. Low	2. Low

Environmental Aspects	Potential Impact	Mitigation	Nature	Magnitude	Extent	Timing	Duration	Reversibility	Consequence	Likelihood	Significance
Biological Resources	• Normal operation: discharge of preliminary treated wastewater during Phase 1	After Mitigation	N/D	L	L	L	O	R	1. Negligible	1. Low	1. Low
	• Normal operation: discharge of treated wastewater during Phase 2	Before Mitigation	N/D	L	L	S	O	R	1.Negligible	1. Low	1. Low
		After Mitigation	N/D	L	L	S	O	R	1.Negligible	1. Low	1. Low
Other Impacts											
Socio-economic	• Land value depreciation	Before Mitigation	N/D	L	L	L	O	R	2. Minor	1. Low	2. Low
		After Mitigation	N/D	L	L	L	O	R	1. Negligible	1. Low	1. Low
	• Improvement in coastal water quality	Before Mitigation	P/D	-	-	-	-	-	B. Beneficial	3. High	+++ Beneficial
		After Mitigation	P/D	-	-	-	-	-	B. Beneficial	3. High	+++ Beneficial
Health & Safety	• Increased health and safety risks to workers.	Before Mitigation	N/D	H	L	L	O	R	4. Major	3. High	12. High
		After Mitigation	N/D	L	L	L	O	R	2. Minor	2. Medium	4. Medium

7. ANALYSIS OF ALTERNATIVES

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

For this purpose, the following options were evaluated and compared:

- No-Project Alternative;
- Project design alternative for the odor control unit;
- Project design alternative for the sea outfall diffusers;
- Alternative management of pre-treatment waste; and
- Alternative sludge management

7.1 NO-PROJECT ALTERNATIVE

The "No Action" alternative implies canceling the project's implementation in its original location, leaving untreated wastewater discharge into the sea in its current situation, with all associated impacts on the marine ecosystem, water resources and public health.

Under this scenario, untreated wastewater from Greater Beirut Northern area and the other localities which will be connected to the proposed project in Burj Hammoud would continue to be discharged directly into the Mediterranean Sea. Although the negative impacts that are caused by the construction phase will be eliminated, but the no-project scenario will pollute the environment negatively by increasing seawater, groundwater and surface water pollution, soil contamination, odor generation, in addition to impacting marine biodiversity and causing adverse health impacts to the people consuming fish (collected from the area), and practicing swimming along the coast.

Given the information presented above, the "No Project" alternative is not a recommended alternative.

7.2 PROJECT DESIGN ALTERNATIVE FOR THE ODOR CONTROL UNIT

One of the most critical aspects of wastewater preliminary treatment relates to the generation of odors that can lead to nearby community nuisance, an issue that was raised several times during the scoping public consultation session. The current designs of the two phases of the Burj Hammoud include odor control units to prevent the possible generation of foul odors during normal operations or in case of a malfunction. The odor control unit adopted in the design of the preliminary treatment headworks is based on the process of oxidation/ scrubbing and the primary and secondary treatment phase is based on the use of bio-scrubbers.

This technology depends on the absorption of chemicals causing foul odors in the air by scrubbing the influent air with water and other chemicals. Systems that rely on chemical scrubbers are highly efficient in removing H2S and ammonia odors, which are the most common odors generated from municipal wastewater infrastructure. Although highly efficient, this system entails higher operational and maintenance costs when compared to other technologies.

Several alternative odor control technologies were considered, and three were selected for further investigation. These technologies are (i) Activated Carbon Filter, ii) Bio-filter, and iii) Bio-trickling filter.

7.2.1 Granular Activated Carbon Filter (GAC)

Activated carbon filters achieve odor removal from an air flow by adsorbing odorous compound and binding them to the surface of an activated carbon bed. The contact time required between the foul air and the activated carbon bed is approximately 2-4 seconds. This technology is simple and highly efficient in removing odors generated due to the presence of high concentrations of Hydrogen Sulphide (H_2S) with up to 99% removal rates. The life of a GAC bed between regenerations can last up to 3 years, and if Ozone and Ozone-Hydrogen Peroxidation is used to enhance the biological activity in GAC by oxidizing organic matter to biodegradable forms, the bed can last about 10 years. The technology is considered environmentally friendly, and eliminates the need to use hazardous chemicals within the OCU.

7.2.2 Bio-filter

Bio-filters are made up of a fixed bed material that is used as growing media for certain microorganisms that can break down odors. Bio-filters are considered efficient in removing a mix of odors and VOCs, however some limitations prevail when removing high concentrations of H_2S. High H_2S levels will induce an acidic medium that can destroy essential microorganisms feeding on complex odorous compounds, as well as sulfur accumulation from H_2S oxidation can hinder the performance of the growing media. Alkaline material can be added to counteract this issue.

7.2.3 Bio-trickling Filter

Bio-trickling filter is a system that uses water and a special media used for microorganisms' growth. Odorous air enters the system and comes in contact with the growing media, and is sprayed with water containing nutrients and minerals. The sprayed water can be recirculated and used again.

This technology is efficient in removing odors due to H2S and other chemicals, however it requires a higher capital investment.

7.2.4 Comparison of Alternative Technologies

Based on the above, the performance and characteristics of the different odor control technologies considered are presented in below.

Table 7-1 Comparison of the Different Odor Control Technologies

Type	Capital Cost	O&M Costs	HSE Risks	H_2S Removal Efficiency	Other Compounds Removal Efficiency
GAC	Low	Low	Low	High	Low
Bio-filter	High	Medium	Low	High	Medium
Bio-trickling filter	High	Medium	Low	High	Medium
Adopted technology: Chemical Scrubber and Oxidation	Medium	High	High	High	High

Although the currently adopted technology for phase 1 of scrubbing and oxidation is highly efficient in removing H_2S along with other odorous compounds, its operation and management cost was found to be the highest among the suggested technologies. In addition, this technology uses hazardous chemicals, which can pose additional dangerous health and safety risks and can have major environmental impacts if not handled, transported and stored properly. Therefore, the implementation of this technology is not recommended.

As for phase 2, bio-scrubber is the currently adopted technology. It consists of a gas scrubber where components are absorbed by wash water, and a biological reactor where biological degradation occurs.

Based on the results of the odor dispersion modeling study conducted for this ESIA (Appendix H) and considering the low capital and O&M costs of the activated carbon filter as well as its high efficiency in removing the H_2S odors, which are highly prevalent at wastewater treatment facilities (relative to other odorous compounds), the adoption of this technology at the Burj Hammoud preliminary treatment headworks is recommended.

7.3 PROJECT DESIGN ALTERNATIVE FOR THE SEA OUTFALLS DIFFUSERS

The wastewater dilution modeling that was performed as part of this ESIA study assessed the performance of the Daoura Sea outfall under variable flow and environmental conditions, as found in Appendix G and found that:

The discharge of the fully treated wastewater is expected to have positive impacts on the quality of the seawater. And the discharge of preliminary treated wastewater during the summer season would not have negative impacts on the safe bathing zone that extends from shoreline to a distance of 300 meters into the sea, along all the areas to the east of the Daoura sea outfall.

For a particular condition during summer, when the prevailing sea currents direction is reversed, the discharged wastewater plume would disperse in the direction of Beirut harbor. The fecal coliforms concentration would be about 200 FC/100ml at the North-Eastern boundary of the Beirut harbor. The marine zone that extends from the northern edge of the plant reclaimed land to Beirut harbor north-eastern boundary is subject to industrial marine activities including large shipping vessels movements, fuel tankers and the like. This zone is not used for bathing, or for recreational activities, especially that there are no shoreline beaches along this zone. Therefore, this zone can’t be considered sensitive.

Based on these findings, no alternative design is suggested for the outfall diffusers, however some recommendation were provided for the existing design including:

- Completely close and disconnect any diffuser that has been buried by the rehabilitation activities. This should be done to ensure that no debris get into the pipe and no wastewater flows get out of these diffusers and lift the reclaimed sediments above it.
- Extend the overflow pipe further into the sea, if needed to compensate for the section that has now become substantially reduced. The extension would require desk studies taking into account the hydraulics, available water heads upstream, economics, and plume dispersion.
- Limit the diversion of wastewater to the emergency outfall to when the main outfall needs maintenance or repairs.

- Ensure that the sea outfall pipe would not become clogged with grit, sand or debris by only conveying effluent to the outfall after in undergoes preliminary treatment.

7.4 ALTERNATIVE MANAGEMENT OF THE PRE-TREATMENT WASTE

The scenario of alternative waste management requires findings ways to dispose of the grit and sand, and grease, fats, and oils that are removed during the preliminary treatment process and collected in the aerated grit and grease removal tanks.

Grit and sand: The collected sand and grit from the screening process at the preliminary headworks will be washed and dewatered then classified in a specific plant. This process will allow the sand and grit to be clean of organic matter thus can be used for landscape and building materials.

Grease, fats, and oils: the quantities removed are predicted to be low and since the WWTP digester will not be executed during the pretreatment phase of the plant, it is recommended that until the digester is executed, the collected grease, fats and oils should be sent to a certified facility for reuse as combustion materials in industrial burners.

7.5 ALTERNATIVE SLUDGE MANAGEMENT

The scenario of alternative sludge management requires finding ways to dispose of the sludge generated from the primary and secondary treatment phase.

Sludge incineration is a viable option for the WWTP. Although it is an efficient process to minimize the amount of sludge sent to landfilling, it generates highly toxic residual waste and has to be handled and landfilled in a manner that complies with environmental and health standards and regulations. The capital and operational costs for incineration is considered significantly high. The capital cost of an incineration plant is estimated to be 2-2.5 times higher than a sludge drying plant and can lead to severe environmental issues (gaseous emissions, slack disposal, etc.).

Another option would be using the dewatered sludge for agricultural uses. This option would require the quality of the dewatered sludge to be compliant with the relevant national standards, hence the sludge should be regularly tested before it is dispatched for agricultural use. The the dewatered sludge will also have to be transported to the location where it would be used as compost.

The adopted technology in the current design, is treating and dewatering the sludge at the WWTP then transposing it to the closest landfilling facility.

8. ENVIRONMENTAL MANAGEMENT PLAN

8.1 INTRODUCTION

This chapter presents the proposed EMP for the Daoura Burj Hammoud Wastewater treatment Plant. The EMP will highlight the main impacts that were identified in the EIA section and relevant control measures, particularly:

- Mitigation measures to be implemented during the construction and operation phases;
- Waste stream management and disposal methods;
- References to control guidelines and standards;
- Responsibilities for the implementation of the plan;
- Verification, monitoring and training requirements;
- Reporting requirements.

The overall objectives of the EMP are 1) to ensure the Project's compliance with applicable environmental legislation and Proponent's requirements; 2) to provide the Client with clear and specific guidelines to undertake monitoring activities and compliance inspection programs; and 3) to support the Contractor and relevant stakeholders in the implementation of mitigation and monitoring plans. The EMP may be subject to updates and modifications throughout the Project lifetime by the Project Proponent.

8.2 ENVIRONMENTAL MANAGEMENT PLAN

A priority list of the most important mitigation measures for the negative impacts identified in the impact analysis shall be summarized in this section of the EIA report. The mitigation plan shall be based on a source and sensitivity approach, allowing the identification and proposition of protective measures for tackling the problems facing each. The mitigation measures proposed here within are an addition to the mitigation measures already included in the design of the project to further reduce its environmental footprint.

Proposed mitigation measures for construction and operation impacts are summarized in Table 8-1 and Table 8-2.

Table 8-1 Environmental Mitigation Plan for the Construction Phase

Environmental Aspect	Project Activities	Impacts before Mitigation	Mitigation Measures	Impacts after Mitigation	Responsibility	Cost Estimate
Emissions						
Air Emissions	• Combustion and exhaust emissions from vehicular transport, generators, and operation of construction equipment; • Airborne particulates from land excavation and clearance.	Medium	• Ensure the contractor uses properly maintained and operated equipment/vehicles. Precautionary control measures for emissions reduction could include proper engine fuel mixtures and regularly serviced exhaust emission systems, suitable engine tuning, and use of low sulfur content diesel; • Avoid idling vehicles and equipment engines that are left running unnecessarily; • Inspect the presence of black smoke from vehicles and engines and undertake remedial maintenance when it is observed to improve engine efficiency; • Promote collective transportation and carpooling for workers when applicable; • Schedule deliveries of raw material and products efficiently and enforce appropriate speed limits; • Ensure that generator emissions are in line with national standards (MoE Decision 8/1, dated 2001) during operation through regular monitoring of CO, NO_X, SO_2, O_2, flue gas temperature, combustion efficiency, and total dust; • Ensure that an effective maintenance plan and schedule is in place for the generator • Keep the project footprint, and thus areas to be excavated, at a minimum; • Provide wet suppression of areas during excavation and of roads where trucks will circulate; • Cover stockpiles and maintain them at minimum heights and form them into the optimum shape to reduce wind erosion; • Install wind breaks to reduce wind speed; • Cover all incoming and outgoing trucks from the site; and • Inform nearby receptors of the construction works, especially for dusty activities.	Low	Contractor and Supervision Consultant	No separate costs estimation - Included in Contractor's scope of works and fees. Part of construction costs.
Noise	• Mobilization and operation of equipment; • Excavation and construction activities; • Vehicles movement (especially trucks); • Operation of generators.	Medium	• Ensure fencing of the construction site before initiation of works; • Fit all machinery and vehicles with effective exhaust silencers as applicable; • Maintain all machinery and vehicles in good condition and avoid leaving equipment idling unnecessarily; • Material stockpiles and other structures should be effectively utilized to reduce noise from on-site activities, where feasible; • Inform nearby residents of the construction plans, including expected duration, prior to initiating the works; • Establish a procedure to respond to noise complaints which can improve relationships with neighbors and help identify sources of noise for future incidents; • Schedule noisy activities, to the extent possible between 7:00 am and 6:00 pm, to minimize nuisance to neighboring receptors; • Limit work hours as much as possible and avoid noisy activities on Sundays and holidays; and • Conduct regular noise monitoring at the nearest receptors to ensure that noise emissions are compliant with national standards (Decision 52/1); and • Provide workers with noise protection equipment when operating noisy equipment, and enforce their use.	Low	Contractor and Supervision Consultant	Part of construction costs. Noise monitoring: \$300/ day. Cost of Ear muffs: USD 26/unit

Wastewater Generation	• Inadequate Storage and Disposal of Wastewater and Sewage • Washing of vehicles on site, without containing the wastewater	Medium	• Provide fully impermeable septic/ holding tanks; • Empty septic/ holding tanks frequently; • Regular inspection of septic/ holding tanks; • Obtain a permit from the Municipality of the relevant Water Establishment to transport and discharge the wastewater and sludge to authorized facilities/ sites; and • Vehicle washing shall only take place in contained maintenance areas offsite or onsite with impermeable concrete pavement and proper drainage.	Low	Contractor, Supervision Consultant and Municipality of Burj Hammoud	No separate costs estimation - Included in Contractor's scope of works and fees
	• Dewatering Activities	Medium	• Prepare a Dewatering Management Plan for approval prior to commencement of Construction works; and • Analyze groundwater quality prior to discharge	Low	Contractor, Supervision Consultant and Municipality of Burj Hammoud	No separate costs estimation - Included in Contractor's scope of works and fees
Solid Waste	• Construction and domestic solid waste generation	Medium	• Segregate at source recyclable domestic waste, construction waste that can be reused/recycled, construction waste to be disposed of, etc. o Domestic waste (paper, cardboard, organic, etc.): ▪ All construction workers and personnel shall be responsible for ensuring that standards of "good housekeeping" are maintained. This will include clearance of all rubbish and work associated debris; ▪ Sorting at source of domestic and general waste is proposed to be implemented. Waste should be sorted into combustible (paper, cardboard, food, and wood) and non-combustible waste (metals, glass, rubble, in addition to plastics) streams by means of suitably labeled containers for safe collection, segregation and handling of all waste streams generated; and ▪ Organic waste should not exceed a 24-hour storage time to avoid attraction of pests and flies. o Hazardous Waste (waste oil, solvents, etc.) ▪ Hazardous waste such as solvents, used batteries, used generator oil and filters, and empty paints' containers should be stored in safe labeled containers and sold to one of the facilities listed in MoE Circular 7/1 of 2017 o Construction Waste: ▪ Excavation waste should be used for levelling/ backfilling activities to the extent possible, transported in trucks on days with low wind activity, and covered with green mesh in order to avoid their release into the environment. • Reuse part of the excavation waste in backfilling; additional unneeded construction waste must be disposed of in an approved Construction and Demolition Waste (CDW) dumpsite in coordination with the Municipality and in agreement with MoE; • Avoid over-ordering of construction materials; • Establish a recording system for the amount of waste generated, recycled, and landfilled; • Progressively carry out rehabilitation of disturbed areas following completion of work in each area (rehabilitation will include reinstatement of soil, surface leveling, re-vegetation and mulching where applicable); • Ensure that standards of "good housekeeping" are maintained (i.e., avoiding littering, preventing storage of combustible waste for more than 24 hours to prevent attraction of pests and flies, continuous clearing of the site from all kinds of waste); and • Cover and contain construction waste stockpiles to avoid them being transported by wind and rain.	Low	Contractor, Supervision Consultant and Municipality of Burj Hammoud	No separate costs estimation - Included in Contractor's scope of works and fees

Accidental Releases	• Accidental Spills of Fuel, Oil and Chemicals	Medium	• Any type of chemical, oil, fuels and lubricants must be stored and handled within containment facilities (e.g. bounded areas, leak proof trays) designed to prevent the release of spills/leaks to the soil and groundwater environment; • Maintenance schedules shall be put in place as part of the inspection procedures of all equipment/generators/machinery for risk minimization; • Maintenance of machines and equipment shall take place off-site or onsite in a contained area with impermeable concrete pavement and drainage for vehicle washing and maintenance; • Oil spill response kits shall be available wherever oils are being used/stored; • Promote awareness among workers on how to handle oil/lubricants; • Train workers on how to clean up small scale spills; • Promote good housekeeping practices during construction; • Ensure drip trays are present when re-fuelling; • Prepare a Spill Emergency Plan specific for the project; • In case of a spill: o Stop the source of spill (close valve, seal pipe, seal hole or as appropriate); o Immediately notify the EHS manager and construction manager who will in turn notify the project proponent and MoE in accordance with the Spill Emergency Plan; o Check for hazards, flammable matters on site; o Clean the spill by removing affected top soil layer by trained employees (they should be wearing appropriate PPE); o Treat the removed layer as hazardous waste and store them on impermeable and solvent resistant plastic sheets such as heavy gauge polyethylene plastic sheets before coordinating with MoE on the recommended disposal/treatment option; and o Adopt as much as possible dry cleaning techniques to decrease resulting wastewater, and to avoid flushing of spills to the aquifer (Sannine Formation – C4).	Low	Contractor and Supervision Consultant	Cost of spill Response Kit: 80 USD Cost of Drip Trays: 60 USD
Depletion of Resources						
Energy Resources	• Electricity consumption and diesel consumption for generator, vehicles and equipment operation	Medium	• Use equipment and vehicles with higher fuel efficiency; • Report and monitor monthly fuel and energy consumption in records to keep track of consumption levels and identify overuse; • Avoid unnecessary idling of vehicles and equipment engines; and • Ensure that an effective Maintenance Plan and Schedule is in place for the generator and equipment.	Low	Contractor and Supervision Consultant	No separate costs estimation - Included in Contractor's scope of works and fees
Water Resources	• Water consumption for construction activities and domestic purposes	Medium	• Adopt water saving techniques and raise construction workers' awareness on the matter so as to avoid over-consumption	Low	Contractor and Supervision Consultant	No separate costs estimation - Included in Contractor's scope of works and fees
Land Resources	• Temporary or permanent change in topography, soil permeability, erosion and collapse from grading, trenching, or excavation	Medium	• Ensure international (ASTM) standards are met during excavation works, compaction and grading activities, in order to minimize expected disturbance during the construction phase; • Manage fixed routes for equipment movement and avoid multiple routes; • Contain and cover all stockpiles to avoid runoff water transporting suspended solids as a result during precipitation events; • Sort excavated material based on reusable agricultural soil and other excavation waste; • Secure transportation and reuse of excavated arable soil in agriculture; and	Low	Contractor and Supervision Consultant	No separate costs estimation - Included in Contractor's scope of works and fees

			• Reuse excavated/cut low agricultural quality materials as general fill where considered suitable.			
Biological Resources	• Rehabilitation of existing sea outfall/overflow pipes	Medium	• Limit activities along the extension area of the pipes only and prevent any disturbances to surrounding marine areas. • Properly remove and dispose of generated construction waste; • Transport and use lubricants and fuel in the sea to the construction site in the appropriate containers to prevent any spills;	Low	Contractor and Supervision Consultant	No separate costs estimation - Included in Contractor's scope of works and fees
Other Impacts						
Socio-economic	• Increased pressure on infrastructure	Medium	• All construction workers and personnel shall be responsible for ensuring that standards of "good housekeeping" are maintained. This will include: o Clear all rubbish and work associated debris; o Sort domestic and general waste into combustible (paper, food, cardboard, and wood) and non-combustible waste (metals, glass, rubble) streams at source by means of suitably labeled containers for safe collection, segregation and handling of all waste streams generated; and o Avoid storage of combustible waste for more than 24 hours to prevent attraction of pests and flies. • Sort and collect hazardous wastes separately from domestic waste. All hazardous waste bags/ containers should be properly labeled so as to prevent occupational health hazards; • Compile details of hazardous wastes, including type, amount and disposal method, to track final destinations and identify opportunities for improvement; • Transport excavation and construction wastes in covered/closed trucks; and • Promote water conservation and energy efficiency during construction.	Low	Contractor and Supervision Consultant	No separate costs estimation - Included in Contractor's scope of works and fees
	• Disturbances from traffic, noise, air emissions and dust generation	Medium	• Implement the dust and noise emissions' and traffic mitigation measures proposed.	Low	Contractor and Supervision Consultant	No separate costs estimation - Included in Contractor's scope of works and fees
Traffic	• Increase in traffic volumes	Medium	• Limit speed on the construction sites to 20 km/h unless otherwise advised, and adopt careful logistical and route planning; • Position any necessary traffic diversion signs and devices correctly. Signs and devices should be clearly displayed in the Arabic and English languages. Temporary traffic signals and signs should be employed to warn of hazards and provide directions, especially on narrow one-lane roads; • Coordinate with Burj Hammoud municipality with respect to the planned road blockages, detours or diversions, and the scheduling of the construction works including material delivery, waste transfer, truck movement and other machinery operations in order to limit the disruption to the neighborhood from traffic inconveniences and traffic flow and to minimize noise and dust generation; • Follow a specific schedule for transport to avoid interference with peak traffic hours and minimize disturbance/delay to commuters at rush hours on the roads leading to the Project construction sites.	Low	Contractor and Supervision Consultant and Municipality of Burj Hammoud	No separate costs estimation - Included in Contractor's scope of works and fees
Health & Safety	• Physical injuries and exposure to dust and noise	Medium	• Prepare and implement an HSE plan for the project; • Train workers on working safely and on identifying work hazards and associated risks. • Provide sufficient lighting and fencing of the facility to prevent animals and humans from entering the site; • Provide warning signs at the entrance of the site to prohibit public access; • Establish of buffering areas around the site; • Make sure ground/floor openings and trenches are fenced or covered;	Low	Contractor and Supervision Consultant	No separate costs estimation - Included in Contractor's scope of works and fees

			• Keep machinery and vehicles passages clear; • Post adequate signs throughout the Construction Area, especially at visible locations, indicating type of operation, potential hazards, and appropriate medical / emergency action response. • Ensure that no employee is exposed to a noise level greater than 85 dB (A) for a duration of more than 8 hours per day without hearing protection. In addition, no unprotected ear should be exposed to a peak sound pressure level (instantaneous) of more than 140 dB(A); • Identify and provide appropriate PPEs that offers adequate protection to the worker (goggles, dust masks, helmets, hearing protection equipment, proper clothing…) and enforce their use; • Maintain the PPE (cleaning when dirty and replacement when damaged or worn out); • Ensure the availability of adequate loading and unloading space; • Prohibit smoking and littering; • Ensure adequate portable fire-fighting equipment is available and regularly maintained; • Provide an emergency action plan and fire hazard inspection procedures; • Ensure that first-aid can be provided at all times. Appropriately equipped first-aid stations should be easily accessible throughout the place of work. • Ensure proper housekeeping on site. • Provide induction to visitors on HSE issues at the site. • Ensure full compliance with CDR HSE procedures.			

Table 8-2 Environmental Mitigation Plan for the Operation Phase

Media	Project Activities	Impacts before mitigation	Mitigation Measures	Impacts after Mitigation	Responsibility	Cost Estimate
Air Emissions	• Odor Emissions from the plant	High	• During detailed design, target for a hydrogen sulfide concentration of 0.25 ppm at the outlet of the OCU stack; such an outlet concentration could correspond to reducing the dynamic hydrogen sulfide concentration to 25 ppm. In addition, the OCU removal efficiency would have to be 99%. With this target met, the calculations reveal that the hydrogen sulfide threshold of 7 □g/m3 would not be exceeded at 40 meters from the outlet stack. • Consider an ambient static hydrogen sulfide concentration would be on average 500 ppm. • Include a chemical dosing station to increase the pH of the influent wastewater to the Daoura WWTP. This would result in an increase of the wastewater pH which in turn would lower the hydrogen sulfide gas emissions. Accordingly, the ambient static hydrogen sulfide gas concentration would be reduced. Chemicals used for this purpose include lime [Ca(OH)2], caustic soda (NaOH) or magnesium hydroxide. The handling and preparation of either lime or caustic soda would be easier than magnesium hydroxide. • Cover the tanks pro provide a building enclosure to the aerated grit chambers. The OCU capacity must be adequate to accommodate the air flow from the aerated grit chambers. • Do not exceed an OCU capacity of 90,000 Nm3/h because an additional increase would result in higher emitted hydrogen sulfide mass flux. • Install an OCU stack of at least 6 meters high from the ground level. Additional height is recommended, if possible, subject to applicable building codes and structural stability considerations. • Plant trees along the boundaries of the proposed plant with a maximum spacing of 3 meters; besides the positive visual impacts, the trees would help absorb odors emissions and would act as a natural barrier for odors emissions containment. • Ensure continuous monitoring on a daily basis of hydrogen sulfide emissions at the emission sources and within the plant boundaries. Measured values are to be compared to the threshold concentrations. Corrective measures and action would be required in case the measured values exceed the threshold concentrations • Ensure the design of the OCU for Phase 2 accounts for cumulative impacts with Phase 1	Low	CDR to include the odor control unit design change and landscaping in the final design and scope of work of Contractor Contractor to design and build the OCU as per revised design BMLWE is responsible to maintain the OCU during operation	Additional costs related to: - Measures to achieve the target sulfide concentration of 0.25 ppm - Chemical dosing for pH increase of influent wastewater - Covering the aerated grit chamber tanks or enclosing the building - Tree planting around the plant Maintenance costs during operation
	• Combustion and exhaust emissions and greenhouse gas emissions	Medium	• Install energy saving lighting fixtures (e.g. LED) instead of regular light bulbs; • Ensure that the specifications of the generators are in line with national standards (Decision 8/1 dated 2001) in terms of air pollutant emissions through regular monitoring; • Regular maintenance of the generators;	Low	Contractor for construction BMLWE for operation	No separate costs estimation - Included in Operator's scope of works and fees
Noise	• Operation of on-site generators and pumps • Maintenance activities	Medium	• Construct the treatment facility with proper sound isolation to reduce noise levels from the pumps; • Ensure regular maintenance of generators and pumps • Ensure that generators are fitted with residential grade noise mufflers and soundproof casing as per the set design of the pumping stations; • Avoid conducting maintenance works on Sundays and holidays and limit them to daytime hours (7:00 am to 5:00 pm); • Establish a grievance mechanism and implement timely and effective actions to minimize impacts from noise in the case of complaints from any of the inhabitants/ nearby receptors; • Conduct noise monitoring near sensitive receptors to ensure that noise levels are compliant with national standards (Decision 52/1).	Low	Contractor for construction BMLWE for operation	Cost of sound isolation for pumps if required Noise monitoring cost: $300/ day.

Wastewater	• Discharge of preliminary-treated wastewater from the outfall pipe	Low	• Ensuring the raw wastewater is always undergoing preliminary treatment before the effluent is conveyed to the Daoura Sea Outfall. This would ensure that the sea outfall pipe would not become clogged with grit, sand and debris • The Operation and Maintenance contract for the preliminary treatment works should stipulate the requirements to collect and test seawater for fecal coliforms counts. Such data would help optimize the dispersion modeling parameters for the Daoura Sea Outfall.	Low	BMLWE	Sampling and testing of seawater
	• Discharge of treated effluent from the sea outfall pipe during Phase 2	Low	• Ensuring the wastewater is always undergoing primary and secondary treatment before the effluent is conveyed to the Daoura Sea Outfall. • The Operation and Maintenance contract for the primary and secondary treatment works should stipulate the requirements to collect and test seawater for BOD and fecal coliforms counts. • Municipalities within the catchment area of the plant should ensure that industrial wastewater is not discharged into the sewer networks without pre-treatment to avoid causing upsets to the biological treatment plant.	Low	BMLWE	-
	• Dewatering of grit and sludge	Medium	• Prepare a Dewatering Management Plan for approval prior to commencement of operation works; and • Analyze seawater quality prior to discharge	Low	Contractor, Supervision Consultant and Municipality of Burj Hammoud	No separate costs estimation - Included in Contractor's scope of works and fees
Solid Waste	• Collected pretreatment process waste	Medium	• Clean screens regularly and drain screenings on a platform. Drained screenings should be properly disposed at the nearest waste management/ disposal facility. This can be done by hiring a specialized contractor to transport and dispose the contaminated coarse materials; • Ensure that all collected wastes are disposed of in authorized landfills. • Reuse grit if it has adequate characteristics. • Oil and grit should be sent to a certified facility for recycling;	Low	BMLWE	No separate costs estimation - Included in Operator's scope of works
	• Disposal of Generated Sludge	Medium	• Ensure that all collected wastes are disposed of in authorized landfills. • Ensure that sludge is treated and dewatered properly and according to standards	Low	BMLWE	No separate costs estimation - Included in Operator's scope of works
	• Domestic Solid Waste	Low	• Minimize waste generation; • Provide waste storage area with sorting and signs for the various types of waste; • Segregate, collect and store solid waste.	Low	BMLWE	No separate costs estimation - Included in Operator's scope of works

Accidental Releases	• Discharge of preliminary-treated wastewater from the emergency outfall pipe	Low	The following additional mitigation measures are recommended to reduce potential impacts further more: • The land reclamation activities, over the Daoura Oveflow Pipe, may have resulted in the burial of about six diffusers. As part of the foreseen rehabilitation works, the overflow pipe needs to be inspected further by divers. If, some of the diffusers have become buried, rehabilitation activities to completely close and disconnect these diffusers would be needed. This would be to ensure that no debris get into the pipe and no wastewater flows get out of these diffusers lifting up the reclaimed sediments above. • There could be a need to extend the overflow pipe further into the sea in light of the fact that its marine section has now become substantially reduced. This would require desk studies to evaluate the extension length taking into account hydraulics, available water heads upstream, economics and plume dispersion. • For proper performance, the raw wastewater must always undergo preliminary treatment before the effluent is conveyed to the Daoura Overflow Pipe. This would ensure that the overflow pipe would not become clogged with grit, sand and debris. • The diversion of the wastewater flow to the Daoura Overflow Pipe should not be practiced randomly. The diversion of wastewater flows to the overflow pipe should only take place when the Daoura Sea Outfall must be put out of service for maintenance or repairs. It would be most suitable to schedule any maintenance or repair activities for the sea outfall during the winter season. • Control discharge of non-municipal wastes and industrial wastes into the sewer network with the help of the Municipality	Low	CDR for overflow design change Contractor for outfall rehabilitation works BMLWE for operation Collaboration with the Municipality	Cost of additional rehabilitation measures
	• Accidental Spills of Fuel, Oil and Chemicals	Medium	• No storage tank should be used for the storage of fuel, oil or chemicals unless its material and construction are compatible with the type of materials to be stored and storage conditions (e.g. pressure and temperature); • All fuel and chemical tanks should be contained in either a double skin tank over concrete floor or inside a concrete bund of at least 110% the capacity of the largest tank. • Drip trays should be installed underneath equipment such as diesel generators and transformers to contain leakage, and when using chemicals; • Keep records of all fuel, oil, chemicals, and diesel; • Reduce the frequency of refueling activity by filling the tanks to the maximal capacity during each refueling operation; • Ensure that the maintenance schedule and checklist already prepared is being efficiently used; • Check tank levels prior to delivery to prevent overfilling through side glass or manually by dipstick logs; • Have a Spill Response Plan in place. • Ensure a supply of suitable absorbent materials is available at re-fuelling points for use in dealing with minor spills. If a leak or spill occurs during loading or offloading operations, the operations must be stopped and the spill must be contained, cleaned up and collected based on the Spill Response Plan. • Ensure that personnel assigned to handle chemicals/oil/fuel are well aware of the requirements. They should be trained prior to commencing their duties.	Low	CDR to modify design to consider mitigation measures Contractor for construction BMLWE for operations	Costs of concrete bunds Cost of drip tray: $200/piece
Depletion of Resources						
Energy Resources	• Electricity consumption	Medium	• Regular maintenance of equipment; • Install energy saving lighting fixtures (e.g. LED) instead of regular light bulbs.	Medium	BMLWE	
Land Resources	• Change in land use • Possible impact on land depreciation and land use change of adjacent plots	Low	• Ensure no odors are generated from the plant by applying identified mitigation measures, particularly for the OCU; • Plant trees along the fence of the pumping stations to reduce its visibility from adjacent plots and improve the aesthetics of the area.	Low	CDR for design and construction BMLWE for operations and maintenance	Specified under odor control measures above

Biological Resources	• Normal operation: discharge of preliminary treated wastewater during Phase 1	Low	• Ensure applying identified mitigation measures to prevent the occurrence of overflows. • Prevent any blockage at the outlet end or malfunction that could lead to flooding or overflow through continuous maintenance of the facility. • Proper management and maintenance of the facility to prevent wastewater overflow and contamination of the soil.	Low	BMLWE	No separate costs estimation - Included in Operator's scope of works and fees
	• Normal operation: discharge of treated wastewater during Phase 2	Low	• Ensuring the wastewater is always undergoing primary and secondary treatment before the effluent is conveyed to the Daoura Sea Outfall. • The Operation and Maintenance contract for the primary and secondary treatment works should stipulate the requirements to collect and test seawater for BOD and fecal coliforms counts. • Municipalities within the catchment area of the plant should ensure that industrial wastewater is not discharged into the sewer networks without pre-treatment to avoid causing upsets to the biological treatment plant.	Low	BMLWE	No separate costs estimation - Included in Operator's scope of works and fees
Other Impacts						
Socio-economic	• Disturbances from odor emissions	High	• Implement the mitigation measures relating to odor generation proposed above	Low	CDR to include the odor control units and landscaping in the final design and scope of work of Contractor Contractor for detailed design and construction of OCU BMLWE for operations and maintenance	Specified under odor control measures above
	• Land value depreciation	Low	• Plant trees at the plant surrounding to have an acceptable landscape and barrier; • Install an appropriate odor control unit to reduce the spread of odors;	Low		
	• Improvement in seawater quality	Beneficial	-	Beneficial	-	-
Health and Safety	• Increased health and safety risks	High	• An alternative OCU needs to be investigated and proposed. The most commonly adopted system is the Granular Activated Carbon (GAC) filter. This system consists of inert material (GAC) placed in a casing to form a filter. There are no hazards whatsoever associated with the handling, storage and use of GAC. • Provide information about exposure to hydrogen sulfide for the operating staff of the Daoura WWTP. The workers doing regular cleaning, maintenance and operational tasks near the plant works should always wear at least disposable protective masks. • Enforce the wearing of masks for operators, workers and/or visitors who intend to be near the plant works for prolonged periods of time. • Comply with the local Health and Safety Requirements, especially the Decree No. 7964/2012 related to the general conditions of public safety in buildings; • Provide appropriate safety equipment, PPE, firefighting equipment and first aid stations; • Emphasize safety education and training for staff and enforce adherence to safety procedures set in and around the facilities; • Ensure proper maintenance of all systems (firefighting, mechanical, electrical, etc.); • Warning of staff about potential hazards during operation and maintenance; • An emergency response plan must be available on site.	Medium	BMLWE	Cost of PPE (boots, gloves, coverall): 102 USD Cost of First Aid Kit: 175 USD Cost of Fire Extinguisher(Powder-6 kg): 55 USD

8.3 IMPLEMENTATION OF THE EMP

Implementation of the EMP requires a clear distribution of roles among concerned stakeholders, as well as an environmental monitoring plan to verify the effectiveness of mitigation measures, a capacity building plan and a well-defined auditing and reporting scheme.

8.3.1 Roles and Responsibilities

Roles and responsibilities of the different institutions involved in the construction and operation of the Project and the implementation of the EMP are shown in Table 8-3.

Table 8-3 EMP Implementation Plan

Institution/Body	Roles and Responsibilities
CDR	Overall responsibility over the EMP Implementation during construction
MoE	Reviews and approves CEMP prepared by contractor and OEMP prepared by operator Ultimately approves EMP implementation reports Conducts site audits as needed to check implementation of EMP
BMLWE	Overall responsibility for overseeing project implementation and operation and EMP Implementation during operation Prepare an OEMP that details how BMLWE will implement the EMP measures during operation OEMP will include a Spill/Overflow contingency plan
Contractor	Prepare a Construction Environmental Management Plan (CEMP) that details how the contractor shall implement the provisions of the EMP; Provide a field HSE officer to ensure implementation of the CEMP Immediately report to the site HSE Officer in case of accidents, spills or other events which have health, safety or environmental implications (and to MoE and/ or MoPH as applicable) in case of serious accidents, spills or other events. In case of incidents, the contractor should fill an incident records form, including how the incident is planned to be addressed.
Supervision consultant(s)	Review CEMP prepared by Contractor; Review and approve Contractor's EMP implementation reports; Supervise the Contractor's implementation of CEMP; Prepare a checklist to be used to supervise Contractor's works; Coordinate with CDR to ensure appropriate reporting of EMP implementation; Identify training needs of concerned parties to ensure EMMP requirements are well-understood and can be implemented.

Municipality of Burj Hammoud/Union of Municipalities	Follow up on the EMP implementation during construction phase; Review citizens' complaints that might be received during construction and operation of the project, and coordinate with concerned parties to properly address them and take the needed action.

8.3.2 Capacity Building Needs

8.3.2.1 Training Needs during Construction Phase

In order to ensure a proper and effective implementation of the EMP, 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:

- General environmental and health awareness for all employees;
- EIA study key findings and recommendations;
- Implementation of the proposed EMP;
- Air pollution control;
- Control of leakages;
- Spill response;
- Wastewater management;
- Water consumption;
- Solid waste management and good housekeeping;
- Hazardous waste management;
- Conserving the top soil for re-vegetation of the site/ another site;
- Traffic and pedestrian safety measures for drivers;
- Occupational health and safety issues; and
- Emergency plan.

8.3.2.2 Training Needs during Operation Phase

It is recommended to train employees and personnel on such issues as:

- Training to ensure that the EMP is well-understood;
- WWTP components and operation process
- Inspection for the implementation of the EMP during operation;
- Odor management/OCU maintenance requirements;
- Sampling, monitoring and record keeping, and reporting procedures;
- Environmental laws, regulation, and standards;
- Spill response;
- Health and safety issues; and
- Emergency plan.

8.4 ENVIRONMENTAL MONITORING PLAN

Compliance monitoring should be conducted to ensure the environmental soundness of the Project. It shall be the responsibility of the designated site HSE Officer during the construction phase and the BMLWE during the operation phase. The proposed monitoring plan for the project is summarized in Table 8-4.

Table 8-4 Proposed Environmental Monitoring Plan

Impacts	Parameters to Monitor	Frequency[6]	Monitoring Location[7]	Standards/Guidelines National/International[8]	Institutional Responsibility	MoE Ref.
Construction						
Air Emissions	• Color and odor of fumes from equipment and construction generators • PM ambient levels • Generator's emissions: PM, NOx, SO_2, CO	• Color and odor of fumes from equipment: weekly • Ambient PM levels: during excavation and earth moving activities • Generator's emissions: once at the start of the works; and in case of complaints from nearby receptors	• Color and odor of fumes from equipment: equipment and generators' exhaust • Ambient PM levels: inside construction site, at nearest receptors • Emissions from generator's stack	• TSP ambient levels: 120 µg/m^3 • Generator emissions: ○ SO_X Maximum Allowable Value: 500 mg/m^3 ○ NO_X Maximum Allowable Value: 500 mg/m^3	Contractor/Supervision consultant	• Ambient Air Quality standards Annex 14 of Decision 52/1 dated 1996 • The general maximum allowable limit values for air pollutants from generators of capacity below 0.5 MW according to Annex 1 of Decision 8/1 dated 2001.
Noise	Leq, Lmax, Lmin, L90 dB(A)	• Three times daily during grading and excavation; • Once daily during concrete pouring, and construction activities; • Once during electricity shortage periods (near generator) • In case of complaints from nearby receptors	• Nearest sensitive receptor and next to generator	• Limit for Ambient Noise Level in Urban Residential Areas with construction sites and near a main road: 50-60 dB	Contractor/Supervision consultant	• Annex 10 of MoE Decision 52/1 dated 1996

[6] Frequency of monitoring can be Daily/ Weekly/ Monthly/ Quarterly/ etc.
[7] Monitoring location is where testing/ sampling will take place; linked directly with most sensitive receptors with highest impact
[8] Standard/ Guidelines: for each mitigation measure, criteria and targets must be identified to indicate acceptable levels/ conditions e.g. ambient air and water guidelines, emission limit values, energy consumption limit values, etc.

Impacts	Parameters to Monitor	Frequency[6]	Monitoring Location[7]	Standards/Guidelines National/International[8]	Institutional Responsibility	MoE Ref.
Solid Waste	• Waste types • Waste generation rates (kg or tons/day) • Waste reused • Waste transported for offsite reuse/recycle • Waste disposed of • Method of disposal	Daily	Construction site	-	Contractor/Supervision consultant	Law 80/2018
Wastewater Generation	• Leakages	Daily	Wastewater pipes, septic tank	-	Contractor/Supervision consultant	Decree No. 2761of 1933 (Provides guidelines related to wastewater management and disposal; related to the pollution caused by the discharge of liquid waste, emphasizes the prohibition of direct or indirect wastewater discharges and waste disposal into water streams)
Energy Resources	• Electricity bills • Fuel bills and fuel quantities consumption follow up	Monthly	Construction site	-	Contractor/Supervision consultant	-

Impacts	Parameters to Monitor	Frequency[6]	Monitoring Location[7]	Standards/Guidelines National/International[8]	Institutional Responsibility	MoE Ref.
Water Resources	• Water consumption (m^3/day)	• Daily records • Monthly report/ water bills	Construction site	-	Contractor/Supervision consultant	-
Socio-economic	• Number/ percentage of local workers	Before commencement of construction works and during construction	-	-	Contractor/Supervision consultant	-
	• GRM records (check Appendix I)	Continuous	-	-	MoEW/ BMLWE	-
Health & Safety	• Proper PPE use • Good housekeeping practices	Continuous	Construction site	-	Contractor/Supervision consultant	
Operation						
Odor Emissions	• H_2S threshold • H_2S outlet concentration • Grievances based on grievance mechanism	• Monthly or based on complaints	At adjacent plot that will be developed by Municipality At nearest sensitive receptor(s) Outlet concentration measured in OCU stack	• H_2S threshold concentration of 7 $\mu g/m^3$ • 0.25 ppm for H_2S outlet concentration forOCU stack	BMLWE	WHO standard

Impacts	Parameters to Monitor	Frequency[6]	Monitoring Location[7]	Standards/Guidelines National/International[8]	Institutional Responsibility	MoE Ref.
Air Emissions	• Generator's emissions: PM, NOx, SO_2, CO • Grievances based on grievance mechanism	• Daily • Generator's emissions: Annually • Continuous	Pretreatment Plant and Nearby communities	-	BMLWE	-
Noise	• Leq, Lmax, Lmin, L90 dB(A) • Grievances based on grievance mechanism	Annually	Near sensitive receptors and generators	Limit for Ambient Noise Level in Urban Residential Areas with construction sites and near a main road : 50-60 dB	BMLWE	Annex 10 of MoE Decision 52/1 dated 1996
Sea water	Fecal coliforms	Pre-commissioning baseline to be established by Contractor Every 3 months during operation	300-m from coastline and near sensitive receptors/bathing locations	100 parts/100 mL	BMLWE	MAP/MEDPOL UNEP WHO
	PH, Temperature, dissolved Oxygen, Suspended solids	Daily during the operation of phase 2	Outfall pipe	Table 2-4 Environmental Limit Values (ELV) for Wastewater to be Discharged	BMLWE	Decision 8/1 of 2001
	BOD, COD, Ammonia, Phosphate, Nitrate, Cyanides, Tannins, Surfactant, Phenols, Alkalinity	• Every 3 months during operation of phase 1, and monthly during the operation of phase 2 • 24 samples per year for BOD testing	Discharged effluent at the Outfall pipe	Table 2-4 Environmental Limit Values (ELV) for Wastewater to be Discharged Table 2-9 IG 19/7 standards	BMLWE	Decision 8/1 of 2001 IG 19/7

Impacts	Parameters to Monitor	Frequency[6]	Monitoring Location[7]	Standards/Guidelines National/International[8]	Institutional Responsibility	MoE Ref.
	Metals: Al, Bo, Cd, Cr, Cu, Fe, Pb, K, Si, Mn, Mo, Ni, Se, Va, Zn, Hg	Pre-commissioning baseline to be established by Contractor for phase 2 Every 6 months during operation of phase 2	Discharged effluent at the Outfall pipe	Table 2-4 Environmental Limit Values (ELV) for Wastewater to be Discharged	BMLWE	Decision 8/1 of 2001
Accidental Leaks	Visually inspect the pumps and pipes for any blockage of the outlet end to prevent flood and overflow. Visually	Monthly	Pumping stations	-	MoEW/ BMLWE	-
Energy Resources	• Electricity bills • Fuel bills and fuel quantities consumption follow up	Monthly	Pumping Stations MBBR	-	BMLWE	-
Socio-economic	GRM (check Appendix I)	Continuous	-	-	MoEW/ BMLWE	
Health & Safety	• Use of PPE by staff • Accidental Releases • Records of Training • Incidence and cause of Incidents and action taken	Records, accidental releases: monthly and upon incidents occurrence	Pumping stations	-	MoEW/ BMLWE	-

9. CONCLUSION AND RECOMMENDATIONS

Beneficial impacts from this project are expected on the environmental and socio-economic level in terms of preventing direct discharge of untreated wastewater into the Mediterranean Sea. The pretreatment of the Wastewater at Burj Hammoud will first remove coarse and fine materials, then grit and grease will be removed, and the effluent will then be discharged into the sea. During Phase 2 of the project which will be built at a later stage, the wastewater will also undergo primary and secondary treatment and will eventually discharge a treated effluent into the sea eliminating a major pollution source that area suffers from currently.

The project is not expected to have major impacts on its environmental and socio-economic surroundings, provided that all mitigation measures are implemented, and the recommended alternatives are chosen for the proposed project.

Of particular importance is to ensure an adequate design, construction and operation of the Odor Control Unit. This EIA has made significant recommendations for an enhanced design of odor control in the pretreatment headworks. While residential areas are relatively far from the plant and are unlikely to be affected by odor, new developments are planned by the municipality in the nearby plot, and therefore very strict odor control measures are necessary to ensure that the development is not negatively affected by the plant.

It is recommended that an updated odor simulation during the detailed design stage to be conducted by the selected contractor to confirm that the modified design meets the required standards and thresholds.

It is also crucial to conduct a specific EIA for Phase 2 of the project, once the detailed design and feasibility study are developed.

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11. APPENDICES

APPENDIX A: MOE'S FEEDBACK

Appendix A1: MoE's Feedback on the Scoping Report

الوزير

رقم التسجيل: ٣٩٩٨/ب٢٠١٩ **بيروت، في** ٣٠/٩/٢٠١٩

جانب رئيس مجلس الإنماء والإعمار
المهندس نبيل عدنان الجسر المحترم

الموضوع: مراجعة تقرير تحديد نطاق تقييم الأثر البيئي العائد لمشروع معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى – محطة برج حمود - قضاء المتن - محافظة جبل لبنان.

المرجع:	- القانون رقم ٤٤٤ تاريخ ٢٠٠٢/٧/٢٩ (حماية البيئة) - القانون رقم ٦٩٠ تاريخ ٢٠٠٥/٨/٢٦ (تحديد مهام وزارة البيئة وتنظيمها) - المرسوم رقم ٢٢٧٥ تاريخ ٢٠٠٩/٦/١٥ (تنظيم الوحدات التابعة لوزارة البيئة وتحديد مهامها وملاكها وشروط التعيين الخاصة في بعض وظائفها) - المرسوم رقم ٨٦٣٣ تاريخ ٢٠١٢/٨/٧ (أصول تقييم الأثر البيئي) - قرار وزير البيئة رقم ١/٢٦١تاريخ ٢٠١٥/٦/١٢ (آلية مراجعة تقارير تحديد نطاق تقييم الأثر البيئي وتقارير تقييم الأثر البيئي) - قرار وزير البيئة رقم ١/٧١٩ تاريخ ٢٠١٩/٩/١٨ (تأليف لجنة تقنية لمراجعة تقرير تحديد نطاق تقييم الأثر البيئي العائد لمشروع معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى - محطة برج حمود - قضاء المتن - محافظة جبل لبنان). - تقرير تحديد نطاق تقييم الأثر البيئي العائد لمشروع معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى - محطة برج حمود المسجل في وزارة البيئة تحت الرقم ٣٩٩٨/ب٢٠١٩، تاريخ ٢٠١٩/٩/٣

تحية طيّبة،

إشارةً الى الموضوع والمرجع المبيّنين أعلاه،

واستناداً إلى تقرير اللجنة التقنية المكلّفة بموجب قرار الوزير المبيّن أعلاه (مرفق ربطاً)؛

تفيد وزارة البيئة بأنّها توافق على التقرير المذكور شرط استكمال النقاط الواردة في تقرير اللجنة التقنية المرفق ربطاً وتوضيحها في تقرير تقييم الأثر البيئي.

وتفضّلوا بقبول فائق الاحترام.

وزير البيئة
فادي جريصاتي

الجمهورية اللبنانية
وزارة البيئة

مرفق ربطاً: تقرير اللجنة التقنية رقم ٣٩٩٨/ب٢٠١٩ تاريخ ٢٠١٩/٩/٢٧
نسخة تبلغ الى:
- وزارة الداخلية والبلديات
- محافظ جبل لبنان
- وزارة البيئة: - مصلحة تكنولوجيا البيئة
  - مصلحة البيئة السكنية
  - أعضاء اللجنة التقنية

بيروت، في ٢٠١٩/٩/٣٠

رقم التسجيل: ٣٩٩٨/ب٢٠١٩

تقرير فني

الموضوع: مراجعة تقرير تحديد نطاق تقييم الأثر البيئي العائد لمشروع معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى – محطة برج حمود - قضاء المتن - محافظة جبل لبنان.

المرجع:	- القانون رقم ٤٤٤ تاريخ ٢٠٠٢/٧/٢٩ (حماية البيئة) - القانون رقم ٦٩٠ تاريخ ٢٠٠٥/٨/٢٦ (تحديد مهام وزارة البيئة وتنظيمها) - المرسوم رقم ٢٢٧٥ تاريخ ٢٠٠٩/٦/١٥ (تنظيم الوحدات التابعة لوزارة البيئة وتحديد مهامها وملاكها وشروط التعيين الخاصة في بعض وظائفها) - المرسوم رقم ٨٦٣٣ تاريخ ٢٠١٢/٨/٧ (أصول تقييم الأثر البيئي) - قرار وزير البيئة رقم ١/٢٦١تاريخ ٢٠١٥/٦/١٢ (آلية مراجعة تقارير تحديد نطاق تقييم الأثر البيئي وتقارير تقييم الأثر البيئي) - قرار وزير البيئة رقم ١/٧١٩ تاريخ ٢٠١٩/٩/١٨ (تأليف لجنة تقنية لمراجعة تقرير تحديد نطاق تقييم الأثر البيئي العائد لمشروع معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى - محطة برج حمود - قضاء المتن - محافظة جبل لبنان). - تقرير تحديد نطاق تقييم الأثر البيئي العائد لمشروع معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى - محطة برج حمود المسجل في وزارة البيئة تحت الرقم ٣٩٩٨/ب٢٠١٩، تاريخ ٢٠١٩/٩/٣

بالإشارة الى الموضوع والمرجع المبينين أعلاه،

تفيد اللجنة بالملاحظات الآتية:

المعلومات المطلوبة في تقرير تحديد نطاق تقييم الأثر البيئي	**المطلوب توضيحه**	**المبرَر**
مقدمة	---	---
معلومات مرجعية	---	---
الاهداف	من الضروري أن يشمل تقرير تقييم الأثر البيئي مختلف المراحل (معالجة متكاملة، بما فيها معالجة الوحول الناتجة عن المرحلة الأولية والثانوية) بما يؤمن توافق المياه المعالجة مع المعايير البيئية الوطنية والقوانين المرعية الإجراء	ورد في الصفحة ٨ أن تقرير تقييم الأثر البيئي هو للمرحلة الأولى من المشروع، أي إنشاء وتشغيل محطة معالجة تمهيدية لمياه الصرف الصحي ولن يشمل المرحلة الثانية نتيجة عدم إيجاد التمويل لها
متطلبات تقييم الاثر البيئي	---	---
منطقة الدراسة	---	---

الجمهورية اللبنانية
وزارة البيئة

التقرير		
إطار السياسات والاطر القانونية	• التحديد بشكل واضح المواد والأحكام ذات الصلة المباشرة بالمشروع، سيما تلك المتعلقة بالمعايير والمتطلبات البيئية • إجراء تحليل لمكامن غياب المواصفات والمعايير المحلية والتحديد بشكل واضح للمعايير الإقليمية والدولية التي ستعتمد، بالاستناد إلى مقاربة علمية واضحة	ورد في التقرير بشكل عام لحظ النصوص التشريعية ذات الصلة
المساعدة في التنسيق بين الإدارات الرسمية ومشاركة العامة	توضيح هذا الأمر وعقد اجتماع العامة خلال مرحلة إعداد تقرير تقييم الأثر البيئي	ورد في التقرير مشاركة اتحاد بلديات بشري، دون أن يرد اي حضور لممثلين عن قضاءي عاليه وبعبدا و/أو بلدياتهما ووزارة البيئة
وصف المشروع المقترح	تحديد نطاق التغطية لهذا المشروع (عدد السكان والمناطق العقارية) بالاعتماد على خريطة وجدول واضحين ومفصلين، مع تحديد الواقع الحالي للتغطية	ورد في التقرير ص. ٩ أن المشروع هو لمعالجة ٢٢٧,٥٠٠ م٣ مياه صرف صحي/ي
	تحديد مواصفات هذه المصبات ومختلف أعمال التأهيل العائدة لها ضمن تقرير الاثر البيئي، ومقارنتها مع المواصفات المرجعية ذات الصلة، استناداً إلى معطيات علمية مناسبة	ورد في التقرير ص. ٩ تحويل المياه بعد المعالجة إلى المصبات البحرية (outfalls) القائمة
	ضرورة لحظ موقع المشروع ومساحته، بكافة مراحله (المرحلتين الأولى والثانية بما فيها معالجة الوحول)	ورد في التقرير ص. ١١ إشارة لموقع ومساحة إنشاء المشروع
	ضم مواصفات وخصائص نظام معالجة الروائح المقترح مع خريطة تبين كيفية تركيزه	ورد في التقرير ص. ١٥ تزويد محطة الضخ العائدة للمشروع بنظام لمعالجة الروائح
	من الضروري أن يتم اختيار خيار واحد ومحدّد لإدارة مختلف النفايات الناتجة عن المشروع، بكافة مراحله وعناصره) (بعد عرض ومقارنة عدة بدائل) مع تفصيل آلية تطبيقه ضمن نطاق المشروع وخارجه	ورد في التقرير ص. ١٥ خيار معالجة النفايات الصلبة الناتجة عن مرحلة المعالجة التمهيدية، بالإضافة إلى ضخ المياه المعالجة إلى المصبات البحرية (في حال معدل الدفق يقل عن ٥,٢ م٣/ث)
	من الضروري تحديد مواصفات كل مولد من المولدات الكهربائية العائدة للمشروع	ورد في التقرير ص. ١٧ الطاقة الإجمالية للمولدات الكهربائية للمشروع

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الجمهورية اللبنانية
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وصف البيئة المحيطة بالمشروع	ذكر المراجع العلمية المعتمدة لوصف البيئة المحيطة بالمشروع (على سبيل المثال البيئة البيولوجية) مع تحديد نوعية مياه البحر بالاستعانة ببيانات المراقبة الصادرة عن مركز علوم البحار	ورد في هذا القسم ذكر للبيئة المحيطة بالمشروع
الآثار البيئية المحتملة للمشروع	- تبرير أسباب هذا الحذف - دراسة الآثار البيئية كماً ونوعاً - أخذ كافة مراحل المشروع بعين الاعتبار في تحديد الآثار البيئية المحتملة	ورد في التقرير ص. ٤٢ الجوانب التي سيتم حذفها من نطاق الدراسة
تحليل البدائل للمشروع	- ضم جدول مقارنة مفصل يبين مختلف الخيارات المتاحة والأسباب الكامنة وراء اعتماد السيناريو الأفضل، بالاعتماد على مراجع علمية واضحة - الأخذ بعين الاعتبار المشروع بكافة مراحله بحيث يتم دراسة خيار التقنيات المتاحة - دراسة الخيارات البديلة لمعالجة الوحول	ورد بشكل عام إدراج دراسة بدائل لمعالجة الروائح وللمصبات البحرية ولإدارة النفايات
خطة الإدارة البيئية	من الضروري إدراج خطة إدارة بيئية مفصلة وشاملة ومحددة وقابلة للقياس والمتابعة ، على أن تأخذ بعين الاعتبار كافة مراحل المشروع وأعمال تأهيل المصبين ومعالجة الوحول	ورد بشكل عام إدراج خطة الإدارة البيئية ضمن التقرير، وقد تم لحظ بعض الإجراءات العامة

بناءً على ما تقدم، تقترح اللجنة التقنية ضرورة توضيح النقاط الواردة أعلاه في تقرير تقييم الأثر البيئي وعدم تجزئة المشروع وفق ما تقتضيه أحكام المرسوم رقم ٢٠١٢/٨٦٣٣.

أعضاء اللجنة:

الإسم	المصلحة	المنصب	الإمضاء
أ. ألفت حمدان	البيئة السكنية	رئيساً	
م. سابين غصن	البيئة السكنية	عضواً مقرراً	
أ.نجيب أبي شديد	البيئة السكنية	عضواً	

الجمهورية اللبنانية
وزارة البيئة

Appendix A2: MoE's Feedback on the EIA Report

الجمهورية اللبنانية
وزارة البيئة

الوزير

رقم التسجيل: ٣٩٩٨/ب٢٠١٩

بيروت، في ٢١ تشرين الثاني ٢٠١٩

جانب رئيس مجلس الإنماء والإعمار
المهندس نبيل عدنان الجسر المحترم

الموضوع: موقف وزارة البيئة من تقرير تقييم الأثر البيئي العائد لمشروع معالجة المياه المبتذلة في المنطقة الساحلية الشمالية لبيروت الكبرى - محطة برج حمود - قضاء المتن - محافظة جبل لبنان.

المرجع:	- القانون رقم ٤٤٤ تاريخ ٢٠٠٢/٧/٢٩ (حماية البيئة) - القانون رقم ٦٩٠ تاريخ ٢٠٠٥/٨/٢٦ (تحديد مهام وزارة البيئة وتنظيمها) - المرسوم رقم ٢٢٧٥ تاريخ ٢٠٠٩/٦/١٥ (تنظيم الوحدات التابعة لوزارة البيئة وتحديد مهامها وملاكها وشروط التعيين الخاصة في بعض وظائفها) - المرسوم رقم ٨٦٣٣ تاريخ ٢٠١٢/٨/٧ (أصول تقييم الأثر البيئي) - قرار وزير البيئة رقم ١/٢٦١تاريخ ٢٠١٥/٦/١٢ (آلية مراجعة تقارير تحديد نطاق تقييم الأثر البيئي وتقارير تقييم الأثر البيئي) - قرار وزير البيئة رقم ١/٧٥٥ تاريخ ٢٠١٩/٩/٣٠ (تأليف لجنة تقنية لمراجعة تقرير تقييم الأثر البيئي العائد لمشروع معالجة المياه المبتذلة في المنطقة الساحلية الشمالية لبيروت الكبرى - محطة برج حمود - قضاء المتن - محافظة جبل لبنان). - تقرير تقييم الأثر البيئي العائد لمشروع معالجة المياه المبتذلة في المنطقة الساحلية الشمالية لبيروت الكبرى - محطة برج حمود المسجل في وزارة البيئة تحت الرقم ٣٩٩٨/ب٢٠١٩، تاريخ ٢٠١٩/٩/٢٤

تحية طيّبة،

بالإشارة الى الموضوع والمرجع المبيّنين أعلاه،

واستناداً إلى تقرير اللجنة التقنية المكلّفة بموجب قرار الوزير المبيّن أعلاه (مرفق ربطاً)؛

تفيد وزارة البيئة بضرورة تعديل التقرير المذكور وفق الملاحظات المبيّنة في تقرير اللجنة التقنيّة المرفق والإعادة، ضمن تقرير شامل ومتكامل، للمراجعة حسب الأصول.

وتفضلوا بقبول فائق الاحترام.

وزير البيئة
فادي جريصاتي

مرفق ربطاً: تقرير اللجنة التقنية رقم ٣٩٩٨/ب٢٠١٩ تاريخ ٢٠١٩/١١/١٢

نسخة تبلغ الى:
- وزارة الداخلية والبلديات
- محافظ جبل لبنان
- الشركة الاستشارية ELARD
- وزارة البيئة: - مصلحة تكنولوجيا البيئة
  - مصلحة البيئة السكنية
  - أعضاء اللجنة التقنية

بيروت، في ٢٠١٩/١١/١٢

رقم التسجيل: ٣٩٩٨/ب٢٠١٩

تقرير فني

الموضوع: مراجعة تقرير تقييم الأثر البيئي العائد لمشروع معالجة المياه المبتذلة في المنطقة الساحلية الشمالية لبيروت الكبرى - محطة برج حمود - قضاء المتن - محافظة جبل لبنان.

المرجع:	- القانون رقم ٤٤٤ تاريخ ٢٠٠٢/٧/٢٩ (حماية البيئة) - القانون رقم ٦٩٠ تاريخ ٢٠٠٥/٨/٢٦ (تحديد مهام وزارة البيئة وتنظيمها) - المرسوم رقم ٢٢٧٥ تاريخ ٢٠٠٩/٦/١٥ (تنظيم الوحدات التابعة لوزارة البيئة وتحديد مهامها وملاكها وشروط التعيين الخاصة في بعض وظائفها) - المرسوم رقم ٨٦٣٣ تاريخ ٢٠١٢/٨/٧ (أصول تقييم الأثر البيئي) - قرار وزير البيئة رقم ١/٢٦١تاريخ ٢٠١٥/٦/١٢ (آلية مراجعة تقارير تحديد نطاق تقييم الأثر البيئي وتقارير تقييم الأثر البيئي) - قرار وزير البيئة رقم ١/٧٥٥ تاريخ ٢٠١٩/٩/٣٠ (تأليف لجنة تقنية لمراجعة تقرير تقييم الأثر البيئي العائد لمشروع معالجة المياه المبتذلة في المنطقة الساحلية الشمالية لبيروت الكبرى - محطة برج حمود - قضاء المتن - محافظة جبل لبنان). - تقرير تقييم الأثر البيئي العائد لمشروع معالجة المياه المبتذلة في المنطقة الساحلية الشمالية لبيروت الكبرى - محطة برج حمود المسجل في وزارة البيئة تحت الرقم ٣٩٩٨/ب٢٠١٩، تاريخ ٢٠١٩/٩/٢٤

بالإشارة الى الموضوع والمرجع المبينين أعلاه،

تفيد اللجنة بالملاحظات الآتية:

المعلومات المطلوبة في تقرير تقييم الأثر البيئي	**المطلوب استكماله**	**المبرّر**
الملخّص التنفيذي	إعادة صياغة الملخص التنفيذي بناء على الملاحظات أدناه	التقرير بكافة اجزائه بحاجة إلى التعديل
قائمة المحتويات	---	---
المقدّمة	تحديد نتائج المخطط وفق نطاق المشروع والقرى المستفيدة منه ونسبة التغطية بشبكات الصرف الصحي	ورد في التقرير ص. ١ ان تنفيذ المشروع يتم بموجب المخطط التوجيهي الصادر عن وزارة الطاقة والمياه
	الالتزام بمبادئ اتفاقية برشلونة لناحية مستوى المعالجة المطلوب للتجمعات السكنية التي تفوق ال٢٠٠٠ نسمة	ورد في التقرير ص. ٣ اعتماد عدد من النصوص التشريعية والمعايير الوطنية والدولية في منهجية إعداد التقرير
التقرير		
إطار السياسات والاطر القانونية	تضمين الجدول هذا المرسوم	لم يرد في الجدول ٢-٢ ذكر لمرسوم تحديد اصول إدارة النفايات الخطرة
	الالتزام بمضمون القرار IG 19/7 حول مستوى المعالجة المطلوبة للتجمعات السكنية التي تفوق ال٢٠٠٠ نسمة	ورد في التقرير ص. ١٤ ذكر لاتفاقية برشلونة كواحدة من المعاهدات ذات الصلة بالمشروع

	توضيح المعيار المعتمد وسبب الاعتماد كما والأخذ بعين الاعتبار مؤشرات أخرى (على سبيل المثال VOCs)	ورد في التقرير ص. ١٥ تراكيز مؤشري غاز كبريتيد الهيدروجين والأمونيا
	تضمين التقرير معايير نوعية مياه البحر (لكافة المؤشرات ذات الصلة) بالاعتماد على المعايير الدولية	ورد في التقرير اعتماد مؤشر الكوليفورم دون غيره بالنسبة لنوعية مياه البحر
	اعتماد المعايير البيئية للمولدات ذات الطاقة الإنتاجية التي تزيد عن ٥٠٠ ك. ف.أ والواردة في القرار الصادر عن وزارة البيئة رقم ٨/١ـ ٢٠٠١	ورد في التقرير ص. ٣٣ أن الطاقة الإنتاجية للمولدات الكهربائية الأربعة هي ١٦٠٠ ك. ف.أ بينما ورد في ص. ١٢ أن المعايير العائدة للمولدات هي ٥٠٠ ملغ/م٣
المساعدة في التنسيق بين الإدارات الرسمية ومشاركة العامة	توضيح كيفية احتساب هذا الحجم والالتزام بملاءمة تصميم المحطة مع هذا الحجم	ورد في التقرير ص. ١٩ أن المحطة هي لمعالجة ٢٢٧,٥٠٠ م٣
	إجراء مشاركة العامة لاطلاعها على كافة مكونات المشروع وملاحظات وزارة البيئة عليه، وفق ما تقتضيه أحكام المرسوم رقم ٢٠١٢/٨٦٣٣	ورد في التقرير مشاركة العامة في مرحلة تحديد نطاق المشروع فقط، وأنه سيتم أيضا مناقشة تقرير تقييم الأثر البيئي مع الجهات المعنية لا سيما رئيس بلدية حمود
	اعتماد خيارات تتوافق مع الواقع الحالي	ورد في التقرير ص. ٢٠ إمكانية اعادة استعمال المياه المعالجة
وصف المشروع المقترح	الإجابة عن هذه الملاحظات في تقرير تقييم الأثر البيئي المعدّل	ورد في تقرير اللجنة الفنية تاريخ ٢٠١٩/٩/٣٠ الملاحظات المطلوب إدراجها ضمن تقرير تقييم الأثر البيئي
	التوضيح بشكل عام لكل مكون من مكونات هذا المخطط	ورد في التقرير ص. ٢٧ مخطط حول مكونات المشروع
	التحديد بشكل واضح للجدول الزمني لتنفيذ وتشغيل مرحلتي المشروع بكافة مكوناته (بما فيها أعمال تأهيل محطتي الضخ وتأهيل المصبين البحريين وإنشاء الشبكات،...)، مع ضرورة ضم كافة المستندات القانونية ذات الصلة والكلفة التقديرية للأشغال العائدة لمختلف مكونات المشروع	ورد في التقرير تنفيذ المشروع على مرحلتين
	تبيان مدى اهلية هذين المصبين وملاءمتهما مع تصميم المحطة المقترح ومعدل الدفق اليومي، بالاعتماد على مراجع علمية مناسبة	ورد في التقرير وجود مصبين بحريين لتصريف المياه المبتذلة

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وصف البيئة المحيطة بالمشروع	تحديد المراجع والبيانات المستخدمة لتحديد نوعية مياه البحر ضمن نطاق المشروع (على سبيل المثال بيانات المراقبة الصادرة عن مركز علوم البحار)	ورد في ص. ٥٤ أن البيئة البيولوجية المحيطة بالمشروع متدهورة
	تحديد الواقع الحالي لمطمر برج حمود الجديدة لجهة فترة التشغيل المتبقية وموعد الإقفال النهائي للمطمر	ورد في التقرير ص. ٥٥ أن إدارة النفايات الصلبة تتم من قبل شركة RAMCO حيث يتم فرز النفايات في معمل الكرنتينا وطمر النفايات في مطمر برج حمود - الجديدة
	توضيح هذا الأمر	لم يرد في التقرير كيفية إدارة النفايات الصناعية والنفايات الناتجة عن المؤسسات الصحية لما لها من تأثير مباشر على المشروع
الآثار البيئية المحتملة للمشروع	• اعتماد وحدات قياس موحّدة بالنسبة لغاز كبيرتيد الهيدروجين، مع ضرورة لحظ المرجع المعتمد لتحديد المعيار مقارنة مع المعيار الوارد في القرار الصادر عن وزارة البيئة رقم ١/٨- ٢٠٠١ • تحليل اثر الغازات الأخرى المنبعثة من جراء تشغيل المشروع على البيئة المحيطة (المركبات العضوية المتطايرة، الأمونيا، ...)	ورد في التقرير ص. ٦٤ – ٦٨ تحليلاً لأثر غاز سولفيد الهيدروجين على البيئة المحيطة بالمشروع
	التحديد بشكل واضح لموقع هذا المطمر الصحي	ورد في التقرير معالجة النفايات الصلبة الناتجة عن تشغيل المشروع والتخلص منها في اقرب مطمر صحي معتمد
	تضمين التقرير الاثار البيئية الناتجة عن أعمال شفط الرمول وإدراجها ضمن مختلف اقسام التقرير (عند الضرورة)	ورد في التقرير وجود أعمال شفط رمول
	إعادة النظر بهذا القسم ليشمل الآثار البيئية الشاملة الناتجة عن مختلف مراحل ومكونات المشروع	ورد في التقرير تحليل الآثار البيئية للمرحلة أولى من المشروع (المعالجة التمهيدية)
تحليل البدائل للمشروع	تحديد المرجع المعتمد في تقييم التقنيات	ورد في التقرير ص. ٩٢ جدول يبين مقارنة لمختلف التقنيات المعتمدة في معالجة الروائح الناتجة عن المشروع
	تحديد البدائل المعتمدة لإدارة الوحول أخذاً بعين الاعتبار المخطط التوجيهي المعدّ لصالح مجلس الانماء والاعمار في العام ٢٠٠٣	لم يرد ذلك في التقرير
	تحديد البدائل للتخلص من النفايات الصلبة بكافة أنواعها، واعتماد حلول قابلة للتطبيق	العودة إلى الصفحة ٩٤ من التقرير حول التخلّص من هذه النفايات

خطة الإدارة البيئية	من الضروري إدراج خطة إدارة بيئية مفصلة وشاملة ومحددة وقابلة للقياس والمتابعة تتضمَن تفصيلاً لكافة الاجراءات الضرورية والمطلوبة، على أن تأخذ بعين الاعتبار كافة مراحل المشروع وأعمال تأهيل المصببين ومعالجة الوحول، كما ولكافة الملاحظات الآنفة الذكر.	ورد بشكل عام إدراج خطة الإدارة البيئية ضمن التقرير، وقد تم لحظ بعض الإجراءات العامة أو إجراءات سوف يتمّ إعدادها وتطويرها في مرحلة لاحقة.

بناءً على ما تقدم، تقترح اللجنة التقنية ضرورة توضيح النقاط الواردة أعلاه والإجابة عليها وعلى تلك الواردة في تقرير اللجنة التقنية حول تقرير تحديد نطاق تقييم الأثر البيئي للمشروع (رقم ٣٩٩٨/ب/٢٠١٩ تاريخ ٢٠١٩/٩/٣٠) في تقرير تقييم الأثر البيئي المعدّل، على ان يتم تزويد الوزارة بتقرير شامل ومتكامل.

أعضاء اللجنة:

الإسم	المصلحة	المنصب	الإمضاء
أ. ألفت حمدان	البيئة السكنية	رئيساً	
م. سابين غصن	البيئة السكنية	عضواً مقرراً	
أ.نجيب أبي شديد	البيئة السكنية	عضواً	

الجمهورية اللبنانية
وزارة البيئة

APPENDIX B: PUBLIC PARTICIPATION ANNOUNCEMENT

دعوة عامة

دراسة تحديد نطاق تقييم الأثر البيئي لمشروع إنشاء محطة التكرير التمهيدي للمياه المبتذلة في الدورة–برج حمود

تتشرف شركة الأرض للتنمية المتطورة للموارد ش.م.ل. (ELARD s.a.l.) التي تقوم بإجراء "دراسة تحديد نطاق تقييم الأثر البيئي لمشروع لمشروع إنشاء محطة التكرير التمهيدي للمياه المبتذلة في الدورة–برج حمود"، بدعوتكم لحضور اجتماع مشاركة العامة الأول الذي سوف يتناول عرضًا للمشروع ومناقشة الآثار البيئية والاجتماعية المحتملة له.

يقع المشروع ضمن الأملاك البحرية العمومية المردومة في برج حمود لإنشاء محطة تكرير تمهيدية للمياه المبتذلة ضمن مشروع الصرف الصحي للمنطقة الشمالية من بيروت الكبرى الذي يستلزم إشغال 65،000 م^2 من الأملاك العامة.

يأتي هذا الاجتماع بهدف الاستماع لآراء واقتراحات المجتمع المدني المحلي، الجهات الرسمية المعنية والمجموعات التي يمكن أن تتأثر بالمشروع المقترح حول الآثار البيئية والاجتماعية والتدابير التخفيفية والبدائل الممكنة للحدّ من الآثار المتوقّعة.

يُعقَد الاجتماع في المكان والزمان المبيّنين أدناه:

المكان: قاعة الثانوية الأرمنية المركزية في برج حمود

الزمان: الاثنين 19 آب 2019 من 10:30 صباحاً حتى 12:30 ظهراً

في حال تعذر حضور الاجتماع، يمكن تزويد كل من وزارة البيئة والإستشاري البيئي بأية ملاحظات وهواجس واقتراحات متعلقة بالمشروع المذكور، وذلك خلال مهلة شهر من تاريخ لصق هذا الإعلان، على العناوين التالية:

وزارة البيئة – مصلحة تكنولوجيا البيئة	**شركة الأرض للتنمية المتطورة للموارد (ELARD)**
مباني اللعازارية – منطقة الباشورة – الطابق السابع – بلوك A1 New وسط بيروت	مبنى فلاس (Playroom) - الطابق الثالث- عمارة شلهوب
بيروت – لبنان	بيروت لبنان
ص.ب. 11/2727	ص.ب. 26141407
هاتف: 976555- 01	هاتف: 888305- 01
فاكس: 976535- 01	فاكس:896793–01، مقسم 141/113
	بريد إلكتروني: kshaar@elard-group.com

آملين حضوركم واستمرار التعاون لكل ما فيه خدمة البيئة وصحة وسلامة الوطن والمواطن.

بيروت، في 22 تموز 2019

APPENDIX C: PUBLIC PARTICIPATION INVITATION LETTERS

مجلس الإنماء والإعمار
بيروت - لبنان

جانب وزارة الداخلية
المديرية العامة للإدارات والمجالس المحلية

(هاتف / فاكس رقم ٦١٠١٤١ - ٠١)
٠١-٦١٠١٢٤

الموضوع: دعوة لحضور اللقاء التشاوري لعرض ومناقشة المعطيات المتعلقة بالأثر البيئي والاجتماعي لمشروع **"معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى – محطة برج حمود "**

تحية وبعد،

حيث أن مجلس الإنماء والإعمار يقوم بتنفيذ دراسة تقييم الأثر البيئي والاجتماعي لمشروع **" معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى – محطة برج حمود"** الممول من البنك الأوروبي للتثمير،

وحيث أن من بين المهام المطلوبة في الدراسة، الاستماع لآراء المجتمع المدني والسلطات المحلية والإدارات المعنية حول الآثار البيئية والاجتماعية التي قد تنتج عن المشروع، واقتراحاتهم المتعلقة بالحلول والتدابير التخفيفية والبدائل الممكنة للحد من الآثار المتوقّعة،

لذلك، نتشرف بدعوتكم لحضور اللقاء التشاوري الذي سوف يعقد اعتباراً من الساعة العاشرة والنصف من قبل ظهر يوم الاثنين في ١٩ آب ٢٠١٩ في قاعة الثانوية الأرمنية المركزية في برج حمود.

الرجاء تأكيد الحضور وإيفاد من ترونه مناسباً للمشاركة.

مجلس الإنماء والإعمار

ملاحظة: للاستفسار ومزيد من المعلومات
الاتصال على الرقم: ٠١-٨٨٨٣٠٥ مقسم ١٤٤

مجلس الإنماء والإعمار

بيروت - لبنان

جانب محافظ جبل لبنان المحترم

(هاتف / فاكس رقم ٥٤٠٤٤٧ - ٠٩)

٠٥/٩٢٤٢٢٦

الموضوع: دعوة لحضور اللقاء التشاوري لعرض ومناقشة المعطيات المتعلقة بالأثر البيئي والاجتماعي لمشروع **"معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى – محطة برج حمود "**

تحية وبعد،

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لذلك، نتشرف بدعوتكم لحضور اللقاء التشاوري الذي سوف يعقد اعتباراً من الساعة العاشرة والنصف من قبل ظهر يوم الاثنين في ١٩ آب ٢٠١٩ في قاعة الثانوية الأرمنية المركزية في برج حمود.

الرجاء تأكيد الحضور وإيفاد من ترونه مناسباً للمشاركة.

مجلس الإنماء والإعمار

ملاحظة: **للاستفسار ومزيد من المعلومات**
الاتصال على الرقم: ٠١-٨٨٨٣٠٥ مقسم ١٤٤

مجلس الإنماء والإعمار

بيروت - لبنان

جانب مؤسسة مياه بيروت وجبل لبنان

(هاتف / فاكس رقم ٣٨٤٠٣٩ - ٠١)

٠١/٢٨٦٥٥١

الموضوع: دعوة لحضور اللقاء التشاوري لعرض ومناقشة المعطيات المتعلقة بالأثر البيئي والاجتماعي لمشروع **"معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى – محطة برج حمود "**

تحية وبعد،

حيث أن مجلس الإنماء والإعمار يقوم بتنفيذ دراسة تقييم الأثر البيئي والاجتماعي لمشروع **" معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى – محطة برج حمود"** الممول من البنك الأوروبي للتثمير،

وحيث أن من بين المهام المطلوبة في الدراسة، الاستماع لآراء المجتمع المدني والسلطات المحلية والإدارات المعنية حول الآثار البيئية والاجتماعية التي قد تنتج عن المشروع، واقتراحاتهم المتعلقة بالحلول والتدابير التخفيفية والبدائل الممكنة للحد من الآثار المتوقّعة،

لذلك، نتشرف بدعوتكم لحضور اللقاء التشاوري الذي سوف يعقد اعتباراً من الساعة العاشرة والنصف من قبل ظهر يوم الاثنين في ١٩ آب ٢٠١٩ في قاعة الثانوية الأرمنية المركزية في برج حمود.

الرجاء تأكيد الحضور وإيفاد من ترونه مناسباً للمشاركة.

مجلس الإنماء والإعمار

الجمهورية اللبنانية - مجلس الإنماء والإعمار

ملاحظة: **للاستفسار ومزيد من المعلومات**
الاتصال على الرقم: ٠١-٨٨٨٣٠٥ مقسم ١٤٤

مجلس الإنماء والإعمار
بيروت - لبنان

جانب وزارة الصحة العامة

(هاتف / فاكس رقم ٦١٥٠٢٠ - ٠١)
٠١/٨٤٢٧٧٥

الموضوع: دعوة لحضور اللقاء التشاوري لعرض ومناقشة المعطيات المتعلقة بالأثر البيئي والاجتماعي لمشروع **"معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى – محطة برج حمود "**

تحية وبعد،

حيث أن مجلس الإنماء والإعمار يقوم بتنفيذ دراسة تقييم الأثر البيئي والاجتماعي لمشروع **" معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى – محطة برج حمود"** الممول من البنك الأوروبي للتثمير،

وحيث أن من بين المهام المطلوبة في الدراسة، الاستماع لآراء المجتمع المدني والسلطات المحلية والإدارات المعنية حول الآثار البيئية والاجتماعية التي قد تنتج عن المشروع، واقتراحاتهم المتعلقة بالحلول والتدابير التخفيفية والبدائل الممكنة للحد من الآثار المتوقّعة،

لذلك، نتشرف بدعوتكم لحضور اللقاء التشاوري الذي سوف يعقد اعتباراً من الساعة العاشرة والنصف من قبل ظهر يوم الاثنين في ١٩ آب ٢٠١٩ في قاعة الثانوية الأرمنية المركزية في برج حمود.

الرجاء تأكيد الحضور وإيفاد من ترونه مناسباً للمشاركة.

مجلس الإنماء والإعمار

ملاحظة: للاستفسار ومزيد من المعلومات
الاتصال على الرقم: ٠١-٨٨٨٣٠٥ مقسم ١٤٤

مجلس الإنماء والإعمار

بيروت - لبنان

جانب وزارة الاشغال العامة والنقل
(هاتف / فاكس رقم ٤٥٩٤٣٤ - ٠٥)

الموضوع: دعوة لحضور اللقاء التشاوري لعرض ومناقشة المعطيات المتعلقة بالأثر البيئي والاجتماعي لمشروع **"معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى – محطة برج حمود "**

تحية وبعد،

حيث أن مجلس الإنماء والإعمار يقوم بتنفيذ دراسة تقييم الأثر البيئي والاجتماعي لمشروع **" معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى – محطة برج حمود"** الممول من البنك الأوروبي للتثمير،

وحيث أن من بين المهام المطلوبة في الدراسة، الاستماع لآراء المجتمع المدني والسلطات المحلية والإدارات المعنية حول الآثار البيئية والاجتماعية التي قد تنتج عن المشروع، واقتراحاتهم المتعلقة بالحلول والتدابير التخفيفية والبدائل الممكنة للحد من الآثار المتوقّعة،

لذلك، نتشرف بدعوتكم لحضور اللقاء التشاوري الذي سوف يعقد اعتباراً من الساعة العاشرة والنصف من قبل ظهر يوم الاثنين في ١٩ آب ٢٠١٩ في قاعة الثانوية الأرمنية المركزية في برج حمود.

الرجاء تأكيد الحضور وإيفاد من ترونه مناسباً للمشاركة.

مجلس الإنماء والإعمار

الجمهورية اللبنانية
مجلس الإنماء والإعمار

ملاحظة: **للاستفسار ومزيد من المعلومات**
الاتصال على الرقم: ٨٨٨٣٠٥-٠١ مقسم ١٤٤

مجلس الإنماء والإعمار

بيروت - لبنان

جانب قائمقام المتن

(هاتف / فاكس رقم ٨٩٠٩٥٠ - ٠١)

الموضوع: دعوة لحضور اللقاء التشاوري لعرض ومناقشة المعطيات المتعلقة بالأثر البيئي والاجتماعي لمشروع **"معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى – محطة برج حمود "**

تحية وبعد،

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وحيث أن من بين المهام المطلوبة في الدراسة، الاستماع لآراء المجتمع المدني والسلطات المحلية والإدارات المعنية حول الآثار البيئية والاجتماعية التي قد تنتج عن المشروع، واقتراحاتهم المتعلقة بالحلول والتدابير التخفيفية والبدائل الممكنة للحد من الآثار المتوقّعة،

لذلك، نتشرف بدعوتكم لحضور اللقاء التشاوري الذي سوف يعقد اعتباراً من الساعة العاشرة والنصف من قبل ظهر يوم الاثنين في ١٩ آب ٢٠١٩ في قاعة الثانوية الأرمنية المركزية في برج حمود.

الرجاء تأكيد الحضور وإيفاد من ترونه مناسباً للمشاركة.

مجلس الإنماء والإعمار

الجمهورية اللبنانية
مجلس الإنماء والإعمار

ملاحظة: للاستفسار ومزيد من المعلومات
الاتصال على الرقم: ٠١-٨٨٨٣٠٥ مقسم ١٤٤

مجلس الإنماء والإعمار

بيروت - لبنان

جانب وزارة الثقافة – المديرية العامة للآثار

(هاتف / فاكس رقم ٦١٢٢٥٩ - ٠١)

الموضوع: دعوة لحضور اللقاء التشاوري لعرض ومناقشة المعطيات المتعلقة بالأثر البيئي والاجتماعي لمشروع "**معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى – محطة برج حمود** "

تحية وبعد،

حيث أن مجلس الإنماء والإعمار يقوم بتنفيذ دراسة تقييم الأثر البيئي والاجتماعي لمشروع **" معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى – محطة برج حمود"** الممول من البنك الأوروبي للتثمير،

وحيث أن من بين المهام المطلوبة في الدراسة، الاستماع لآراء المجتمع المدني والسلطات المحلية والإدارات المعنية حول الآثار البيئية والاجتماعية التي قد تنتج عن المشروع، واقتراحاتهم المتعلقة بالحلول والتدابير التخفيفية والبدائل الممكنة للحد من الآثار المتوقّعة،

لذلك، نتشرف بدعوتكم لحضور اللقاء التشاوري الذي سوف يعقد اعتباراً من الساعة العاشرة والنصف من قبل ظهر يوم الاثنين في ١٩ آب ٢٠١٩ في قاعة الثانوية الأرمنية المركزية في برج حمود.

الرجاء تأكيد الحضور وإيفاد من ترونه مناسباً للمشاركة.

مجلس الإنماء والإعمار

ملاحظة: للاستفسار ومزيد من المعلومات
الاتصال على الرقم: ٠١-٨٨٨٣٠٥ مقسم ١٤٤

مجلس الإنماء والإعمار
بيروت - لبنان

جانب وزارة البيئة

(هاتف / فاكس رقم ٩٧٦٥٣٥ - ٠١)

الموضوع: دعوة لحضور اللقاء التشاوري لعرض ومناقشة المعطيات المتعلقة بالأثر البيئي والاجتماعي لمشروع **"معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى – محطة برج حمود "**

تحية وبعد،

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وحيث أن من بين المهام المطلوبة في الدراسة، الاستماع لآراء المجتمع المدني والسلطات المحلية والإدارات المعنية حول الآثار البيئية والاجتماعية التي قد تنتج عن المشروع، واقتراحاتهم المتعلقة بالحلول والتدابير التخفيفية والبدائل الممكنة للحد من الآثار المتوقّعة،

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الرجاء تأكيد الحضور وإيفاد من ترونه مناسباً للمشاركة.

مجلس الإنماء والإعمار

ملاحظة: **للاستفسار ومزيد من المعلومات**
الاتصال على الرقم: ٠١-٨٨٨٣٠٥ مقسم ١٤٤

مجلس الإنماء والإعمار
بيروت - لبنان

جانب وزارة الزراعة

(هاتف / فاكس رقم ٨٥٠٣٣٣ - ٠١)

<u>الموضوع:</u> دعوة لحضور اللقاء التشاوري لعرض ومناقشة المعطيات المتعلقة بالأثر البيئي والاجتماعي لمشروع "**معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى – محطة برج حمود** "

تحية وبعد،

حيث أن مجلس الإنماء والإعمار يقوم بتنفيذ دراسة تقييم الأثر البيئي والاجتماعي لمشروع **" معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى – محطة برج حمود"** الممول من البنك الأوروبي للتثمير،

وحيث أن من بين المهام المطلوبة في الدراسة، الاستماع لآراء المجتمع المدني والسلطات المحلية والإدارات المعنية حول الآثار البيئية والاجتماعية التي قد تنتج عن المشروع، واقتراحاتهم المتعلقة بالحلول والتدابير التخفيفية والبدائل الممكنة للحد من الآثار المتوقّعة،

لذلك، نتشرف بدعوتكم لحضور اللقاء التشاوري الذي سوف يعقد اعتباراً من الساعة العاشرة والنصف من قبل ظهر يوم الاثنين في ١٩ آب ٢٠١٩ في قاعة الثانوية الأرمنية المركزية في برج حمود.

الرجاء تأكيد الحضور وإيفاد من ترونه مناسباً للمشاركة.

مجلس الإنماء والإعمار

<u>ملاحظة:</u> للاستفسار ومزيد من المعلومات
الاتصال على الرقم: ٠١-٨٨٨٣٠٥ مقسم ١٤٤

مجلس الإنماء والإعمار

بيروت - لبنان

جانب وزارة الطاقة والمياه

(هاتف / فاكس رقم ٤٤٩٦٣٩ - ٠١)

<u>الموضوع:</u> دعوة لحضور اللقاء التشاوري لعرض ومناقشة المعطيات المتعلقة بالأثر البيئي والاجتماعي لمشروع **"معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى – محطة برج حمود "**

تحية وبعد،

حيث أن مجلس الإنماء والإعمار يقوم بتنفيذ دراسة تقييم الأثر البيئي والاجتماعي لمشروع **" معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى – محطة برج حمود"** الممول من البنك الأوروبي للتثمير،

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لذلك، نتشرف بدعوتكم لحضور اللقاء التشاوري الذي سوف يعقد اعتباراً من الساعة العاشرة والنصف من قبل ظهر يوم الاثنين في ١٩ آب ٢٠١٩ في قاعة الثانوية الأرمنية المركزية في برج حمود.

الرجاء تأكيد الحضور وإيفاد من ترونه مناسباً للمشاركة.

مجلس الإنماء والإعمار

الجمهورية اللبنانية
مجلس الإنماء والإعمار

<u>ملاحظة:</u> للاستفسار ومزيد من المعلومات
الاتصال على الرقم: ٠١-٨٨٨٣٠٥ مقسم ١٤٤

مجلس الإنماء والإعمار

بيروت - لبنان

جانب محافظ مدينة بيروت المحترم
(هاتف / فاكس رقم ٠١-٩٨٦٠٠٦)

الموضوع: دعوة لحضور اللقاء التشاوري لعرض ومناقشة المعطيات المتعلقة بالأثر البيئي والاجتماعي لمشروع **"معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى – محطة برج حمود "**

تحية وبعد،

حيث أن مجلس الإنماء والإعمار يقوم بتنفيذ دراسة تقييم الأثر البيئي والاجتماعي لمشروع **" معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى – محطة برج حمود"** الممول من البنك الأوروبي للتثمير،

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لذلك، نتشرف بدعوتكم لحضور اللقاء التشاوري الذي سوف يعقد اعتباراً من الساعة العاشرة والنصف من قبل ظهر يوم الاثنين في ١٩ آب ٢٠١٩ في قاعة الثانوية الأرمنية المركزية في برج حمود.

الرجاء تأكيد الحضور وإيفاد من ترونه مناسباً للمشاركة.

مجلس الإنماء والإعمار

الجمهورية اللبنانية
مجلس الإنماء والإعمار

ملاحظة: **للاستفسار ومزيد من المعلومات**
الاتصال على الرقم: ٠١-٨٨٨٣٠٥ مقسم ١٤٤

مجلس الإنماء والإعمار

بيروت - لبنان

جانب المديرية العامة للتنظيم المدني

(هاتف / فاكس رقم ٨١٥٥٢٣ - ٠١)

الموضوع: دعوة لحضور اللقاء التشاوري لعرض ومناقشة المعطيات المتعلقة بالأثر البيئي والاجتماعي لمشروع "**معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى – محطة برج حمود** "

تحية وبعد،

حيث أن مجلس الإنماء والإعمار يقوم بتنفيذ دراسة تقييم الأثر البيئي والاجتماعي لمشروع **" معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى – محطة برج حمود"** الممول من البنك الأوروبي للتثمير،

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لذلك، نتشرف بدعوتكم لحضور اللقاء التشاوري الذي سوف يعقد اعتباراً من الساعة العاشرة والنصف من قبل ظهر يوم الاثنين في ١٩ آب ٢٠١٩ في قاعة الثانوية الأرمنية المركزية في برج حمود.

الرجاء تأكيد الحضور وإيفاد من ترونه مناسباً للمشاركة.

مجلس الإنماء والإعمار

الجمهورية اللبنانية مجلس الإنماء والإعمار

ملاحظة: للاستفسار ومزيد من المعلومات
الاتصال على الرقم: ٠١-٨٨٨٣٠٥ مقسم ١٤٤

مجلس الإنماء والإعمار

بيروت - لبنان

جانب وزارة المالية – مديرية الشؤون العقارية

(هاتف / فاكس رقم ٦٤٨٧٥١ - ٠١)

<u>الموضوع:</u> دعوة لحضور اللقاء التشاوري لعرض ومناقشة المعطيات المتعلقة بالأثر البيئي والاجتماعي لمشروع "**معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى – محطة برج حمود** "

تحية وبعد،

حيث أن مجلس الإنماء والإعمار يقوم بتنفيذ دراسة تقييم الأثر البيئي والاجتماعي لمشروع **" معالجة مياه الصرف الصحي في المنطقة الساحلية الشمالية لبيروت الكبرى – محطة برج حمود"** الممول من البنك الأوروبي للتثمير،

وحيث أن من بين المهام المطلوبة في الدراسة، الاستماع لآراء المجتمع المدني والسلطات المحلية والإدارات المعنية حول الآثار البيئية والاجتماعية التي قد تنتج عن المشروع، واقتراحاتهم المتعلقة بالحلول والتدابير التخفيفية والبدائل الممكنة للحد من الآثار المتوقّعة،

لذلك، نتشرف بدعوتكم لحضور اللقاء التشاوري الذي سوف يعقد اعتباراً من الساعة العاشرة والنصف من قبل ظهر يوم الاثنين في ١٩ آب ٢٠١٩ في قاعة الثانوية الأرمنية المركزية في برج حمود.

الرجاء تأكيد الحضور وإيفاد من ترونه مناسباً للمشاركة.

مجلس الإنماء والإعمار

<u>ملاحظة:</u> للاستفسار ومزيد من المعلومات
الاتصال على الرقم: ٠١-٨٨٨٣٠٥ مقسم ١٤٤

ELARD

حضرة رئيس و أعضاء بلدية برج حمود المحترمين
بلدية برج حمود- شارع أرمينيا- برج حمود
هاتف: 260155 - 01
فاكس:260156 - 01

بيروت، في 1 آب، 2019
مرجعنا: رك / 2019 /352

<u>الموضوع:</u> إجتماع مشاركة العامة ضمن دراسة تحديد نطاق تقييم الأثر البيئي لمشروع إنشاء محطة التكرير التمهيدي للمياه المبتذلة في الدورة-برج حمود

تحية طيبة وبعد،

تتشرف شركة الأرض للتنمية المتطورة للموارد ش.م.ل. (ELARD s.a.l.) التي تقوم بإجراء دراسة تحديد نطاق تقييم الأثر البيئي لمشروع إنشاء محطة التكرير التمهيدي لمعالجة المياه المبتذلة في الدورة-برج حمود، بدعوتكم لحضور اجتماع مشاركة العامة الذي سوف يتناول عرضًا للمشروع ومناقشة الآثار البيئية والاجتماعية المحتملة له.

يقع المشروع ضمن الأملاك البحرية العمومية المردومة في برج حمود لإنشاء محطة تكرير تمهيدية للمياه المبتذلة ضمن مشروع الصرف الصحي للمنطقة الشمالية من بيروت الكبرى الذي يستلزم إشغال 65،000 م^2 من الأملاك العامة.

يأتي هذا الاجتماع خلال مرحلة تحديد نطاق الدراسة (scoping phase) بهدف الاستماع لأراء وهواجس المجتمع المدني المحلي والمجموعات التي تتأثر بالمشروع المقترح حول الآثار البيئية والاجتماعية التي قد تنتج عن المشروع، واقتراحاتهم المتعلقة بالحلول والتدابير التخفيفية والبدائل الممكنة للحد من الآثار المتوقعة.

يُعقد الاجتماع في المكان والزمان المبيّنين أدناه:

<u>المكان:</u> قاعة الثانوية الأرمنية المركزية في برج حمود

<u>الزمان:</u> الاثنين 19 آب 2019 من 10:30 صباحاً حتى 12:30 ظهراً

لتأكيد الحضور أوالاستفسار عن الموضوع، الرجاء الاتصال بالأنسة تينا الخوري على الرقم 01/888305، مقسم 141.

أملين حضوركم والتعاون لكل ما فيه خدمة وصحة وسلامة الوطن والمواطن.

وتفضّلوا بقبول فائق الإحترام،

رامز كيال،
المدير العام

بلدية بيروت
مصلحة امانة المجلس البلدي

الرقم ..... ١٣٧٣ / ٢ / ٢٠١٩

تاريخ الاستلام ..... ٢٠ / ٨ / ٢٠١٩

وع إنشاء محطة التكرير التمهيدي

ملاحظة : لا يمكن اعطاء ايضاحات المعاملات بدون هذا الملم

قوم بإجراء دراسة تحديد نطاق تقييم

ورة-برج حمود، بدعوتكم لحضور

اجتماع مشاركة العامة الذي سوف يتناول عرضًا للمشروع ومناقشة الآثار البيئية والاجتماعية المحتملة له.

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وتفضّلوا بقبول فائق الإحترام،
رامز كيال،
المدير العام

ELARD S.A.L.

ELARD

Earthlink & Advanced Resources Development S.A.L.
Member of ELARD Holding S.A.L.

جانب رئيس اتحاد المتن الشمالي الساحلي والأوسط المحترم
قصر المؤتمرات_ضبيه
هاتف: 04-521110

بيروت، في 1 آب، 2019
مرجعنا: رك / 2019 /354

الموضوع: إجتماع مشاركة العامة ضمن دراسة تحديد نطاق تقييم الأثر البيئي لمشروع إنشاء محطة التكرير التمهيدي للمياه المبتذلة في الدورة-برج حمود

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آملين حضوركم والتعاون لكل ما فيه خدمة وصحة وسلامة الوطن والمواطن.

وتفضّلوا بقبول فائق الإحترام،
رامز كيال،
المدير العام

اتحاد بلديات المتن
رقم التسجيل ٤٢٧
تاريخ التسجيل ٨/٨

EARTHLINK & ADVANCED RESOURCES DEVELOPMENT
ELARD S.A.L.
R.C. 2035062
Beirut Lebanon

APPENDIX D: PUBLIC PARTICIPATION PRESENTATION

إجتماع مشاركة العامة الأول

دراسة تقييم الأثر البيئي لمشروع إنشاء محطة التكرير التمهيدي للمياه المبتذلة في الدورة-برج حمود

تحديد نطاق تقييم الأثر البيئي

19آب 2019
الثانوية الأرمنية المركزية

ELARD

البرنامج

- أهداف الجلسة
- لمحة عن المشروع
- الإطار القانوني العام
- وصف المشروع
- نتائج الزيارة الميدانية والوضع الراهن
- الآثار البيئية المحتملة والتدابير التخفيفية المقترحة
- تحديد البدائل
- خطة الإدارة البيئية
- أسئلة ومناقشة

Page 2/

أهداف الجلسة

- مناقشة نطاق دراسة تقييم الأثر البيئي للمشروع وآثاره المحتملة
- مناقشة أية مخاوف/ هواجس بيئية، اجتماعية أو اقتصادية محتملة لم يتم التطرّق إليها
- اقتراحات لمعالجة هذه المخاوف/ تخفيفها

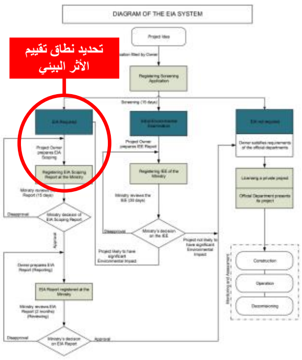
Page 3/

لمحة عن المشروع

- تنفيذ المشروع: مجلس الإنماء والإعمار
- المسؤول عن تشغيل : مؤسسة مياه بيروت وجبل لبنان
- الجهة المقرضة: البنك الأوروبي للتثمير (EIB)
- الاستشاري المسؤول عن الدراسة الهندسية: ACE
- الاستشاري المسؤول عن دراسة تقييم الأثر البيئي: شركة الأرض للتنمية المتطورة للموارد ELARD

Page 4/

الإطار القانوني العام



- على صاحب المشروع أن يحدد، بالتنسيق مع وزارة البيئة، نطاق تقييم الأثر البيئي لمشروعه وفقاً للمعلومات المبينة في الملحق رقم 7 من المرسوم 8633/2012، والقرار 261/1 (2015)

الإطار القانوني العام

رقم القانون / القرار/ المرسوم	نص القاون
مرسوم رقم 2761 (1933)	المبادئ التوجيهية المتعلقة بإدارة مياه الصرف الصحي والتخلص منها
قرار وزارة البيئة رقم 52/1 (1996)	تحديد المواصفات والنسب الخاصة للحد من تلوث الهواء والمياه والتربة
القانون 221 (2000)	تنظيم قطاع المياه
مرسوم 8/1 (2001)	تحديد المواصفات والنسب الخاصة للمياه المبتذلة
القانون 444 (2002)	قانون حماية البيئة
مرسوم رقم 11958 (2004)	تنظيم الحماية والوقاية والسلامة في البناء
مرسوم رقم 8633 (2012)	مرسوم تقييم الأثر البيئي
قانون رقم 77 (2018)	المخطط التوجيهي العام للمياه وأحواض المياه في لبنان والشروط المتعلقة بنوعية المياه والحفاظ على جودتها، وإدارة كافة المرافق العامة للمياه
قانون رقم 78 (2018)	قانون حماية نوعية الهواء

الإطار القانوني العام

قرار مجلس الوزراء رقم 1/2016 القاضي بإنشاء محطة معالجة الصرف الصحي.

الجمهورية اللبنانية
مجلس الوزراء
الامانة العامة

رقم المحضر : ٩٠
رقم القرار : ١
سنة : ٢٠١٦

من محضر جلسة مجلس الوزراء

المنعقدة في : السراي الكبير يوم : السبت الواقع في : ٢٠١٦/٣/١٢

الموضوع: معالجة وضع النفايات المنزلية الصلبة .

خامساً: الموافقة على طلب بلديتي برج حمود والجديدة – البوشرية – السد استثمار الاراضي التي ستنتج عن ردم النفايات في نطاقها وفق الخرائط المرفقة والمحددة باللون الاحمر وذلك وفق القوانين والأصول المرعية الاجراء باستثناء الارض المخصصة للانشاءات العامة (محطة تكرير المياه المبتذلة).

الإطار القانوني العام

من أهداف إنشاء محطة التكرير التمهيدي للمياه المبتذلة التقيد بشروط **اتفاقية برشلونة لحماية البيئة البحرية والمنطقة الساحلية للبحر المتوسط** من خلال الحد من المصادر البرية الملوثة مثل مياه الصرف الصحي.

وصف المشروع

- يأتي هذا المشروع ضمن مخطط الصرف الصحي للمنطقة الشمالية من بيروت الكبرى
- يهدف المشروع إلى إنشاء محطة لتكرير المياه المبتذلة في برج حمود-الدورة على مرحلتين:
  - المرحلة الأولى: محطة تكرير تمهيدي لمعالجة حوالي 276,250 م^3 من المياه المبتذلة (العام 2022)
  - المرحلة الثانية: محطة معالجة أولية وثانوية للصرف الصحي (العام 2030)
- يمتد المشروع على مساحة 65,000 م^2 من الأملاك البحرية العمومية المردومة الناتجة عن إزالة جبل النفايات في برج حمود.

وصف المشروع

الجدول الزمني للمشروع

2020 أعمال البناء و تأهيل المصب البحري

2022 أوّل تشغيل محطة التكرير التمهيدي

2030 بدء تشغيل محطة التكرير المرحلة الثانية

28 شهر

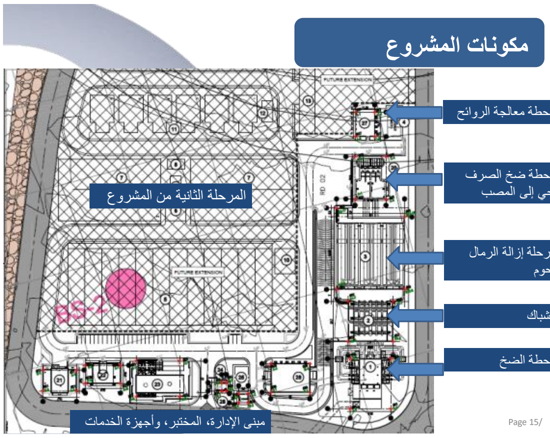
موقع المشروع

الموقع المقترح لإنشاء محطة تكرير الصرف الصحي

موقع المشروع


موقع المشروع
الموقع المقترح لإنشاء محطة تكرير الصرف الصحي
المرحلة الثانية
المرحلة الأولى
Page 13/

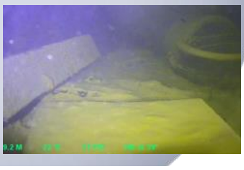

اتجاه المياه المبتذلة من المحطة إلى المصب البحري
اتجاه المياه المبتذلة من الشبكة إلى المحطة


مكونات المشروع
5. محطة معالجة الروائح
4. محطة ضخ الصرف الصحي إلى المصب
3. مرحلة إزالة الرمال والشحوم
2. الشباك
1. محطة الضخ
المرحلة الثانية من المشروع
BS-2
مبنى الإدارة، المختبر، وأجهزة الخدمات
Page 15/


مكونات المشروع
خط التصريف الأساسي بطول 1,777 م
خط التصريف الإحتياط بطول 620 م
محطة ضخ الصرف الصحي إلى المصب
• بعد المعالجة التمهيدية للصرف الصحي سيتم تصريف المياه المبتذلة في البحر عن طريق خط تصريف، بواسطة الجاذبية.
• في المرحلة الثانية من المشروع سيتم إستعمال 4 مضخات.
Page 20/

مكونات المشروع

- تنفيذ أعمال إعادة تأهيل للمصب.



مكونات المشروع

محطة معالجة الروائح

- تستند محطة معالجة الروائح على عملية الأكسدة (oxidation) / الغسل (scrubbing) لتدمير الروائح عن طريق تحويل الملوثات الضارة إلى مركبات مستقرة.
- تعتمد عملية الغسل على إستعمال حمض الكبريت (H_2SO_4)، هيدروكسيد الصوديوم (NaOH)، وهيبوكلوريت الصوديوم (NaOCl) في عملية التنظيف.
- قبل المعالجة، يتألف الهواء من حوالي 25 ppm من H_2S. أمّا بعد المعالجة، يجب أن تكون فعالية إزالة الغازات أكبر من 98٪ وأن يكون تركيز H_2S في الهواء المعالج أقل من 0.2 ppm.

نتائج الزيارة الميدانية

- أجرى فريق العمل زيارة للموقع تم خلالها:
  - مسح منطقة المشروع
  - تقييم أولي للثروة البيولوجية
  - قياسات الضوضاء
  - تقييم أولي للآثار والإرث الثقافي

الوضع الراهن

<u>**موقع إنشاء محطة معالجة الصرف الصحي**</u>

الوضع الراهن

- التقييم البيولوجي:

لا آثار سلبية على التنوع البيولوجي البري خلال مرحلة الإنشاء بما أن موقع المشروع على أرض مردومة.

تقييم الآثار:

لا يوجد آثار في موقع المشروع

الأماكن المجاورة الحساسة

الوضع الراهن

- قياس الضوضاء:
- تم قياس الضوضاء في موقع المشروع والأماكن المجاورة القريبة، والبيانات التي تم جمعها لم تتجاوز معايير وزارة البيئة المنصوص عليها في القرار 52/1 للمناطق الصناعية (60-70 ديسيبل)

نتيجة القياس (L_{90}) (dBA)	الحد الأقصى (dBA)	
59.5	60-70	N1
57.2		N2
49.9		N3

تقييم الأثر البيئي والاجتماعي

- ستشمل دراسة تقييم الأثر البيئي المحاور التالية:

المحاور المشمولة	
مرحلة الإنشاء	مرحلة التشغيل
• نوعية الهواء • مستوى الضوضاء • التربة, المياه الجوفية, ومياه البحر • النفايات الصلبة • حركة السير • الوضع الاجتماعي والاقتصادي • السلامة العامة وسلامة العمال.	• نوعية الهواء • مستوى الضوضاء • التربة, المياه الجوفية, ومياه البحر • النفايات الصلبة • الثروة البيولوجية البحرية • الوضع الاجتماعي والاقتصادي • سلامة العمال

- لكل من هذه المحاور سيتم تحديد وتقييم الآثار الإيجابية والسلبية المتوقعة خلال مرحلة الإنشاء والتشغيل

الآثار الإيجابية للمشروع

- **الآثار الإيجابية للمشروع:**
- تكرير أولي للمياه المبتذلة الناتجة عن المنطقة الشمالية من بيروت الكبرى
- التخفيف من الآثار السلبية الناتجة من المياه المبتذلة على نوعية مياه البحر الساحلية
- التخفيف من الروائح في منطقة المشروع الناتجة عن تصريف المياه المبتذلة مباشرةً على الساحل وفي مجرى نهر بيروت
- توفير فرص عمل أثناء مرحلة الإنشاء و التنفيذ

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تقييم الآثار البيئية والاجتماعية

		تقييم الأهمية					
		ضئيلة 1	بسيطة 2	معتدلة 3	كبيرة 4	كارثية 5	مفيدة B
إحتمالات الحدوث	منخفض L=1	1	2	3	4	5	+
	متوسط M=2	2	4	6	8	10	++
	مرتفع H=3	3	6	9	12	15	+++

دليل

القبولية	
مفيدة	+ to +++
منخفضة	1 to 3
متوسطة	4 to 9
مرتفعة	10 to 15

إحتمالات الحدوث
(1) منخفض -L
(2) متوسط -M
(3) مرتفع -H

تقييم الأهمية
1- ضئيلة
2- بسيطة
3- معتدلة
4- كبيرة
5- كارثية
B- مفيدة (+)

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الآثار المحتملة خلال مرحلة الإنشاء

- **نوعية الهواء:** غبار وملوثات أخرى
- **مستوى الضوضاء:** أعمال البناء
- **التربة والمياه الجوفية:** احتمال تسرب الوقود من الآليات
- **مياه البحر:** تسرب الوقود ومواد البناء أثناء أعمال صيانة خط المصب البحري
- **النفايات الصلبة:** مخلفات نفايات بناء المحطة وأعمال صيانة خط المصب البحري

- **الوضع الاجتماعي والاقتصادي:** خلق فرص عمل واحتمال انزعاج عمال المؤسسات الأقرب من الضجيج والغبار
- **حركة السير:** ازدياد الضغط على الطرقات المؤدية إلى المشروع نتيجة حركة تنقل الآليات
- **السلامة العامة وسلامة العمال:** احتمال وقوع حوادث العمل

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الآثار المحتملة خلال مرحلة التشغيل

محطة معالجة الروائح

نوعية الهواء:
- إحتمال انبعاث الروائح من المحطة
- انبعاث الملوثات من المولدات

إن إمكانية إنبعاث الروائح من المحطة ضئيلة بسبب وجود محطة لمعالجة الروائح.

إعتماد هذه التدابير التخفيفية تخفض إمكانية إنبعاث الروائح بشكل إضافي:
- صيانة وكشف دوري على محطة معالجة الروائح
- إنشاء آلية لتلقي الشكاوى
- صيانة دائمة وكشف دوري على المولدات

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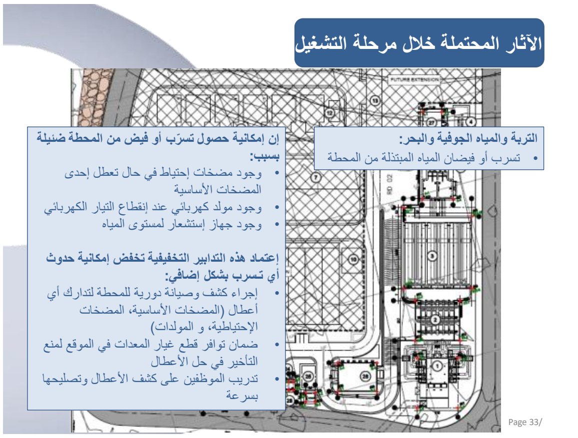
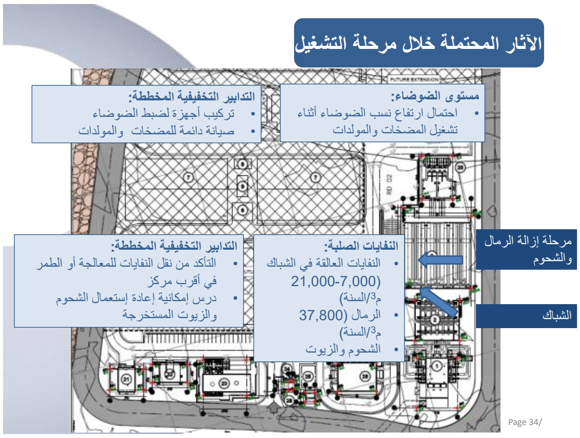

الآثار المحتملة خلال مرحلة التشغيل
التربة والمياه الجوفية والبحر:
• تسرب أو فيضان المياه المبتذلة من المحطة
إن إمكانية حصول تسرّب أو فيض من المحطة ضئيلة بسبب:
• وجود مضخات إحتياط في حال تعطل إحدى المضخات الأساسية
• وجود مولد كهربائي عند إنقطاع التيار الكهربائي
• وجود جهاز إستشعار لمستوى المياه
إعتماد هذه التدابير التخفيفية تخفض إمكانية حدوث أي تسرب بشكل إضافي:
• إجراء كشف وصيانة دورية للمحطة لتدارك أي أعطال (المضخات الأساسية، المضخات الإحتياطية، و المولدات)
• ضمان توافر قطع غيار المعدات في الموقع لمنع التأخير في حل الأعطال
• تدريب الموظفين على كشف الأعطال وتصليحها بسرعة
Page 33/


الآثار المحتملة خلال مرحلة التشغيل
مستوى الضوضاء:
• احتمال ارتفاع نسب الضوضاء أثناء تشغيل المضخات والمولدات
التدابير التخفيفية المخططة:
• تركيب أجهزة لضبط الضوضاء
• صيانة دائمة للمضخات والمولدات
مرحلة إزالة الرمال والشحوم
الشباك
النفايات الصلبة:
• النفايات العالقة في الشباك (7,000-21,000 م3/السنة)
• الرمال (37,800 م3/السنة)
• الشحوم والزيوت
التدابير التخفيفية المخططة:
• التأكد من نقل النفايات للمعالجة أو الطمر في أقرب مركز
• درس إمكانية إعادة إستعمال الشحوم والزيوت المستخرجة
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الآثار المحتملة خلال مرحلة التشغيل
الثروة البيولوجية البحرية ونوعية مياه البحر:
صرف المياه المبتذلة المعالجة أولياً فقط في البحر
التدابير التخفيفية المخططة:
سيتم دراسة كيفية إنتشار المياه المبتذلة في البحر وبناء على النتائج تحدد التدابير التخفيفية المناسبة
الوضع الاجتماعي والاقتصادي :
تأثير المحطة على المشاريع المستقبلية في الأرض المجاورة من الضوضاء وإحتمال انبعاث الروائح
الوضع الاجتماعي والاقتصادي:
التقيد بتدابير التخفيف من الضجيج ومنع إنبعاث الروائح المذكورة سابقاً
Google Earth
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تحديد البدائل
• إن دراسة تقييم الأثر البيئي ستتضمن تحليل مبدئي عام لبدائل المشروع:
إنشاء المشروع الحالي
عدم إنشاء المشروع
إنشاء المشروع بتصميم بديل
Page 37/

خطة الإدارة البيئية

- **تتضمن خطة الإدارة البيئية:**
  - تدابير تخفيفية للآثار السلبية المترتّبة عن المشروع
  - برنامج الرصد والمراقبة: العوامل التي يجب مراقبتها - تواتر المراقبة – مسؤوليات المراقبة
  - بناء القدرات والإطار المؤسساتي

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أسئلة ومناقشة

أية أسئلة/ هواجس/ اقتراحات/ توصيات؟

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APPENDIX E: PUBLIC PARTICIPATION ATTENDANCE SHEET

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إجتماع مشاركة العامة الأول

دراسة تحديد نطاق تقييم الأثر البيئي لمشروع إنشاء محطة معالجة الصرف الصحي لمنطقة بيروت الكبرى الشمالية

19 آب 2019

قاعة الثانوية الأرمنية المركزية في برج حمود

Name الاسم	Organization المؤسسة	Position المركز	Phone number رقم الهاتف	Email البريد الالكتروني
حنا شواح	نقيب الصيادين	[illegible]	٠٢ ٨١٤٤٧٢	
المحامي اسعد صالح	مجلس البلدية		٠٣ ٢٥٢٠٢٦	
Jessy Issa	بلدية برج حمود	قسم الأشغال	03/751060	jessy.issa@gmail.com
Nabil Kahalé	بلدية سن الفيل	رئيس البلدية	03/679680	
ZIAD AL Ghourayeb	CDR	Project Manager	03/829222	Ziadg@cdr.gov.lb
Abounayan Nazareth	بلدية برج حمود	عضو بلدية	03/310462	Nazarethabounayan@gmail.com
شارل سبع	حزب الكتائب	ممثل النائب سامي الجميل	03/151569	Charle_sabaa@hotmail.com
جورج اسطفان	بلدية برج حمود		71/838654	
Arpi Mangassarian	architecte	برج حمود	03.652235	arbatim@gmail.com
عصام زيتون	بلدية برج حمود / بلدية سن الفيل	رئيس البلدية	03 636268	

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إجتماع مشاركة العامة الأول

دراسة تحديد نطاق تقييم الأثر البيئي لمشروع إنشاء محطة معالجة الصرف الصحي لمنطقة بيروت الكبرى الشمالية

19 آب 2019

قاعة الثانوية الأرمنية المركزية في برج حمود

Name الاسم	Organization المؤسسة	Position المركز	Phone number رقم الهاتف	Email البريد الاكيروني
Edouard Kojayan	برج حمود	مستشار البلدية مفوض صحي	03 308829 / ٧١٩٣٠٠٠٤	مهندس متقاعد
Georgy Darahend		محاسب البلدية	03 404691	
P. Mardi Naaman	Eglise Notre dame du Liban	بلدية برج حمود	03 448931	
Meghry Yeretsian		بلدية برج حمود	78/932943	
Dr. Khalid Nakhle'	Ministry of energy and water	Advisor to the minister	03/344957	nakhle.1@hotmail.com
Dr. Raffi Gergian	Ministry of Culture Directorate General of Antiquities	Architect Archaeologist	03/747105	raffigergian@free.fr
Assem Fedawi	CDR	مدير تكليف الرئاسة	03/600777	assemf@cdr.gov.lb
ELIE Abou jaoude	بلدية انطلياس النقاش	رئيس البلدية	03/302703	Elieaboujaudeh@yahoo.com
Hagop Simonian	بلدية برج حمود	مهندس مدني	01/253103	jack-simon1@hotmail.com

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إجتماع مشاركة العامة الأول

دراسة تحديد نطاق تقييم الأثر البيئي لمشروع إنشاء محطة معالجة الصرف الصحي لمنطقة بيروت الكبرى الشمالية

19 آب 2019

قاعة الثانوية الأرمنية المركزية في برج حمود

Name الاسم	Organization المؤسسة	Position المركز	Phone number رقم الهاتف	Email البريد الالكتروني
Charbel Hayek	Hfoury Engineering and contracting	Project Manager	03855450	CharbelHayek@Hfouryengineering.com
Michel Batrout	St. Joseph school	Accountant	70/787136	
Andre	كتائب برج حمود			
Raymond Ayvazian	عضو مجلس بلدية برج حمود		03/413526	raymond.ayvazian@gmail.com
Youssef Karam	CDR		03656310	ykaram@cdr.gov.lb
Elias Daoud	ACE	Head of water Resources Section	03842224	elias.daoud@ace-intl.com
HAGOP TERZIAN			03.314141	hagopterzian@gmail.com
VASKEN Baghdassarian				
Dany Khoury	UCC	CEO	03/394003	

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إجتماع مشاركة العامة الأول

دراسة تحديد نطاق تقييم الأثر البيئي لمشروع إنشاء محطة معالجة الصرف الصحي لمنطقة بيروت الكبرى الشمالية

19 آب 2019

قاعة الثانوية الأرمنية المركزية في برج حمود

Name الاسم	Organization المؤسسة	Position المركز	Phone number رقم الهاتف	Email البريد الاكيروني
		عضو بلدي	03/755503	هوفيك بربريان Hberberian@Hotmail
Maryhelene Awad	Bourj hammoud Municipality	employee	81/777289	helena.presence@gmail.com
رويد الشمالي	للبلدية برج حمود	كاتب	79-141389	
RAYMONA JUREIBINI	D Beirut	Owner	03-292946	
Ghada Rida	EBML	Chief of service	03-810356	Ghadarida@gmail.com
Salman solh	EBML	11	03-281715	
George salameh	Fanar municipality	رئيس		

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إجتماع مشاركة العامة الأول

دراسة تحديد نطاق تقييم الأثر البيئي لمشروع إنشاء محطة معالجة الصرف الصحي لمنطقة بيروت الكبرى الشمالية

19 آب 2019

قاعة الثانوية الأرمنية المركزية في برج حمود

Name الاسم	Organization المؤسسة	Position المركز	Phone number رقم الهاتف	Email البريد الاكيروني
مارلين مراد		قائم مقام		
روميه كرم				
فؤاد شديد	بلدية المطيلب	رئيس		
ناتشي ملكونيان		دكتور		
الياس سلامة	Khoury contracting			
معود الأشقر				
	ديوان المحاسبة ex			
هوفيك بدريان				
Eddy Abillama		نائب		
باتريك ترجيان				
ادي معلوف		نائب		
فريج صابونجيان				
بيار الأشقر				

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إجتماع مشاركة العامة الأول

دراسة تحديد نطاق تقييم الأثر البيئي لمشروع إنشاء محطة معالجة الصرف الصحي لمنطقة بيروت الكبرى الشمالية

19 آب 2019

قاعة الثانوية الأرمنية المركزية في برج حمود

Name الاسم	Organization المؤسسة	Position المركز	Phone number رقم الهاتف	Email البريد الاكيروني
عصام زيتون	بلدية بياقوت	رئيس		
الياس متني		نائب		
Karim shaar	ELARD	Environmental specialist	01 888305	
Tina ElKhoury	ELARD	//	//	
Ricardo Khoury	ELARD	VP	//	
Joseph Eid	ELARD		//	

ELARD

إجتماع مشاركة العامة الأول

دراسة تحديد نطاق تقييم الأثر البيئي لمشروع إنشاء محطة معالجة الصرف الصحي لمنطقة بيروت الكبرى الشمالية

19 آب 2019

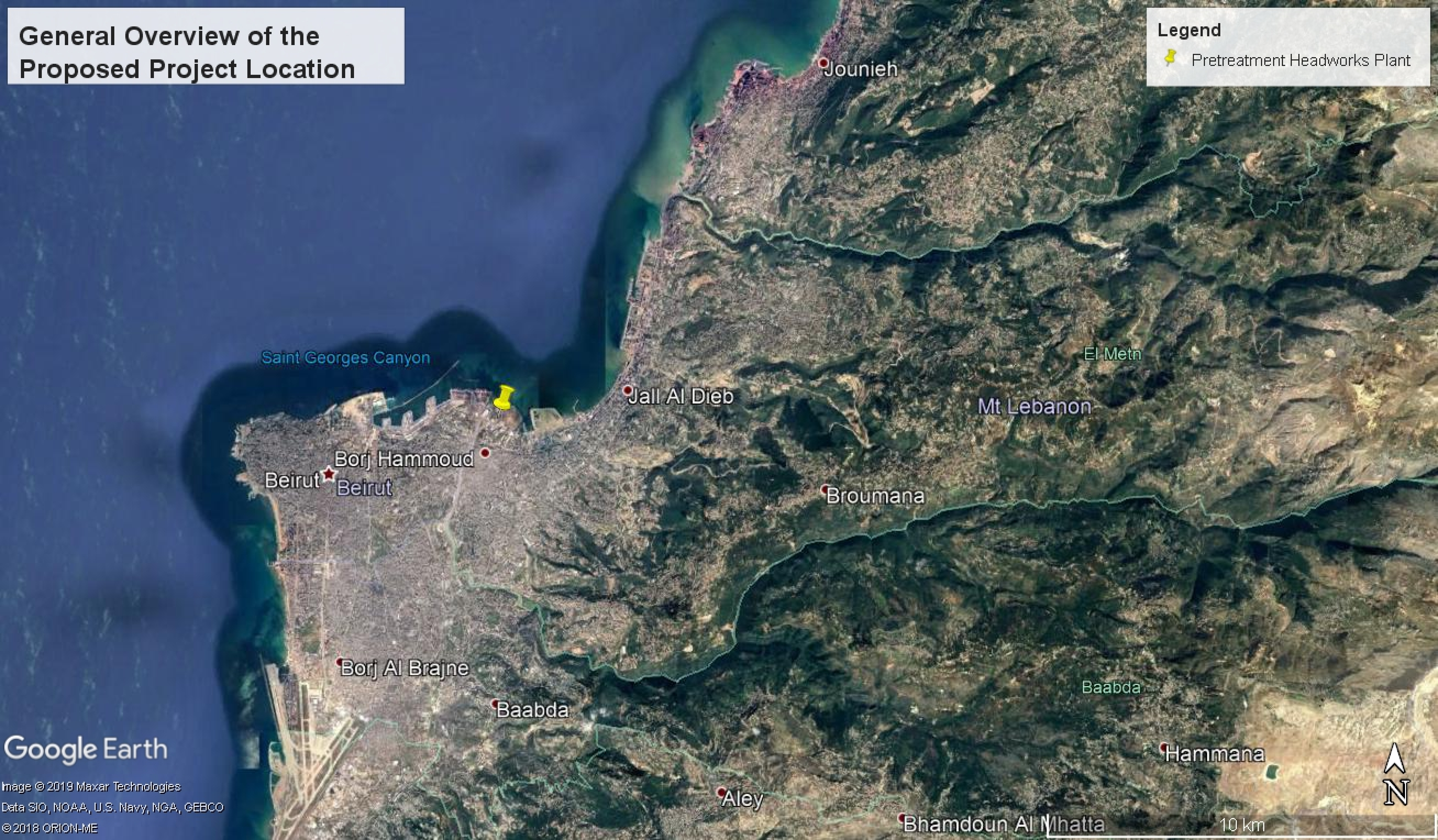
قاعة الثانوية الأرمنية المركزية في برج حمود

Name الاسم	Organization المؤسسة	Position المركز	Phone number رقم الهاتف	Email البريد الاكيروني
[illegible]				
جان شواح				
ايلي فلوبو	اتحاد بلديات بشري	رئيس		
[illegible]		دكتور		
سيمون درغام				
نبيل كحالة	بلدية سن الفيل	رئيس		
ميرنا المر	اتحاد بلديات المتن	رئيس		
هاكوب ترزيان		نائب		
جورج سلامة	بلدية الفنار	رئيس		
شارل سابا		ممثل النائب سامي الجميل		
الان كون		نائب		
خالد نخلة	وزارة الطاقة			
محمد مكاوي		محافظ جبل لبنان		

APPENDIX F: DOCUMENTS REQUIRED AS PER MOE CIRCULAR 9/1 DATED 2014

- Appendix F1: Aerial View of the Project Site
- Appendix F2: Council of Ministers Decision 1 Dated 12/03/2016

Appendix F1: *Aerial View of the Project Site*


General Overview of the Proposed Project Location
Legend
Pretreatment Headworks Plant
Jounieh
Saint Georges Canyon
El Metn
Jall Al Dieb
Mt Lebanon
Borj Hammoud
Beirut
Beirut
Broumana
Borj Al Brajne
Baabda
Baabda
Google Earth
Hammana
Image © 2019 Maxar Technologies
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2018 ORION-ME
Aley
Bhamdoun Al Mhatta
10 km
N

Appendix F2: *Decision 1 Dated 12/03/2016*

الجمهوريـة اللبنانيـة
مجلس الوزراء
الامانة العامة

مجلس الإنماء والإعمار
مكتب الرئاسة
تاريخ الورود ٢٠١٦/٣/١٥
رقم ٢٧٧٠/ص

ن.ر/س.غ

رقم المحضر : ٩٠
رقم القرار : ١
سنة : ٢٠١٦

من محضر جلسة مجلس الوزراء

المنعقدة في : السراي الكبير يوم : السبت الواقع في : ٢٠١٦/٣/١٢

الموضوع: معالجة وضع النفايات المنزلية الصلبة .

المستندات:- قانون المحاسبة العمومية وتعديلاته.

- المرسوم الاشتراعي رقم ١١٨ تاريخ ١٩٧٧/٦/٣٠ وتعديلاته (قانون البلديات).
- القانون رقم ٢٨٠ تاريخ ٢٠١٢/٤/٣٠ (اعطاء حوافز مالية للبلديات المحيطة بمطمر عبيه – عين درافيل ...).
- قرارا دولة رئيس مجلس الوزراء رقم ٢٠١٥/٤٧ تاريخ ٢٠١٥/٢/٢٨ (تشكيل لجنة لتقييم العروض كافة المتعلقة بالخطة الشاملة للنفايات المنزلية الصلبة بما فيها عروض الاشراف) ورقم ٢٠١٥/٦٣ تاريخ ٢٠١٥/٣/٣٠ (تعديل اسم ممثل مكتب وزير الدولة لشؤون التنمية الادارية في اللجنة المذكورة)
- قرارات مجلس الوزراء رقم ٣٤ تاريخ ٢٠١٠/٤/٦ (مواضيع عاجلة تتعلق بادارة النفايات الصلبة) ورقم ٥٥ تاريخ ٢٠١٠/٩/١ (تقرير اللجنة الوزارية اقتراح خطة تتعلق بادارة النفايات الصلبة في المناطق اللبنانية كافة) ورقم ٤٦ تاريخ ٢٠١٤/١٠/٣٠ المعدل بالقرار رقم ١ تاريخ ٢٠١٥/١/١٢ (تكليف مجلس الانماء والاعمار المباشرة فوراً باعداد دفتر الشروط لاجراء مناقصة مفتوحة لتلزيم اعمال كنس النفايات وجمعها ونقلها في نطاق محافظة بيروت ومعظم محافظة جبل لبنان ومحافظة لبنان الشمالي ...) ورقم ٤٦ تاريخ ٢٠١٤/١١/١٣ (احالة عرض وزارة البيئة لدفتر شروط اعمال كنس النفايات وجمعها ونقلها في نطاق محافظة بيروت ومعظم محافظة جبل لبنان ومحافظة لبنان الشمالي الى اللجنة الوزارية المكلفة اعداد خطة وطنية شاملة للنفايات الصلبة لاعداد تقرير حوله في ضوء مداولات مجلس الوزراء) ورقم ٧ تاريخ ٢٠١٥/٥/٧ (الموافقة على تعديل بعض فقرات قرار مجلس الوزراء رقم ١ تاريخ ٢٠١٥/١/١٢) ورقم ١ تاريخ ٢٠١٥/٨/٢٥ (اعتماد اقتراح

س.غ

الجمهوريـة اللبنانيـة

مجلس الوزراء

الامانة العامـة

رقـم المحضر : ٩٠

رقم القرار : ١

تاريخ القرار : ٢٠١٦/٣/١٢

وزير البيئة بعدم الموافقة على نتائج مناقصات خدمات النفايات المنزلية الصلبة ، وتكليف اللجنة الوزارية البحث في البدائل ورفعها الى مجلس الوزراء بأسرع وقت ممكن) ورقم ١ تاريخ ٢٠١٥/٨/٢٧ (تكليف وزير الداخلية والبلديات الطلب الى البلديات واتحادات البلديات الإبلاغ عن استعدادها وخططها لتحمل مسؤولياتها في معالجة النفايات المنزلية الصلبة، كل في نطاقها الجغرافي، وذلك بأسرع وقت ممكن لاتخاذ القرار المناسب بشأنها) ورقم ١ تاريخ ٢٠١٥/٩/٩(خطة معالجة وضع النفايات المنزلية الصلبة) ورقم ١ تاريخ ٢٠١٥/١٢/٢١ (معالجة وضع النفايات المنزلية الصلبة ...)

- اقتراح دولة رئيس مجلس الوزراء في الجلسة.

قرار المجلس

اطلع مجلس الوزراء على المستندات المذكورة آنفا ،

وبعد المداولة ،

قرر المجلس ما يلي :

أولاً:

- الموافقة على إنشاء مركزين مؤقتين للمعالجة والطمر الصحي في كل من برج حمود، الجديدة - البوشرية - السد ومصب نهر الغدير.
- الموافقة على اعادة فتح مطمر الناعمة لمدة شهرين لاستيعاب النفايات المتراكمة عن المرحلة السابقة وتطبيق القانون رقم ٢٠١٤/٢٨٠ المتعلق بالحوافز المالية للبلديات المحيطة به.
- يحدد مركز المعالجة والمطمر الصحي لقضاءي الشوف وعاليه في مرحلة لاحقة بالتشاور مع البلديات المعنية.
- الموافقة على توزيع النفايات الناتجة عن منطقة بيروت الإدارية في المراكز المستحدثة بموجب هذا القرار وفي معمل صيدا.

- يتم إنشاء وتطوير معامل المعالجة والفرز والمطامر الصحية وفق القواعد العلمية والبيئية بالتنسيق مع البلديات المعنية.

ثانياً:

- تكليف وزيري المالية والداخلية والبلديات اعداد مشروع قانون للحوافز تعطى للبلديات التي تقع في نطاقها معامل الفرز والمعالجة والمطامر الصحية. والموافقة على اقرار دفعة قدرها /٨/ مليون دولار اميركي لهذه السنة قابلة للتمديد بقرار من مجلس الوزراء لكل من البلديات التالية التي يقع في نطاقها المعامل والمطامر وذلك ريثما يقر القانون وهي:
  ١- برج حمود.
  ٢- الجديدة – البوشرية – السد .
  ٣- الشويفات.
  ٤- برج البراجنة.
  ٥- المنطقة الخدماتية الثانية (الشوف وعاليه).

تدفع من حساب البلديات المستفيدة من معالجة وطمر نفاياتها في الصندوق البلدي المستقل.

- دفع مبلغ ٦ دولار اميركي عن كل طن من النفايات المتراكمة التي تصل الى معمل الناعمة تحسم من مستحقات البلديات المستفيدة في الصندوق البلدي المستقل.

ثالثاً: التأكيد على قرارات مجلس الوزراء المتعلقة بالحل المستدام لاسيما:

- الاجراءات التنفيذية لتلزيم مشاريع تحويل النفايات الى طاقة باعتماد احدث التقنيات الضامنة لسلامة البيئة.
- حق البلديات او اتحادات البلديات أو المناطق الخدماتية بأن تدير معالجة نفاياتها على مسؤوليتها اذا أرادت بموافقة اللجنة المشكلة بموجب البند (خامساً) من القرار رقم ١ تاريخ ٢٠١٥/١٢/٢١.
- البدء بتطبيق مراحل الفرز من المصدر.

الجمهوريـة اللبنانيـة
مجلس الوزراء
الامانة العامـة

س.غ
رقـم المحضر : ٩٠
رقم القرار : أ
تاريخ القرار : ٢٠١٦/٣/١٢

رابعـا : تخصيص مبلغ خمسين مليون دولار اميركي لتغطية مشاريع انمائية في البلدات المحيطة بكل مطمر من المطامر الثلاثة وموزعة على اربع سنوات على أن يعد مشروع قانون برنامج لتمويل هذه المشاريع يحال الى المجلس النيابي.

خامساً: الموافقة على طلب بلديتي برج حمود والجديدة – البوشرية – السد استثمار الاراضي التي ستنتج عن ردم النفايات في نطاقها وفق الخرائط المرفقة والمحددة باللون الاحمر وذلك وفق القوانين والأصول المرعية الاجراء باستثناء الارض المخصصة للانشاءات العامة (محطة تكرير المياه المبتذلة).

سادساً: الموافقة على طلب بلدية الشويفات استثمار الاراضي التي ستنتج عن ردم النفايات في نطاقها وفق الخرائط المرفقة والمحددة باللون الاحمر وذلك وفق القوانين والأصول المرعية الاجراء على ان لا يكون هناك اي عائق لاقامة محطة لتكرير المياه المبتذلة ومعمل لمعالجة النفايات على مصب نهر الغدير بالتنسيق مع البلدية المعنية.

سابعاً: تكليف وزير الداخلية والبلديات تشكيل لجنة من ممثلي وزارات الداخلية والبلديات، البيئة، المالية ومكتب وزير الدولة لشؤون التنمية الادارية وبمساعدة هيئات المجتمع المدني والـ U.N.D.P و الـ U.N.E.P. لمراقبة آليات ومراحل التنفيذ على ان تعمل هذه اللجنة تحت الاشراف المباشر لوزير الداخلية والبلديات.

ثامناً: تكليف مجلس الانماء والاعمار القيام بمناقصات للشركات المؤهلة كل وفق اختصاصها خلال مهلة شهرين في مناطق الخدمات الحالية في بيروت الادارية وجبل لبنان ما عدا جبيل على ان توزع الكميات بالتساوي وذلك للاعمال التالية:

١- الكنس والجمع والنقل.
٢- الفرز والمعالجة.
٣- الطمر الصحي.
٤- إنشاء وتطوير معامل الفرز والمطامر الصحية والاعمال الهندسية اللازمة للانشاءات بما فيها الانشاءات البحرية.
٥- الدراسات والاشراف على الاعمال. 4

الجمهوريـة اللبنانيـة

مجلس الوزراء

الامانة العامــة

س.غ

رقــم المحضر : ٩٠

رقم القرار : أ

تاريخ القرار : ٢٠١٦/٣/١٢

- تستمر شركتا سوكلين وسوكومي بالاعمال التي كانت تقوم بها لحين اتمام المناقصة واعطاء امر المباشرة بالتنفيذ للشركات التي ترسو عليها الالتزامات اعلاه ولكل من هذه الاعمال.
- تدفع تكاليف العقود اعلاه، بما فيها عقود تسيير المرحلة الانتقالية من مستحقات البلديات المستفيدة من الصندوق البلدي المستقل.

4

أمين عام مجلس الوزراء

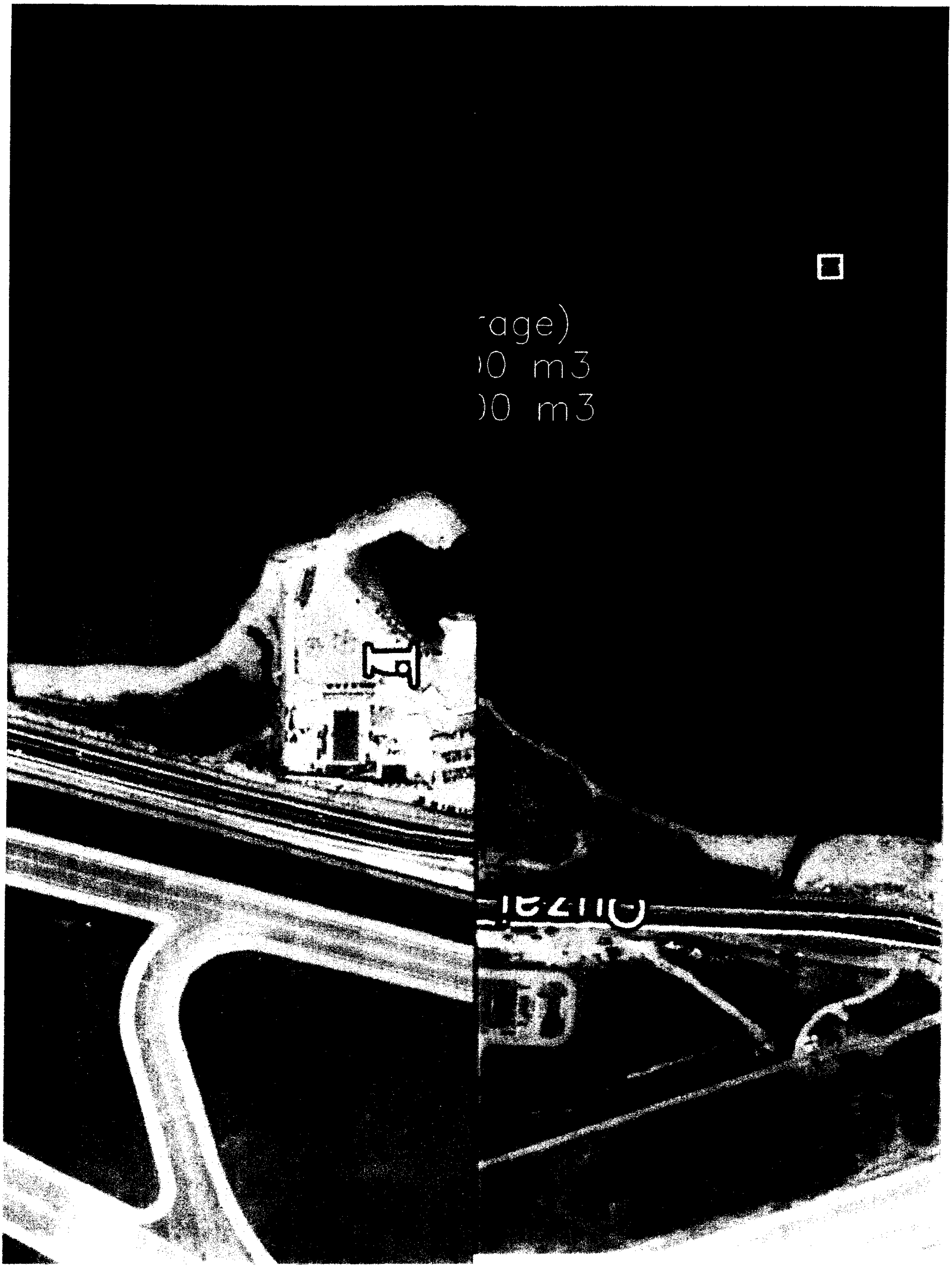
فؤاد فليفل

يبلغ لجانب :

- رئاسة مجلس الوزراء
- مجلس الانماء والاعمار
- السادة الوزراء
- وزارة الزراعة
- وزارة الداخلية والبلديات
- وزارة البيئة
- وزارة الماليـة
- مكتب وزير الدولة لشؤون التنمية الادارية
- المديرية العامة لرئاسة الجمهورية
- المديرية العامة لرئاسة مجلس الوزراء
- مؤسسة المحفوظات الوطنية
- مركز المعلوماتية
- المحفوظات

بيروت في ٢٠١٦/٣/١٢

الجمهورية اللبنانية
فرع الشؤون الوزارية
رئاسة مجلس الوزراء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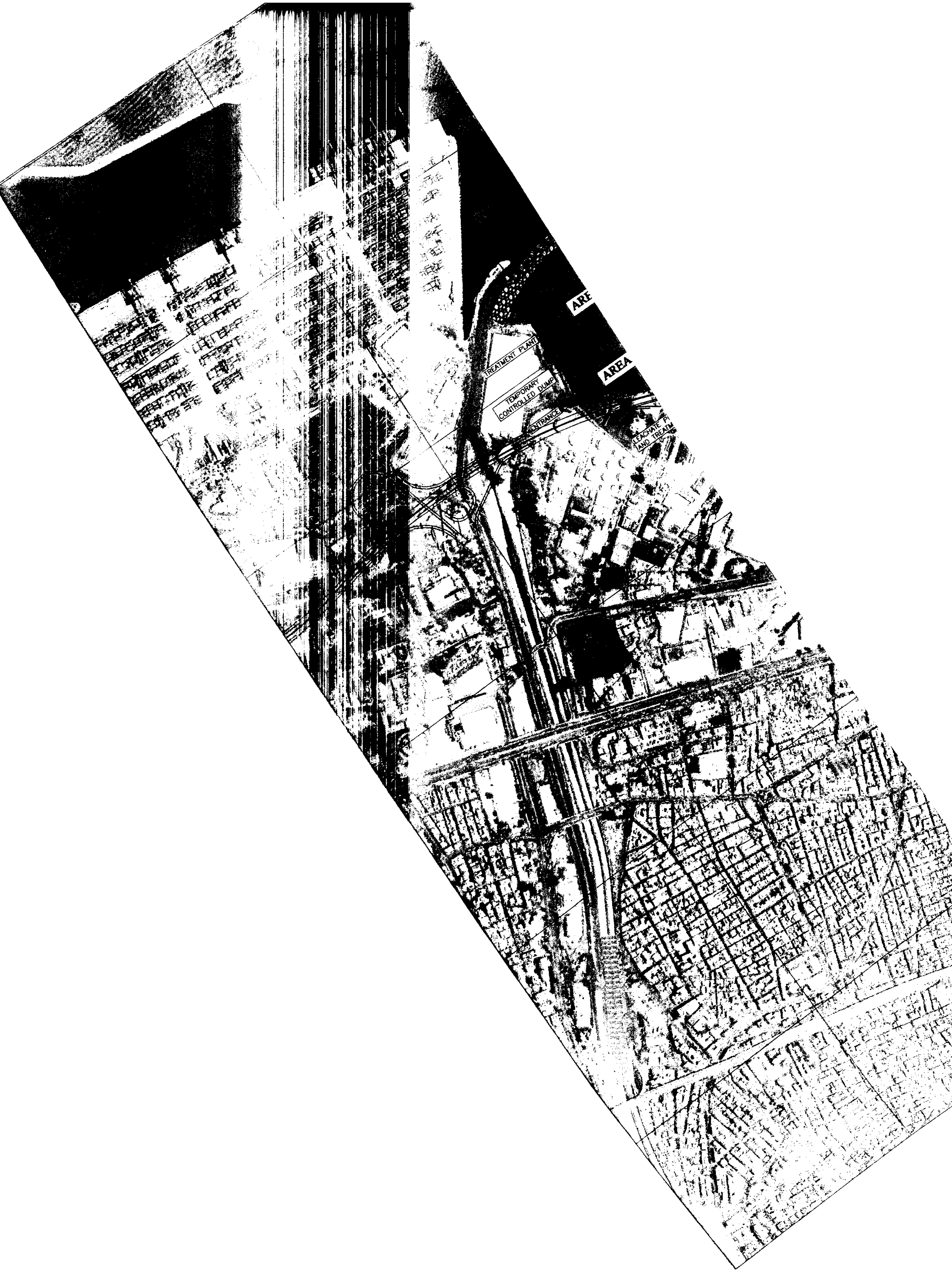

AREA
AREA
TREATMENT PLANT
TEMPORARY
CONTROLLED DUMP
ENTRANCE
LEACHATE

APPENDIX G: DILUTION MODELING

1 INTRODUCTION

This report presents the analysis and findings related to the anticipated performance of the Daoura Sea Outfall and the Daoura Overflow Pipe.

As Lebanon is one of the signatory countries of the Mediterranean Action Plan (MAP) convention, the legal guidelines applicable for the required level of wastewater treatment are defined in the protocol "Convention for the Protection of the Mediterranean Sea Against Pollution" termed the "Barcelona Convention" which is part of the MAP. The contracting parties have agreed that the Environmental Quality Criteria for Bathing Waters shall conform to the WHO/UNEP environmental quality criteria concerning fecal coliforms (FC) with the requirements to have the count of FC not exceeding 100 per 100 ml at the edge of the safe bathing zone in the Mediterranean Sea. The safe bathing zone is defined as the sea region within 300 meters from the shoreline.

The dilution modeling for the sea outfall would enable the prediction of the anticipated maximum pollutant concentrations in the Safe Bathing Zone. Current regulations require that the concentration of fecal coliforms (FC) should not exceed 100 FC/100 ml at the edge of the Safe Bathing Zone. The safe bathing zone extends from the shoreline to a distance of 300 meters. The concentrations of wastewater constituents such as BOD_5 and Total Nitrogen are normally less than 500 mg/l. Such constituents would be diluted to about 0 mg/l at a short distance from the sea outfall discharge ports. On the other hand, raw wastewater contains fecal coliforms that could have a concentration as high as 10,000,000 FC/100ml. The sea outfall must provide the required dilution in order to have the count of fecal coliforms less than the threshold limit of 100 #fc/100 ml at the edge of the Safe Bathing Zone.

Meeting the requirements for safe bathing would also ensure that fishing activities along the shoreline are not jeopardized by the wastewater discharges.

In order to assess the anticipated performance of the sea outfalls, we have evaluated, adopted, defined and/or calculated, among others:

- Anticipated discharged wastewater flows for the years 2020 and 2050;
- Fecal coliforms count in raw and preliminary treated wastewater;
- Characteristics of the existing Daoura sea outfall;
- Characteristics of the existing Daoura overflow pipe;
- Bathymetry;
- Sea currents speed and direction;
- Sea water temperature;
- Sea water salinity; and
- Dilution.

In addition to this Introduction, this report covers the following:

- Basic design data;
- Marine data;
- Dilution calculations; and
- Conclusions and Recommendations.

The Basic Design Data chapter includes information related to the projected wastewater flows for the horizons 2020 and 2050, fecal coliforms counts in raw and preliminary treated wastewater, characteristics of the existing Daoura sea outfall and characteristics of the existing Daoura overflow pipe.

The Marine Data chapter includes information related to bathymetry, sea currents, seawater temperature, seawater salinity and seawater density.

The Dilution Calculations chapter includes information related to the dilution calculations for the Daooura sea outfall and the Daoura overflow pipe. Two dilution calculation approaches are presented and applied for the various wastewater discharge conditions.

The Conclusions and Recommendations chapter provides the main conclusions and recommendations in light of the findings.

2 BASIC DESIGN DATA

2.1 INTRODUCTION

The basic design data used in the analyses of the performance of the Daoura sea outfall and the Daoura overflow pipe are given hereafter.

2.2 WASTEWATER FLOWS

The projected wastewater flows for the two horizons 2020 and 2050 are given in Table 2-1. The indicated data in Table 2-1 are taken from Chapter 2, Section 2.1 of the report "Pretreatment Headworks at Daoura WWTP – Final Design Report – February 2019" prepared by the Consultant ACE for the CDR.

Table 2-1: Wastewater Flows for the Daoura Sea Outfall

Parameter	Unit	Year 2020	Year 2050
Population Equivalents	pe	1,400,000	2,000,000
Average wastewater flow	m^3/s	2.63	3.76
Peak wastewater flow Dry Weather	m^3/s	3.65	5.21
Peak wastewater flow Wet Weather	m^3/s	4.19	5.99

2.3 FECAL COLIFORMS COUNT

The count of fecal coliforms in the wastewater flow conveyed through the sea outfall is an important parameter in the assessment of the outfall performance.

In Chapter 2, Section 2.1 of the report "Pretreatment Headworks at Daoura WWTP – Final Design Report – February 2019" prepared by the Consultant ACE for the CDR, the following is indicated "For the purpose of this study, an estimate for the population served as well as typical wastewater characteristics for the area have been provided by Ministry of Energy and Water Master Plan (MEW)." The mentioned report does not contain information regarding fecal coliforms and/or wastewater characteristics.

Under normal operating conditions, the raw wastewater would be preliminary treated at the proposed Daoura WWTP pretreatment works then discharged to the Mediterranean Sea via the sea outfall. Under emergency conditions, part of or all the preliminary treated wastewater flow incoming to the proposed Daoura WWTP could be diverted to the overflow pipe. Accordingly, under normal and emergency conditions the discharged wastewater would be preliminary treated.

In what follows, the count of fecal coliforms would be defined in the raw wastewater and the preliminary treated wastewater.

2.3.1 Fecal Coliforms Count in Raw Wastewater

The United Nations Environment Programme (UNEP) Mediterranean Action Plan (MAP) publication "Guidelines for Submarine Outfall Structures for Mediterranean Small and Medium-Sized Coastal Communities", Athens, 1996 indicates on page 14 in Table 3: Design Parameters for Domestic Wastewater (dry weather) that the count of faecal coliforms in raw wastewater is: 10^7 FC/100ml.

The United Nations Environment Programme (UNEP) Mediterranean Action Plan (MAP) publication "Guideline on Sewage Treatment and Disposal for the Mediterranean Region", MAP Technical Reports Series No. 152, Athens, 2004 indicates on page 10 in Table 1: Typical composition of municipal wastewater that the count of total coliforms in raw wastewater is: 10^6 – 10^9 TC/100ml. Thus, the average value would be about 10^8 TC/100ml. The ratio of fecal coliforms (FC) to total coliforms (TC) is typically 1/10. Therefore, the average value for the fecal coliforms, in raw wastewater, would be 10^7 FC/100ml.

The wastewater book "Wastewater Engineering, Treatment and Reuse" by Metcalf & Eddy, fourth edition, indicates on page 111 in Table 2-25: Microorganisms concentrations found in untreated wastewater that the count of total coliforms is 10^7 – 10^9 TC/100ml and the count of fecal coliforms is 10^6 – 10^8 FC/100ml. Based on this book, the ratio of fecal coliforms (FC) to total coliforms (TC) is 1/10 and the average value for the fecal coliforms, in raw wastewater, would be 10^7 FC/100ml.

In the Feasibility Study for Ghadir Wastewater Treatment Plant undertaken by CES-BTD, the count of fecal coliforms in raw wastewater was set at 10,000,000 #/100 ml i.e. 10^7 FC/100ml.

In the Feasibility Study for Saida Drainage Zone undertaken by Jouzy & Partners, the count of fecal coliforms in raw wastewater was set at 8,000,000 #/100 ml

Considering all the above, for this study, the **count of fecal coliforms in the raw wastewater would be considered equal to 10^7 FC/100ml**.

2.3.2 Fecal Coliforms Count in Preliminary Treated Wastewater

The United Nations Environment Programme (UNEP) Mediterranean Action Plan (MAP) publication "Guideline on Sewage Treatment and Disposal for the Mediterranean Region", MAP Technical Reports Series No. 152, Athens, 2004 indicates on page 45 in Table 8: Degree of treatment achieved by various processes that the total coliforms removal efficiency after pretreatment would be 10%.

The Daoura wastewater treatment plant pretreatment works consist of inlet screens (50 mm opening), coarse screens (15 mm opening), fine screens (6 mm opening) and aerated grit/grease removal tanks.
The Daoura WWTP pretreatment works would be expected to achieve a removal efficiency of 10% for the total and fecal coliforms.

Considering 10% removal efficiency after preliminary treatment, the **count of fecal coliforms in the preliminary treated wastewater would be considered equal to 10^6 FC/100ml**.

2.4 CHARACTERISTICS OF THE EXISTING DAOURA SEA OUTFALL

The characteristics of the existing Daoura Sea Outfall, as defined in the report "Rehabilitation and Recommendation Report – Inspection and Survey of Daoura Sea Outfall – September 2010" prepared by EDT Offshore for the CDR, are the following:

Material:	Welded Steel
Reported Wall thickness:	15.88 mm
Nominal inside diameter:	1,700 mm
Length as surveyed by EDTO:	1,777 m
Reinforced Concrete External Coating Thickness:	210 - 222 mm
Number of diffusers:	36@10 m centers
Diffuser internal diameter:	approx. 223 mm

Based on the above indicated characteristics and additional data given in the report by EDT Offshore, Figure 2-1 is a graphical representation of the Daoura Sea Outfall showing the pipe and the diffuser. As can be depicted from Figure 2-1, the Daoura Sea Outfall is laid with its top flush with the sea bed. The diffuser centerline is located at about 0.45 meters from the sea bed.

2.5 CHARACTERISTICS OF THE EXISTING DAOURA OVERFLOW PIPE

The characteristics of the existing Daoura Overflow Pipe, as defined in the report "Rehabilitation and Recommendation Report – Inspection and Survey of Daoura Sea Outfall – September 2010" prepared by EDT Offshore for the CDR, are the following:

Material:	Welded Steel
Reported Wall thickness:	15.88 mm
Nominal inside diameter:	2,000 mm
Length as surveyed by EDTO:	620 m
Reinforced Concrete External Coating Thickness:	270 mm
Number of diffusers:	26@5 m centers
Diffuser internal diameter:	approx. 407 mm

Based on the above indicated characteristics and additional data given in the report by EDT Offshore, Figure 2-2 is a graphical representation of the Daoura Overflow Pipe showing the pipe and the diffuser. As can be depicted from Figure 2-2, the Daoura Overflow Pipe is laid with its top flush with the sea bed. The diffuser centerline is located at about 0.65 meters from the sea bed.

Figure 2-1: Daoura Sea Outfall Cross Section

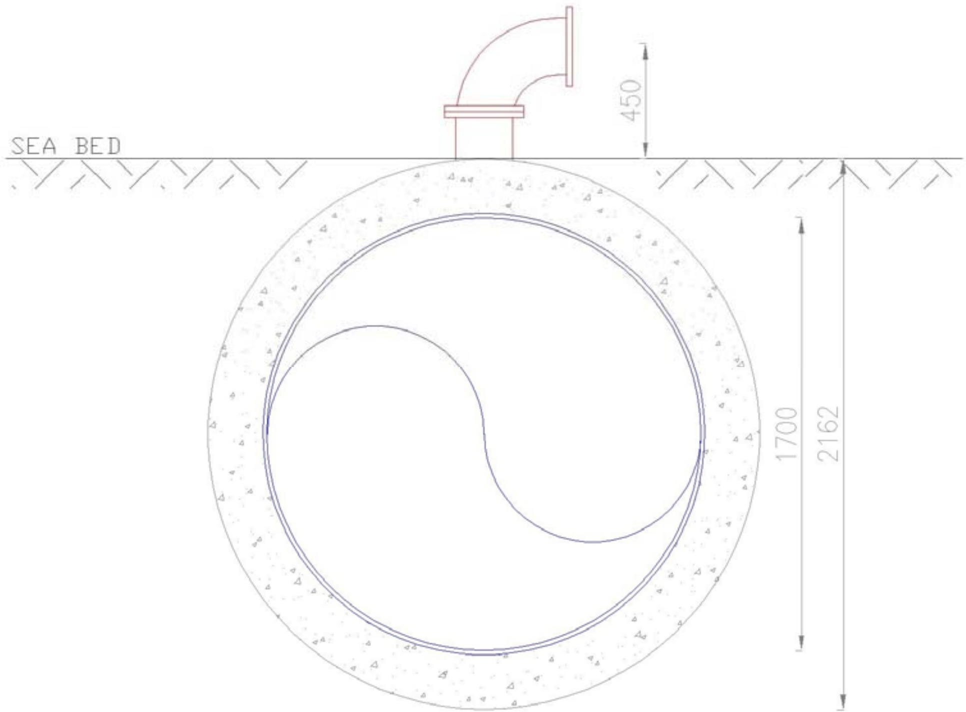
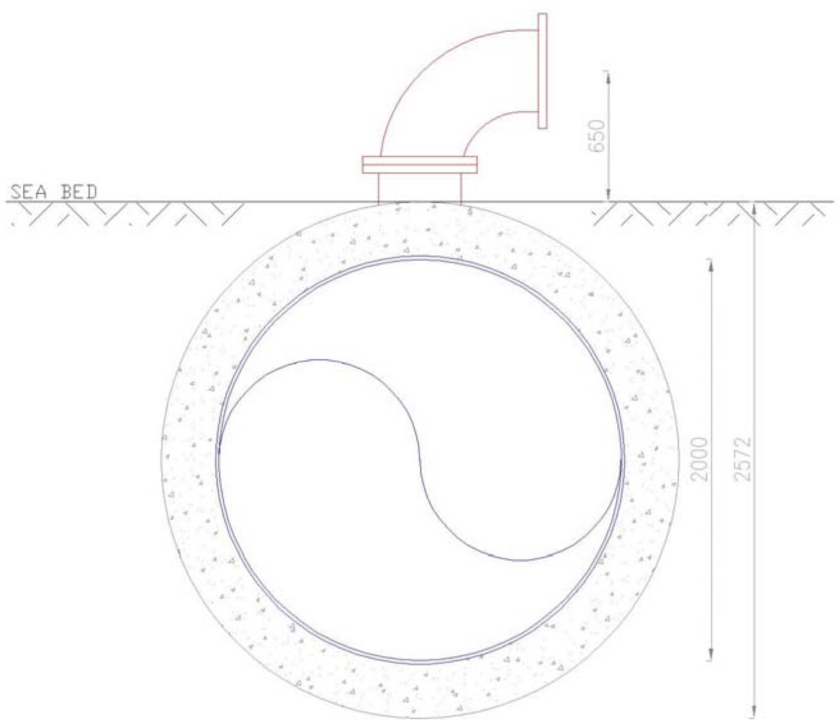


Figure 2-2: Daoura Overflow Pipe Cross Section



3 MARINE DATA

3.1 GENERAL

The bathymetry data are obtained from the EDT Offshore survey conducted in 2010.

3.2 BATHYMETRY

The sea bed levels along the Daoura sea outfall diffuser section and the Daoura overflow pipe diffuser section define the bathymetry data required for the analyses of the outfalls performance.

3.2.1 BATHYMETRY DATA FOR THE EXISTING DAOURA SEA OUTFALL

The bathymetry data for the existing Daoura Sea Outfall are extracted from Plate 12 of the report "Rehabilitation and Recommendation Report – Inspection and Survey of Daoura Sea Outfall – September 2010" prepared by EDT Offshore for the CDR.

Table 3-1 shows the sea bed levels in relation to the distance from the shoreline with the survey cumulative distances being as defined on Plate 12 of EDT Offshore report.

Table 3-1: Sea Bed Levels and Sea Bed Slopes

EDTO Cumulative Distance (m)	Partial Distance (m)	Cumulative Marine Distance (m)	Sea Bed Level (m)	Sea Bed Slope (%)
760	0	0	8.00	-
800	40	40	8.44	1.10
900	100	140	9.15	0.71
1000	100	240	10.50	1.35
1100	100	340	13.00	2.50
1200	100	440	16.75	3.75
1300	100	540	21.40	4.65
1400	100	640	26.25	4.85
1500	100	740	31.40	5.15
1600	100	840	36.55	5.15
1700	100	940	42.00	5.45
1800	100	1040	47.60	5.60
1900	100	1140	54.20	6.60
2000	100	1240	61.25	7.05
2025	100	1265	63.40	2.15

As indicated in the EDT Offshore report, the Daoura sea outfall extends from shoreline to a total length of 1,777 meters. However, according to Plate 12 of the same report, considering the last station at 2025 m and the shoreline station was at station 460 m, the marine section would have a length of 1,565 meters. We have concluded that the first section of the sea outfall, with a length of 248 meters, is under reclaimed land. We discuss in a later section the present prevailing conditions and the difference between the present conditions and those related to the year 2010 when the bathymetry survey was conducted. To be noted that the shoreline station is now shifted to cumulative distance 760 meters instead of the previous station at 460 meters. With reference to Table 3-1, the sea bed slope varies along the sea outfall alignment with the average sea bed slope being about 4.38%.

The Daoura sea outfall terminates with a diffusers section equipped with 36 diffusers spaced at 10 meters center to center. Accordingly, the last 350 meters marine section contains the diffusers. This section extends from cumulative distance 1,675 meters to cumulative distance 2,025 meters. The first diffuser is located at cumulative distance of 1,675 meters at a sea bed depth of 40.6 meters. The last diffuser is located at cumulative distance of 2,025 meters at a sea bed depth of 63.4 meters. The average sea bed depth of the sea outfall diffusers section is 52.0 meters.

3.2.2 BATHYMETRY DATA FOR THE EXISTING DAOURA OVERFLOW PIPE

The bathymetry data for the existing Daoura Overflow Pipe are extracted from Plate 12 of the report "Rehabilitation and Recommendation Report – Inspection and Survey of Daoura Sea Outfall – September 2010" prepared by EDT Offshore for the CDR.

As indicated in the EDT Offshore report, the Daoura overflow pipe extends from shoreline to a total length of 620 meters. According to Plate 12 of the EDT Offshore report, the last cumulative distance station for the overflow pipe is at 850 meters. Considering that the shoreline station was at 460 meters, the marine section would have a length of 390 meters. We have concluded that the first section of the overflow pipe, with a length of 230 meters, is under reclaimed land.

The Daoura overflow pipe terminates with a diffusers section equipped with 26 diffusers spaced at 5 meters center to center. Accordingly, the last 125 meters marine section contains the diffusers. This section extends from cumulative distance 725 meters to cumulative distance 850 meters. The first diffuser is located at cumulative distance of 725 meters at a sea bed depth of about 8.0 meters. The last diffuser is located at cumulative distance of 850 meters at a sea bed depth of about 8.8 meters. The average sea bed depth of the overflow pipe diffusers section is 8.40 meters.

3.3 SEA CURRENTS AND SEAWATER TEMPERATURE

The sea currents magnitude and direction, as well as the seawater temperatures were obtained from Lebanese Shelf Model (LSM) developed by the National Council for Scientific Research. The Lebanese Shelf Model (LSM) is a high resolution nested hydrodynamic model. It was constructed at the Marine Research Center/National Council for Scientific Research, Jounieh, as a part of the EU project "Mediterranean Network to Assess and Upgrade Monitoring and Forecasting Activity in the Region (MAMA)".

The sea currents magnitude and direction, as well as the seawater temperatures, throughout the year, for the Daoura sea outfall discharge location, are given in Table 3-2.

Figure 3-1 shows the sea currents magnitude and direction, as well as the seawater temperatures, for the month of July extending from July 1st to July 10th.

Figure 3-2 shows the sea currents magnitude and direction, as well as the seawater temperatures, for the month of December extending from December 1st to December 10th.

Table 3-2: Sea Currents Magnitude and Direction, and Seawater Temperature

Month	Days	Seawater Temperature (°C)	Sea Current Speed (cm/s)	Sea Currents Direction
January	1-10	19.4	10-12	North East
January	11-20	18.9	10-12	North East
January	21-31	18.6	15-20	North East
February	1-10	18.4	20-25	North East
February	11-20	18.0	20-25	North East
February	21-28	18.0	10-15	North East
March	1-10	17.8	10-15	North East
March	11-20	17.8	10-15	North East
March	21-31	18.0	10-15	North East
April	1-10	18.2	8-12	North East
April	11-20	18.4	7-10	North East
April	21-30	19.2	7-10	South West
May	1-10	20.4	8-10	South
May	11-20	22.0	12-15	North East
May	21-31	23.7	15-17	North East
June	1-10	25.0	17-20	North East
June	11-20	26.5	15-22	North East
June	21-30	27.5	14-20	North East
July	1-10	28.0	13-20	North East
July	11-20	28.5	10-20	North East
July	21-31	28.5	12-20	North East
August	1-10	28.5	15-22	North East
August	11-20	28.2	15-17	North East
August	21-31	28.5	10-15	South West
September	1-10	28.8	7-12	South West
September	11-20	27.9	7-10	East
September	21-30	27.0	10-12	North East
October	1-10	24.9	10-12	North East
October	11-20	24.0	9-10	North East
October	21-31	23.0	10-13	North East
November	1-10	22.0	13-15	North East
November	11-20	21.4	13-16	North East
November	21-30	21.3	19-22	North East
December	1-10	20.7	21-26	North East
December	11-20	20.4	22-29	North East
December	21-31	19.8	25-30	North East

Figure 3-1: Sea Currents Direction and Magnitude, Seawater Temperature – Summer

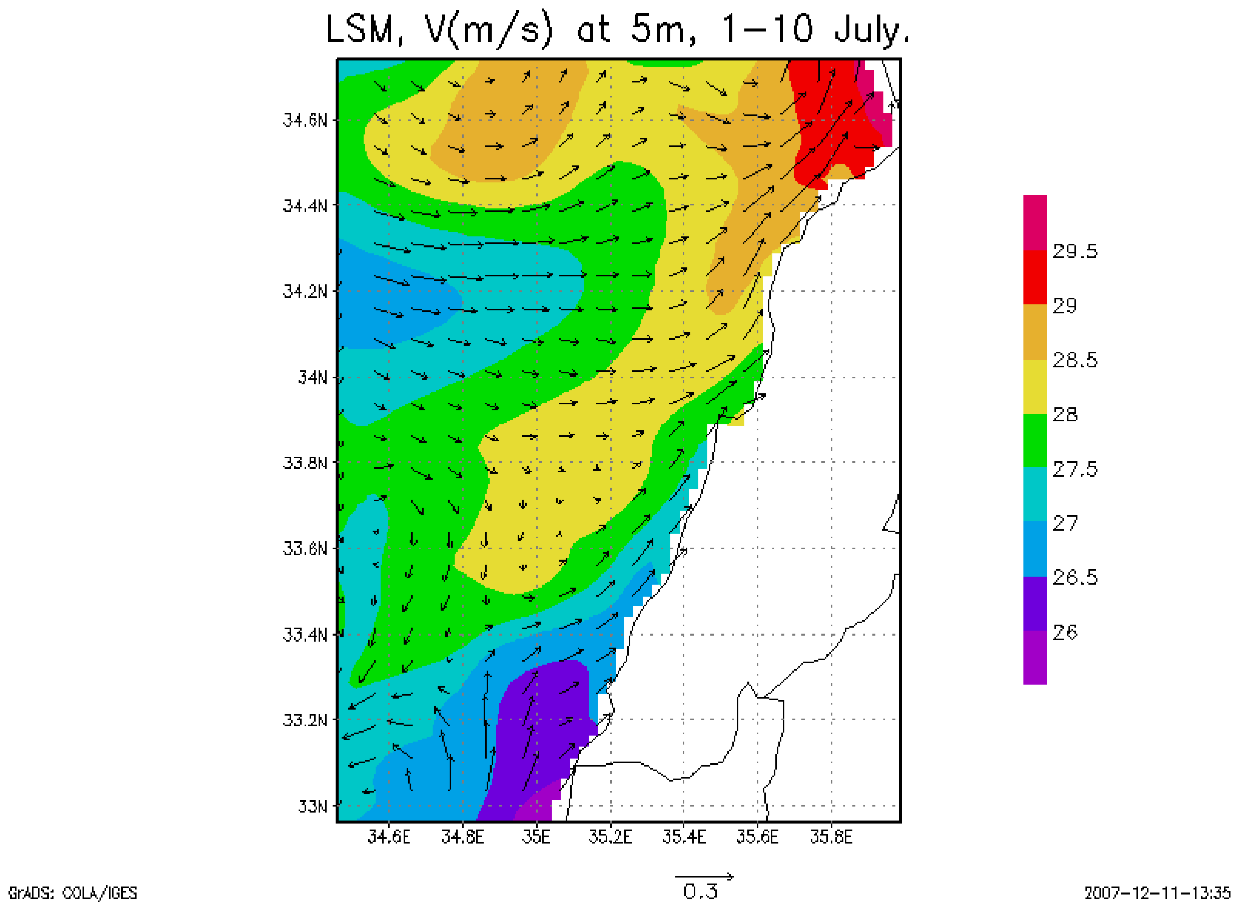
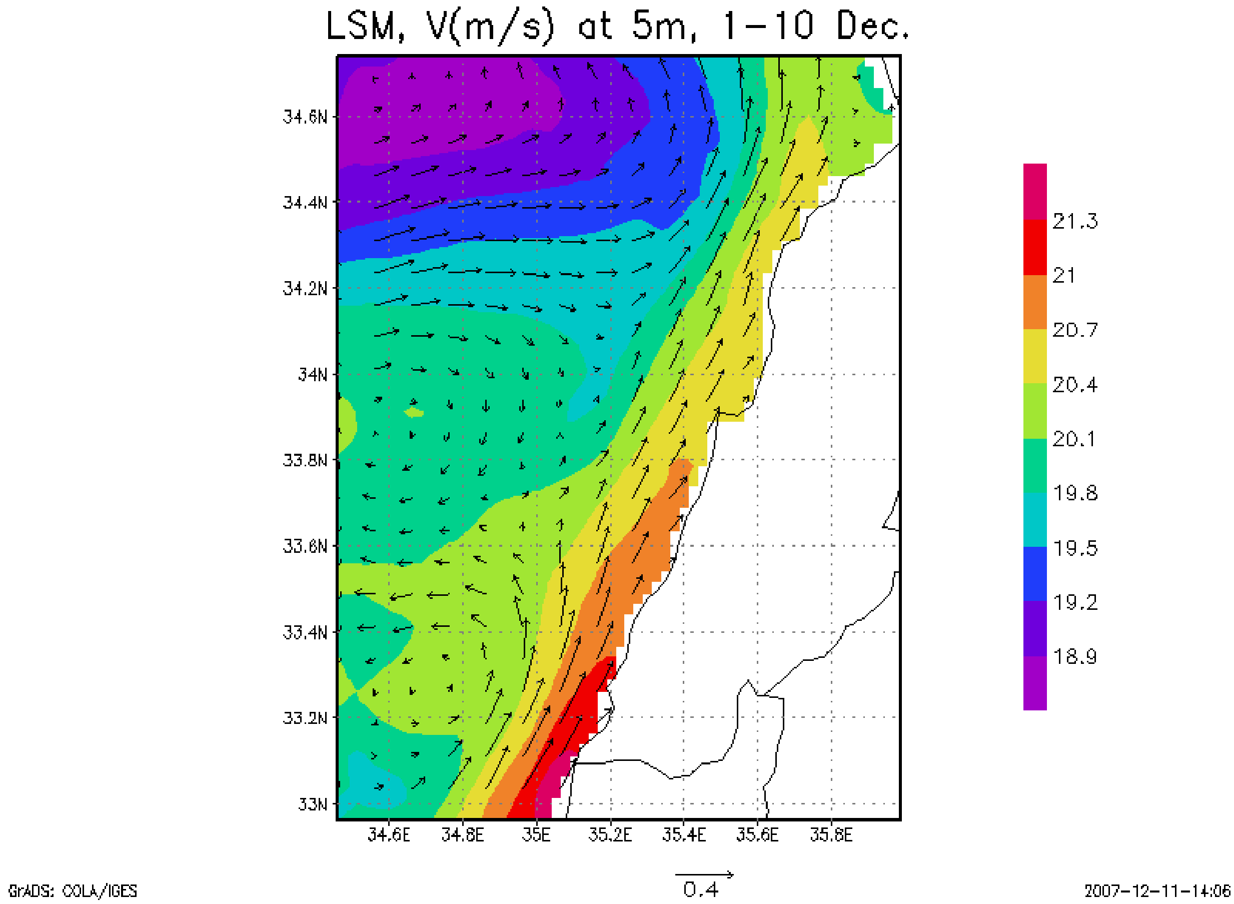


Figure 3-2: Sea Currents Direction and Magnitude, Seawater Temperature – Winter



The prevailing sea currents, at the Daoura sea outfall discharge location, have a direction towards the North-East as can be depicted from Figure 3-1 and Figure 3-2. The examination of the sea currents direction year-round reveals the direction is predominantly North-East.

Based on the sea currents speed data given in Table 3-2, the sea current speed ranges from 7 cm/s to 30 cm/s.

Based on the sea currents speed data given in Table 3-2, the seawater temperature ranges from 17.8 °C to 28.8 °C.

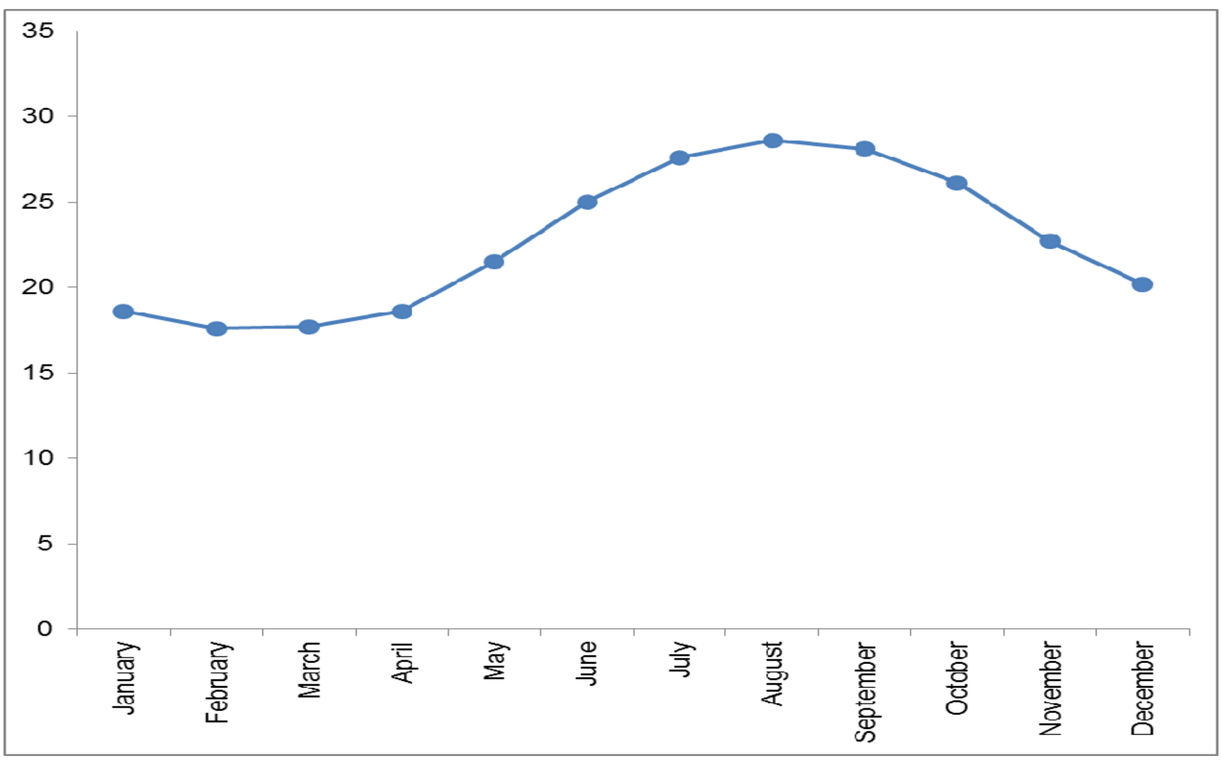
Additional seawater temperature data, available online from the website "seatemperature.org" was also analyzed. The seawater temperature data at two locations Beirut (south of the

Daoura site) and Jounieh (north of the Daoura site) are the same. The seawater temperature data are given in Table 3-3 and shown on Figure 3-3.

Table 3-3: Seawater Monthly Temperature

Month	Average Temperature (°C)	Minimum Temperature (°C)	Maximum Temperature (°C)
January	18.6	17.2	20.1
February	17.6	17.0	18.3
March	17.7	16.8	18.6
April	18.6	16.9	20.3
May	21.5	19.1	24.0
June	25.0	23.2	26.9
July	27.6	25.8	29.5
August	28.6	27.7	29.5
September	28.1	27.4	28.8
October	26.1	24.1	28.2
November	22.7	20.2	25.2
December	20.2	18.6	21.8
Mean Value	**22.7**	**21.2**	**24.3**

Figure 3-3: Seawater Average Monthly Temperature (°C)



As can be seen from Table 3-3, the average seawater temperature deviations from minimum and maximum values are relatively small at about 1.5 ^{o}C.

3.4 SEAWATER SALINITY

A study performed over El-Mina area in Tripoli and around the Palm Islands from March 1991 to February 1992, recorded relative high water salinity over the surface of the sea at 39 ppt. This measured salinity is in line with modeled salinity data obtained from the National Council for Scientific Research.

The Lebanese National Center for Marine Sciences (NCMS) conducted, offshore of Batroun city, a long-term research program that extended from the year 2000 to the year 2013.
A monitoring station, referred to as Station B2, was positioned offshore in the sea at coordinates: N 34°14.856 and E 35°36.067). Water samples were collected monthly during daytime (between 07:00 and 11:00). Sampling frequency was homogeneous over the time.
Water temperature (°C) and salinity were measured at five different depths (0, 20, 40, 60 and 80 m). At each depth, the temperature was recorded with a reversing thermometer (Richter & Wiese type, 0.05°C precision) and the salinity was determined with a Beckman induction salinometer (model RS7-C with a precision of 0.001).

Considering the comprehensive and extensive real data collected by the NCMS and that the seawater salinity is comparable along the Lebanese coastal zone, the seawater salinity data are extracted from the findings of the NCMS. The Daoura sea outfall diffuser section is located between sea bed depths of 40 to 62.5 meters. The measured NCMS data at depths 0, 20, 40 and 60 meters are analyzed.

The average, minimum and maximum values for the seawater salinity are given in Table 3-4.

Table 3-4: Seawater Salinity

Water Depth (m)	Average Salinity (ppt)	Minimum Salinity (ppt)	Maximum Salinity (ppt)
0	39.24	38.20	39.72
20	39.26	38.66	39.84
40	39.18	38.10	39.70
60	39.13	38.06	39.97
Mean Value	**39.20**	**38.26**	**39.81**

As can be seen from Table 3-4, the seawater salinity does not show major variations from the top of the seawater surface to a depth of 60 meters. Accordingly, the seawater column is considered to be homogeneous with a relatively constant salinity.

3.5 SEAWATER DENSITY

Considering the comprehensive and extensive real data collected by the NCMS and that the seawater density is comparable along the Lebanese coastal zone, the seawater density data are extracted from the findings of the NCMS. The Daoura sea outfall diffuser section is located between sea bed depths of 40 to 62.5 meters. The measured NCMS data at depths 0, 20, 40 and 60 meters are analyzed.

The average, minimum and maximum values for the seawater density are given in Table 3-5.

Table 3-5: Seawater Density

Water Depth (m)	Average Density (kg/m^3)	Minimum Density (kg/m^3)	Maximum Density (kg/m^3)
0	1027.01	1024.74	1028.78
20	1027.16	1025.07	1028.78
40	1027.43	1024.98	1028.76
60	1027.88	1026.43	1028.78
Mean Value	**1027.37**	**1025.31**	**1028.78**

As can be seen from Table 3-5, the seawater density does not show major variations from the top of the seawater surface to a depth of 60 meters. Accordingly, the seawater column is considered to be homogeneous with a relatively constant density.

4 DILUTION CALCULATIONS

4.1 INTRODUCTION

For the dilution calculations, two calculation approaches would be performed:

- The equations recommended in the World Bank Technical Paper 77 (WB TP77) shall be used as per the national Standard Practice Document No. 11 or SPD11 requirements; and

- Calculations using the software Cormix shall be performed.

According to SPD11 requirements, the dilution calculations are to be conducted considering the World Bank Technical Paper 77 approach. We have also performed dilution calculations using the software Cormix in order to double-check the dilution results given by the World Bank Technical Paper 77 approach.

4.2 ADOPTED CRITERIA

For the dilution calculations, the following criteria shall be adopted:

4.2.1 Wastewater Discharge Conditions

The Consultant ACE defined the wastewater flows considering average flows, peak dry weather flows and peak wet weather flows.

The dilution calculations would be performed for six discharge conditions as defined hereafter.

Condition 1: Average Day Flow Year 2020
Condition 2: Peak Dry Weather Flow Year 2020
Condition 3: Peak Wet Weather Flow Year 2020
Condition 4: Average Day Flow Year 2050
Condition 5: Peak Dry Weather Flow Year 2050
Condition 6: Peak Wet Weather Flow Year 2050

The main concern from the wastewater discharges to the Mediterranean Sea relate to ensuring that the threshold level of 100 FC/100 ml is not exceeded at the edge of the safe bathing zone. Accordingly, the bathing season is the main period of the year during which the sea outfall performance is to be assessed.

The peak bathing and recreational season is considered to extend from the beginning of June until the end of August.

The climate changes pertaining to global warming and other factors, have affected the weather in Lebanon with increased temperature and dryness through half of the year. In that regard, we consider that the dry season extends from the beginning of April until the end of September. It is further considered that the peak wet weather flow would not occur during the dry season.

Accordingly, for the peak bathing and recreational season, extending from the beginning of June until the end of August, the wastewater flows discharged to the sea are the Average Day flow and the Peak Dry Weather flow.

The wet season is considered to extend from the beginning of October until the end of March. Normally, bathing and recreational activities would not take place during the wet season. However, in consideration to the climate changes, we shall consider that bathing and recreational activities could take place during the months of October and March. Knowing that precipitation and increased underground flows would occur during the month of March rather than the month of October, we shall consider that the month of March would represent the period during which the peak wet weather flow would occur.

4.2.2 Rate of Fecal Coliforms Decay T_{90}

The rate of fecal coliforms decay, expressed as T_{90}, is the time taken for 90% of the fecal coliform bacteria to die of.

The United Nations Environment Programme (UNEP) Mediterranean Action Plan (MAP) publication "Guidelines for Submarine Outfall Structures for Mediterranean Small and Medium-Sized Coastal Communities", Athens, 1996 indicates on page 16 in Table 4: Proposed Values for Computation Parameters that the fecal coliforms T_{90} value is in the range of 1.5 – 2.5 hours. On page 17, the report indicates "Normal safe values for Mediterranean conditions lie in the order of 2.5 hours for faecal coliforms."

The United Nations Environment Programme (UNEP) Mediterranean Action Plan (MAP) publication "Guideline on Sewage Treatment and Disposal for the Mediterranean Region", MAP Technical Reports Series No. 152, Athens, 2004 indicates on page 48 that the value of T_{90} for feacal coliforms is equal to 2.5 hours.

The count of fecal coliforms reaching the shoreline decreases with shorter T_{90} values.

In this study, to be conservative, the fecal coliforms T_{90} value shall be taken equal to 2.5 hours.

4.2.3 Sea Current Speed

The sea current speed affects the dilution and the rate at which the fecal coliforms travel back toward the shoreline. The lower the sea surface current speed, the more time it takes for the coliforms to travel and therefore the higher the mortality rate which leads to lower fecal coliforms counts reaching the shoreline. However, the lower the sea current speed at the bottom, the lower would be the initial dilution which leads to higher fecal coliforms counts reaching the shoreline.

The United Nations Environment Programme (UNEP) Mediterranean Action Plan (MAP) publication "Guidelines for Submarine Outfall Structures for Mediterranean Small and Medium-Sized Coastal Communities", Athens, 1996 indicates on page 16 in Table 4: Proposed Values for Computation Parameters that the surface sea current speeds are in the range of 20 – 30 cm/s.

The range of sea current speeds suggested by the UNEP is well within the range of anticipated sea current speeds as elaborated in this report under Marine Data – Sea Currents.

During the peak bathing and recreational season extending from the beginning of June until the end of August, the sea current speeds range from 10 cm/s to 22 cm/s.

During the dry season extending from the beginning of April until the end of September, the sea current speeds range from 7 cm/s to 22 cm/s.

In this study, for the peak bathing and recreational season extending from the beginning of June until the end of August, the sea current speed shall be taken equal to 20 cm/s. In addition, a sensitivity analysis would be done to check the performance of the sea outfall for sea current speeds of 15 cm/s and 25 cm/s.

With reference to the part of this report “Marine Data – Sea Currents”, during the relatively wet season extending from the beginning of October until the end of March, the sea current speeds range from 9 cm/s to 30 cm/s.

In this study, for the wet season represented by the month of March, the sea current speed shall be taken equal to 15 cm/s. In addition, a sensitivity analysis would be done to check the performance of the sea outfall for sea current speeds of 20 cm/s and 25 cm/s.

4.2.4 Seawater Temperature

The anticipated seawater temperatures are elaborated in this report under Marine Data – Sea Currents and Seawater Temperature. During the peak bathing and recreational season extending from the beginning of June until the end of August, the seawater temperature ranges from 25.0 ^{o}C to 28.6 ^{o}C.

In this study, for the peak bathing and recreational season extending from the beginning of June until the end of August, the seawater temperature shall be taken equal to 27 ^{o}C.

With reference to the part of this report “Marine Data – Sea Currents and Seawater Temperature”, during the relatively wet season extending from the beginning of October until the end of March, the seawater temperature ranges from 16.8 ^{o}C to 24.9 ^{o}C.

In this study, for the wet season represented by the month of March, the seawater temperature shall be taken equal to 18 ^{o}C.

4.2.5 Seawater Salinity

The seawater salinity does not show major variations from the top of the seawater surface to a depth of 60 meters. Accordingly, the seawater column is considered to be homogeneous with a relatively constant salinity. The extended set of seawater salinity data analyzed shows stable seawater salinity levels from year to year.

In this study, the seawater salinity shall be taken equal to 39.2 ppt.

4.2.6 Seawater Density

The extended set of seawater salinity density data analyzed shows stable seawater density levels from year to year. The seawater density does not show major variations from the top of the seawater surface to a depth of 60 meters. Accordingly, the seawater column is considered to be homogeneous with a relatively constant density. In this study, the seawater density shall be calculated based on the seawater temperature and the seawater salinity.

4.2.7 Wind Speed

The wind speed affects the dispersion of the plume. The wind speed is an input parameter required when analyzing dilution using the Cormix software. In this study a representative wind speed is adopted for each season.

During the peak bathing and recreational season extending from the beginning of June until the end of August, the wind speed shall be taken equal to 2 m/s. This value represents breeze wind conditions and is recommended as a typical value to be adopted by the Cormix software manual.

During the wet season represented by the month of March, the wind speed shall be taken equal to 5 m/s. This value represents light wind conditions and is recommended as a typical value to be adopted by the Cormix software manual.

4.2.8 Wastewater Temperature

During the peak bathing and recreational season extending from the beginning of June until the end of August, the wastewater temperature shall be taken equal to 24 ^{o}C.

During the wet season extending from the beginning of October until the end of March, the wastewater temperature shall be taken equal to 20 ^{o}C.

4.2.9 Wastewater Density

The density of wastewater is essentially the same as that of water. The density of wastewater varies with the liquid temperature. The density of wastewater is taken from Appendix C of the book Wastewater Engineering – Treatment and Reuse, Metcalf & Eddy, 4th Edition.

For a wastewater temperature of 20 ^{o}C, the wastewater density is: 998.20 kg/m^3.
For a wastewater temperature of 24 ^{o}C, the wastewater density is: 997.24 kg/m^3.

4.2.10 Summary of Adopted Criteria

The adopted criteria for the analyses of the performance of the sea outfall and overflow pipe during the dry season and the wet season are summarized hereafter.

4.2.10.1 Adopted Criteria – Dry Season

During the peak bathing and recreational season extending from the beginning of June until the end of August, the following criteria are adopted:

Sea current speed	= 20 cm/s
Sea current speed (sensitivity analysis)	= 15 cm/s and 25 cm/s
Wind speed	= 2 m/s
Wastewater temperature	= 24 ^{o}C
Wastewater density	= 997.24 kg/m^3
Seawater temperature	= 27 ^{o}C
Seawater salinity	= 39.2 ppt
T_{90} for Fecal Coliforms	= 2.5 h
Fecal Coliforms in raw wastewater	= 10,000,000 FC/100ml
Fecal Coliforms in preliminary treated wastewater	= 1,000,000 FC/100ml

The wastewater discharge conditions to be studied during the dry season are:

Condition 1: Average Day Flow Year 2020
ADF2020 Wastewater Flow = 2.63 m^3/s.

Condition 2: Peak Dry Weather Flow Year 2020
PDW2020 Wastewater Flow = 3.65 m^3/s.

Condition 4: Average Day Flow Year 2050
ADF2050 Wastewater Flow = 3.76 m^3/s.

Condition 5: Peak Dry Weather Flow Year 2050
PDW2050 Wastewater Flow = 5.21 m^3/s

4.2.10.2 Adopted Criteria – Wet Season

During the wet season, represented by the month of March, the following criteria are adopted:

Sea current speed	= 15 cm/s
Sea current speed (sensitivity analysis)	= 20 cm/s and 25 cm/s
Wind speed	= 5 m/s
Wastewater temperature	= 20 ^oC
Wastewater density	= 998.2 kg/m^3
Seawater temperature	= 18 ^oC
Seawater salinity	= 39.2 ppt
T_{90} for Fecal Coliforms	= 2.5 h
Fecal Coliforms in raw wastewater	= 10,000,000 FC/100ml
Fecal Coliforms in preliminary treated wastewater	= 1,000,000 FC/100ml

The wastewater discharge conditions to be studied during the wet season are:

Condition 1: Average Day Flow Year 2020
ADF2020 Wastewater Flow = 2.63 m^3/s.

Condition 2: Peak Dry Weather Flow Year 2020
PDW2020 Wastewater Flow = 3.65 m^3/s.

Condition 3: Peak Wet Weather Flow Year 2020
PWW2020 Wastewater Flow = 4.19 m^3/s.

Condition 4: Average Day Flow Year 2050
ADF2050 Wastewater Flow = 3.76 m^3/s.

Condition 5: Peak Dry Weather Flow Year 2050
PDW2050 Wastewater Flow = 5.21 m^3/s

Condition 6: Peak Wet Weather Flow Year 2050
PWW2050 Wastewater Flow = 5.99 m^3/s.

4.3 PREVAILING CONDITIONS

The most recent aerial photograph is used to show the prevailing conditions. The layout plan, showing the existing sea outfall and overflow pipe, is given as Figure 4-1.

We have noticed major differences in the landscape between the present layout plan given as Figure 4-1 and the layout plans as given in EDTO and ACE reports as:

Plate 1 in the report “Rehabilitation and Recommendation Report – Inspection and Survey of Daoura Sea Outfall – September 2010” prepared by EDT Offshore for the CDR;

Plate 12 in the report “Rehabilitation and Recommendation Report – Inspection and Survey of Daoura Sea Outfall – September 2010” prepared by EDT Offshore for the CDR; and

Figure 1 in the report “Pretreatment Headworks at Daoura WWTP – Final Design Report – February 2019” prepared by the Consultant ACE for the CDR.

The layout plan as given by EDTO as Plate 1 in the report “Rehabilitation and Recommendation Report – Inspection and Survey of Daoura Sea Outfall – September 2010” is reproduced as Figure 4-2.

In order to outline the differences in the landscape, we have outlined the new land reclamation boundaries and highlighted the older boundaries. The result is given as Figure 4-3. The new boundaries are outlined by the red colored lines. The old boundaries are outlined by the yellow colored dashed lines. The additional land reclamation resulted in the following:

- A new zone has been created in the Beirut Harbor;
- A new reclaimed land has been created east of the Bourj Hammoud dump site; and
- The western and northern boundaries of the Bourj Hammoud dump site have expanded.

The additional land reclamation west and north of the Bourj Hammoud dump site resulted in the following:

The Daoura sea outfall, as given in EDTO report, was covered by land reclamation debris for a distance of about 205 meters. The section of the Daoura sea outfall, extending from the previous reclamation boundary into the sea, had a length of 1,565 meters. At present, the Daoura sea outfall is covered by land reclamation debris for a distance of 505 meters. The older reclamation boundary has shifted inward into the sea by about 300 meters. The section of the Daoura sea outfall extending to the sea now has a length of 1,265 meters;

The Daoura overflow pipe, as given in EDTO report, was covered by land reclamation debris for a distance of about 230 meters. The section of the Daoura overflow pipe extending to the sea had a length of 390 meters. At present, the Daoura overflow pipe is covered by land reclamation debris for a distance of 530 meters. The older reclamation boundary has shifted inward into the sea by about 300 meters. The section of the Daoura overflow pipe extending to the sea now has a length of 90 meters. The diffusers of the Daoura overflow pipe are installed on the end section of the pipe over a length of 125 meters. Since now, only 90 meters of the overflow pipe end section is under water, six to seven diffusers could have become buried. Therefore, the number of functional diffusers, along the overflow pipe, could now be reduced from 26 to 20 or 19.

Figure 4-1: Daoura Sea Outfall Layout Plan, Year 2019

Figure 4-2: Daoura Sea Outfall – EDTO Layout Plan, Year 2010.

<u>Figure 4-3:</u> Additional Land Reclamation

4.4 DAOURA SEA OUTFALL DIFFUSERS

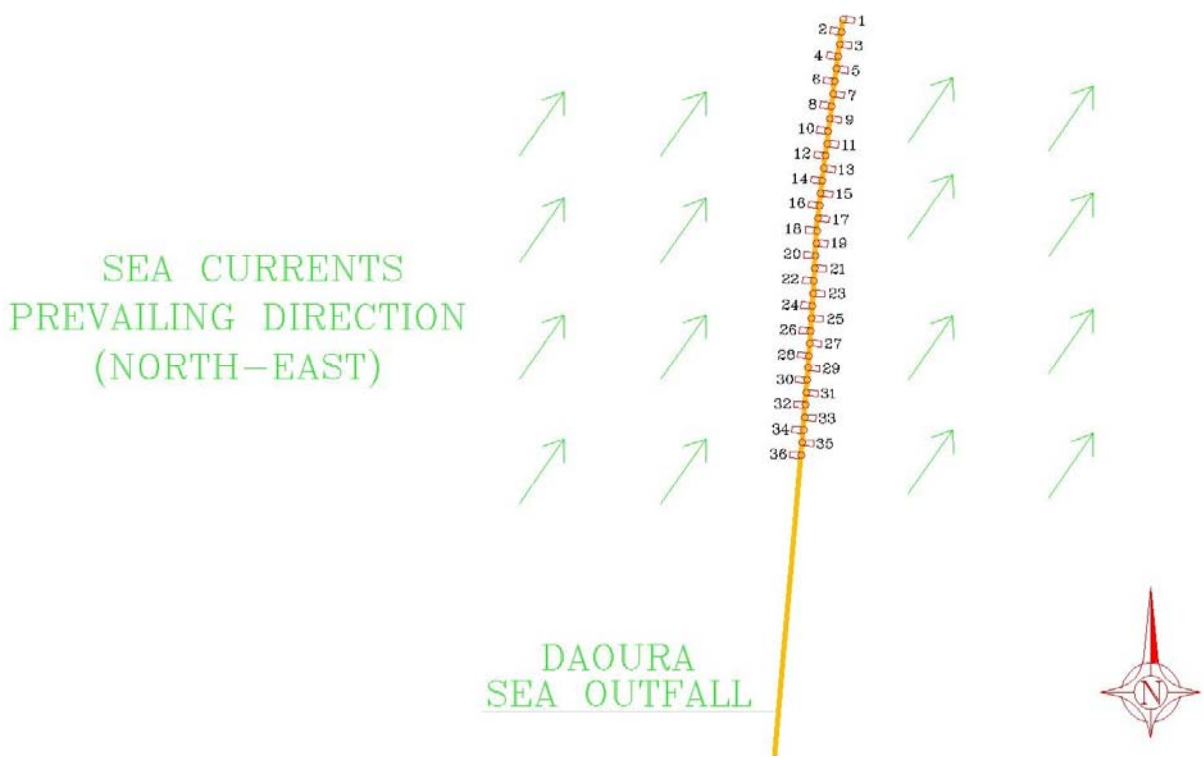
The Daoura sea outfall is equipped with 36 diffusers at its end section. The diffusers section extends over a length of 350 meters with the diffusers being spaced at 10 meters center to center. The internal diameter of the diffusers is approximately 223 mm. Figure 4-4 shows the Daoura sea outfall diffusers section. The diffusers are marked with numbers from 1 to 36. The diffusers were installed with alternating directions with half of the diffusers oriented toward the East and the other half oriented toward the West. As indicated in EDTO rehabilitation report, the broken and/or missing diffusers would be replaced and the new ones would be installed respecting the old orientation.

The prevailing sea currents have a North-East direction. This direction is typical during the peak bathing and recreational season, and the wet season represented by the month of March.

Considering the prevailing sea currents direction and the diffusers orientation, the angle formed between the diffusers orientation and the sea currents direction is about 45 degrees.

It is important to note that the Daoura sea outfall diffusers extend in the sea beyond the influence of the Beirut harbor breakwaters.

<u>Figure 4-4:</u> Daoura Sea Outfall – Diffusers Section



APPENDIX H: ODOR DISPERSION MODELLING

1. DAOURA PRELIMINARY TREATMENT PLANT – ODORS IMPACTS ASSESSMENT

1.1 GENERAL

Special care is taken in assessing odor emissions at the Daoura Preliminary Treatment Plant (PTP).

The main odorous compound of concern is hydrogen sulfide (H_2S). Hydrogen sulfide is an odorous and colorless gas which is formed from the anaerobic decomposition of organic matter containing sulfur or from the reduction of mineral sulfites to sulfates. It is not formed under an excess supply of oxygen.

Typically, the hydrogen sulfide (H_2S) gas is formed in wastewater collection systems that are conducive to creating septic conditions. Collection systems in warm climates that have a flat grade or do not have the flow-through velocities to prevent the stagnation of fluid, allow the septic conditions to occur. In general, septic conditions occur when bacteria use all of the available oxygen while decomposing organic matter in wastewater for energy. Sewers with low velocities encourage the growth of anaerobic bacteria in a slime layer coating the sewer. These bacteria reduce sulfur compounds such as sulfates (SO_4^{2-}), thereby producing sulfides. The sulfides combine with hydrogen to produce the hydrogen sulfide. Sulfates occur naturally in domestic wastewater since they originate from the water consumed.

The following chemical equations illustrate the formation of H_2S:

SO_4^{2-} + Organic Matter $\rightarrow$ $S^{2-} + H_2O + CO_2$

$S^{2-} + 2H^+ \rightarrow H_2S$

Under anaerobic (septic) wastewater conditions, sulfides cannot be oxidized. Therefore, they combine with hydrogen to produce hydrogen sulfide gas, creating the "rotten egg" odor associated with septic wastewater.

Factors that affect the formation of sulfides and hydrogen sulfide in the wastewater collection system include:

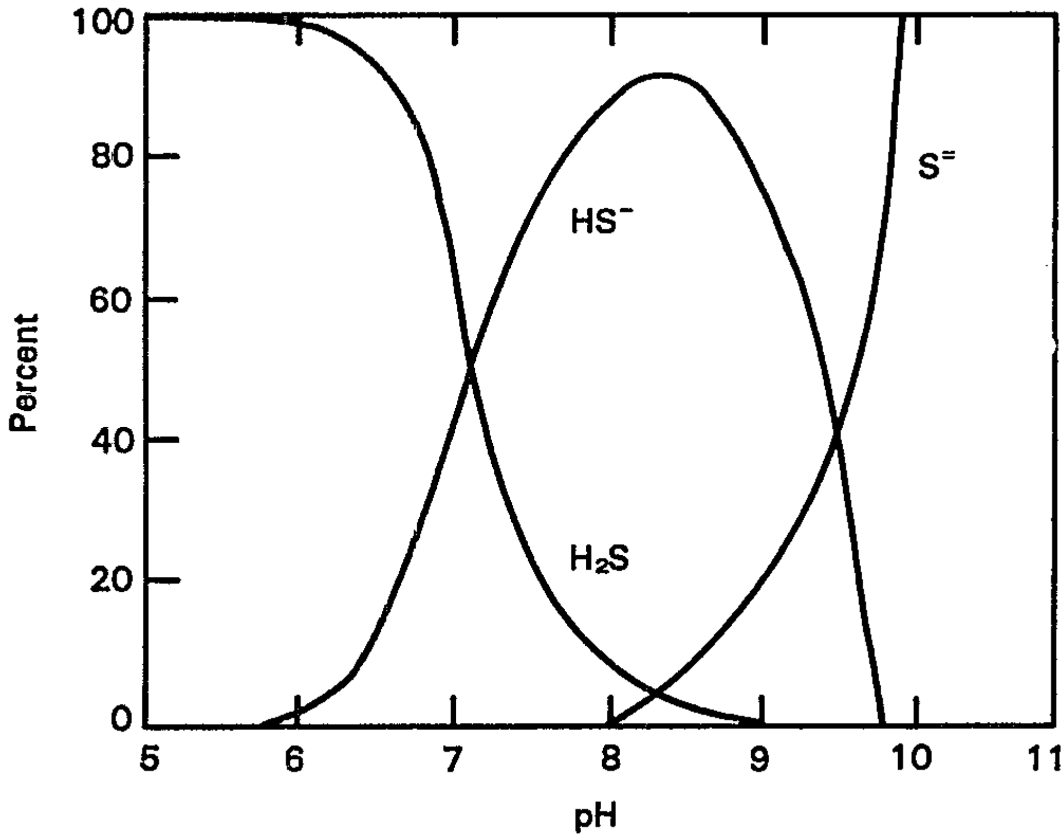
Biochemical oxygen demand (BOD): a high concentration of organic matter, measured as BOD_5, will increase the bacterial growth thus deplete the dissolved oxygen and increase the sulfides production.

Dissolved oxygen (DO): The dissolved oxygen level in the wastewater is the determining parameter for breaking down of the carbonaceous matter occurring either in an aerobic or anaerobic situation. Aerobic bacteria generally dominate the outer layer of the biofilm formed in a sewer at a DO concentration more than 1 mg/l. At increased DO levels, the sulfide formation would be reduced due to the limited degradation by anaerobic bacteria. A low level of DO favors growth of anaerobic microorganisms and subsequently higher sulfide production rates.

Wastewater pH: The pH is the controlling factor for the dissociation of hydrogen sulfide into dissolved hydrogen sulfide gas (H_2S), hydrogen sulfide ion (HS^-), and sulfide ion (S^{2-}) in wastewater. The distribution of dissolved H_2S:HS^- is approximately 50:50 at pH 7, whereas at pH 6, the distribution changes to 90% dissolved H_2S: 10% HS^- in wastewater. This dissolved hydrogen sulfide is released to the atmosphere from the solution and the release is enhanced under turbulent conditions. Therefore, a decrease in the wastewater pH would increase the hydrogen sulfide gas emission in the sewers. The chemical equilibrium relationship between hydrogen sulfide gas and dissolved sulfides is illustrated in Figure 1.

It is very important to understand this chemical equilibrium relationship in order to minimize hydrogen sulfide gas emissions by controlling the wastewater pH.

Figure 1: Hydrogen Sulfide Gas and Dissolved Sulfides versus pH



Wastewater temperature: The bacterial activities are increased at higher wastewater temperatures. Increased bacterial activities result in more oxygen demand and lower dissolved oxygen levels. This would result in more sulfide production.

Hydraulic residence time: At higher hydraulic residence time, the dissolved oxygen would be depleted faster. This would result in more sulfide production.

The respiratory system is the main route of human exposure to hydrogen sulfide. In its acute, hydrogen sulfide intoxication is mainly the result of action on the nervous system. At concentrations of 15 mg/m^3 and above, hydrogen sulfide causes conjunctival irritation. Serious eye damage is caused by a concentration of 70 mg/m^3. Hydrogen sulfide causes odor nuisance at concentrations far below those that cause health hazards.

Normally, cities odor control design criteria stipulate the requirement to control H_2S concentrations at the discharge point to **less than 1 ppm**.

In addition to odor, several human health-related problems are potentially associated with the occurrence of hydrogen sulfide. The human health-related effects in relation to hydrogen sulfide concentrations are given in Table 1 [10].

Table 1: Human health-related effects in relation to Hydrogen Sulfide concentration

Hydrogen Sulfide Concentration (ppm)	Human Effect or Odor
0.0001 – 0.002	Threshold odor limit
0.5 – 30	Unpleasant and strong smell
10 – 50	Headache, nausea and eye-nose-throat irritation
50 – 300	Eye and respiratory injury
300 – 500	Life threatening
> 700	Immediate death

It is important to note that hydrogen sulfide loses its characteristics smell (rotten eggs) at about 50 ppm. As H_2S is typically not detected by its smell at those concentrations it is dangerous, instruments or alarm systems for its monitoring should be used.

Ammonia is also considered as an odorous compound which is to be mitigated. Ammonia is a colorless acrid-smelling gas. Much of the ammonia in air results from decomposition of organic matter and other biological activities. Ammonia vapor is irritating to the eyes and the respiratory tract. Damages to the bronchial epithelium and the alveolar membrane have been documented at high concentrations. Elevated ammonia concentrations over a long period of time may eventually be detrimental to the environment. The odor impacts resulting from ammonia would be studied.

The principal sources of odors in wastewater treatment facilities include the following:

Wastewater collection systems

One of the key sources of odor is the biological conversion under anaerobic conditions of compounds containing nitrogen N and sulfur S (high odor potential). Also, odor can be released due to turbulence.

Wastewater treatment facilities

Headworks, including influent lift station, screening works and grit removal tanks:

High odor potential due to release of gases generated in the wastewater collection system.

Primary Sedimentation Tanks:

Moderate odor potential due to high organic loading, poor settling and high detention time.

Sludge handling units including sludge storage tanks, sludge thickeners and sludge dewatering works:

High odor potential due to release of gases resulting from biological degradation of organic matter.

1.2 DAOURA PRELIMINARY TREATMENT PLANT – ODOR CONTROL UNIT

The proposed Odor Control Unit (OCU) for the Daoura PTP is described by the Consultant ACE in Section 4.8 “Odor Control Unit” of the report “Pretreatment Headworks at Daoura WWTP – Final Design Report – February 2019” prepared by the Consultant ACE for the CDR.

The Consultant ACE describes the Daoura PTP OCU as follows:

“The Odor Treatment Plant shall generally be based on the process of oxidation/scrubbing to destroy odors by conversion of malodorous contaminants to non-objectionable stable compounds.

The scrubbing process shall be of the vertical, counter-current, multiple (2 or 3) stage type.

Sulfuric Acid (H_2SO_4), Caustic soda (NaOH) and sodium hypochlorite (NaOCI) solutions shall be used for the scrubbing process.

A minimum of 10 air exchanges per hour shall be achieved for the areas with high odor release potential (inlet P.S., screen area, screen and grit handling areas, etc.) and min. 5 exchanges per hour for the non-critical building areas (control rooms, etc.).

The approximate resulting air-flows according to the above criteria are as follows:

Inlet P.S.:	30,000 Nm^3/hr
Screening Bldg.:	50,000 Nm^3/hr
Effluent P.S.:	10,000 Nm^3/hr

Min. total capacity of the Odor Treatment Plant shall be 90,000 Nm^3/ hr of air.
Before treatment it is considered that the air is with an average concentration of 25 ppm of H_2S, and an hourly peak concentration as high as 100 ppm.

After treatment the efficiency of odorous gases removal shall be greater than 98 % and H_2S concentration in the treated gas shall be less than 0.2 ppm.

The scrubber towers are pre-engineered and designed and built by a well-qualified manufacturer.”

1.3 ASSESSMENT OF THE DAOURA PTP ODOR CONTROL UNIT

To be noted here that we have requested additional information regarding the OCU including the chemicals storage tanks with a drawing showing layout and elevation of the tanks and the scrubber towers. Such information seems not to have been prepared by the Consultant ACE. The only data we have is the description of the system as given in the previous section.

1.3.1 OCU System

The OCU proposed by ACE consists of scrubber towers that would be using sulfuric acid H_2SO_4. We assess that the use of a hazardous chemical such as sulfuric acid for odor control is not acceptable. The issues relate to the handling of the hazardous chemical from its origin source, along the travel path, at Beirut harbor when imported, along the Lebanese roadways and inside the plant. A non-informed worker just touching or getting splashed with sulfuric acid would have the body part disintegrated. Exposure to sulfuric acid would cause permanent burns and if it touches the eyes immediate blindness would result.

The storage tanks of sulfuric acid need to be contained within concrete curbs in order to curtail any leakage. It would be very dangerous not to foresee containment curbs for the sulfuric acid. We could not find any mention of containment curb in the description of the proposed OCU for the Daoura PTP.

Due to potential hazards inherent with the handling, storage and use of sulfuric acid, this EIA does not recommend this proposed OCU for the Daoura PTP.

An alternative OCU needs to be investigated and proposed.

Based on our experience, conducting odor dispersion studies for over twenty wastewater treatment plants, the most commonly adopted system is the Granular Activated Carbon (GAC) filter. This system consists of inert material (GAC) placed in a casing to form a filter. There are no hazards whatsoever associated with the handling, storage and use of GAC.

Biological filters could also be investigated.

Another common system used in large-scale plants is a combination of biofilters and GAC filters. The air would first be treated by the biofilters, then by the GAC filters.

1.3.2 OCU Inlet H_2S Concentrations

For any proposed OCU, the odor emissions are affected by the concentration of hydrogen sulfide H_2S leaving the outlet stack of the OCU. This outlet concentration is directly related to the inlet concentration and the OCU removal efficiency.

For the Daoura PTP, the Consultant ACE considered that the inlet concentration of H_2S to the OCU would be on average 25 ppm and may have an hourly peak of 100 ppm. A removal efficiency of 98% is considered by the Consultant ACE.

The Daoura PTP would be servicing a very large project area with a very extensive wastewater collection system. Accordingly the raw wastewater travel time in the wastewater collection system would be high. The more time it takes for the raw wastewater to reach the plant, the higher the emitted concentration of hydrogen sulfide would be. This would be due to the formation and accumulation of sulfides.

We have conducted odor dispersion modeling for the largest wastewater treatment plant in Dubai namely Al Aweer wastewater treatment plant. The wastewater system leading to the plant is extensive. Al Aweer plant had an original design capacity of 260,000 m^3/d but was lately expanded to 325,000 m^3/d to service the higher flows reaching it. We can say that the Daoura PTP is of comparable capacity to Al Aweer plant since during the short term (horizon 2020) it would be servicing an average day flow of 227,500 m^3/d and for the long term (horizon 2050) the average day flow would be 325,000 m^3/d.

For Al Aweer plant, the international contractor Veolia was awarded the expansion of the plant. For the additional treatment works that included odor control, Veolia proposed OCU consisted of biofilters followed by GAC filters. For Al Aweer, Veolia adopted 400 ppm as average inlet H_2S concentration and 800 ppm as peak inlet H_2S concentration. Our calculations for Al Aweer plant revealed that the peak inlet H_2S concentration would be 1000 ppm. Before Dubai municipality took drastic measures to reduce odors emissions, Al Aweer plant was repeatedly featured in the media for being a major source of odors nuisance to the nearby residents although nearest receptors were located some 1.5 km away from the plant site.

Based on our practical experience, the inlet maximum H_2S concentration of 100 ppm adopted by the Consultant ACE is substantially under estimated for the Daoura PTP. The adopted inlet H_2S concentration is normally detected at medium scale plants and not at large scale plants such as the Daoura PTP.

At the specified removal efficiency of 98% and a potential actual peak inlet H_2S concentration of 800 ppm, the outlet H_2S concentration at the discharge stack would be 1.6 ppm. The outlet concentration from the discharge stack should always be specified not to exceed 1 ppm but preferably 0.5 ppm. To achieve an outlet concentration of 0.5 ppm for an inlet concentration of 800 ppm at 10 air changes would require a removal efficiency of 99.38%.

This EIA assesses that the adopted inlet maximum H_2S concentration of 100 ppm and the specified required removal efficiency of 98% are both under estimated.

1.3.3 Emission Sources Serviced by the OCU

The sources serviced by the OCU of the Daouara PTP are identified by the Consultant ACE to be:

- Inlet Pumping Station;
- Screening Building; and
- Effluent Pumping Station.

These three emission sources are identified on the schematic drawing prepared by the Consultant ACE and included here as Figure 2.

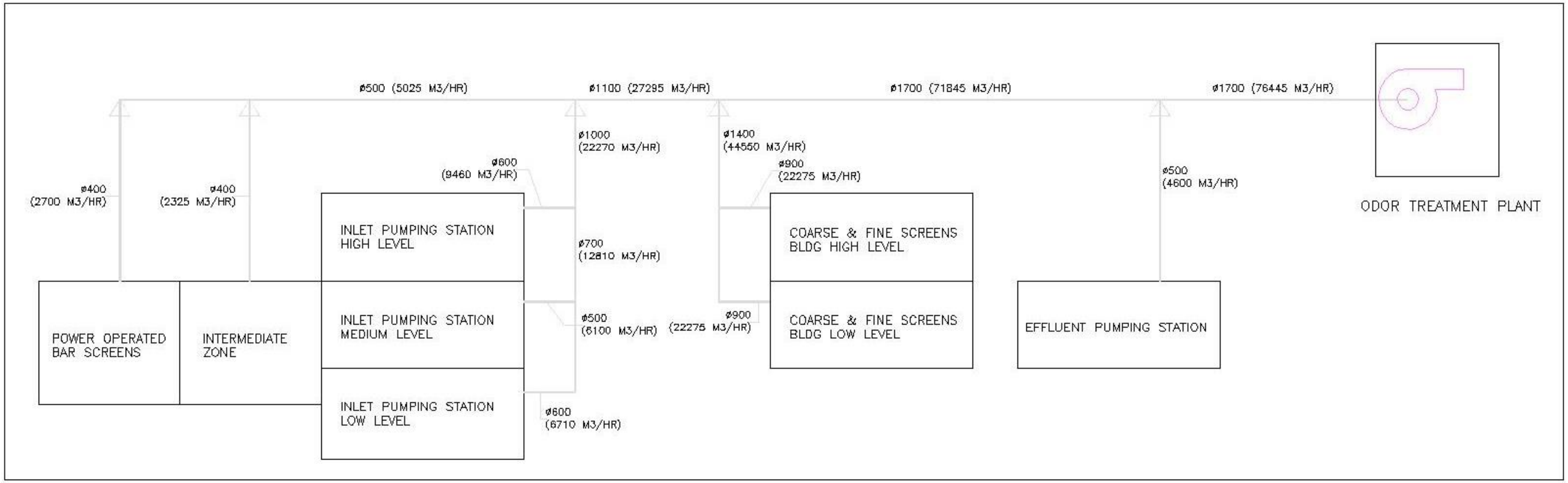
There is a major problem with the Consultant ACE identification of the emissions sources. To understand the problem, the basic phenomenon of hydrogen sulfide emission from the liquid solution to the atmosphere needs to be reminded.

The hydrogen sulfide gas that forms in the liquid solution escapes to the atmosphere through such actions as turbulence to the liquid volume, for example as wastewater gets in contact with restricted openings through a screen. But most importantly, the hydrogen sulfide gas gets pushed by air flow fed into the liquid.

The major odor emission source at the Daoura PTP would be the Aerated Grit Chambers.

For the aerated grit chambers, the Consultant proposes, for Phase 1, three (3) air blowers with two (2) duty and one (1) standby, with each air blower being rated at 1,000 Nm^3/h. For Phase 2, one (1) additional air blower is proposed by the Consultant. Therefore, for Phase 1, some 2,000 Nm^3/h of air would be mixing the volume of the aerated grit chambers and in Phase 2, the air supply would increase to 3000 Nm^3/h. The air supplied would result in major hydrogen sulfide emissions above the water surface of the aerated grit chambers.

Figure 2: Consultant ACE Emission Sources Serviced by the OCU



The Consultant ACE did not foresee collecting and treating the foul air from the aerated grit chambers. Without collecting the air passing through the aerated grit chambers, most of the odor emissions would not be captured and treated by the proposed OCU. In order to capture and treat the foul air from the aerated grit chambers, the tanks surfaces could be covered. Another way, to capture and treat this foul air would be to provide an enclosure building around the aerated grit chambers.

Most of the time the preference is to have the tanks located inside a building space. This is due to the fact that these tanks are equipped with travelling bridges having top and bottom scrappers attached. It is possible to provide covers on the top surface but in this case the space required for the travelling bridges moving parts would need to be tightly sealed. Another reason for not covering the tanks is to allow visual inspection and quicker access to the tanks equipment. That is why the preferred option is to have a building enclosing these tanks. Figure 3 shows aerated grit chamber located inside an enclosed building.

Figure 3: Aerated Grit Chambers inside an enclosed building

Based on the above, this EIA considers that capturing and treating the foul air from above the surface of the aerated grit chambers is a mandatory requirement for proper odors emission mitigation and control. This mandatory requirement is achievable through covering the surfaces of the tanks or housing the aerated grit chambers inside a building.

The air flow numbers given by the Consultant ACE in Figure 2 result in a total air inflow of 76,445 m^3/h to the OCU. To this air flow, must be added the additional air flows from the aerated grit chambers.

The Daoura PTP layout drawing shows that for Phase 2, the total water surface area of the aerated grit chambers would be:

3 trains x 36 m L x 12 m W = 1,296 m^2 say 1,300 m^2.

Reference is made to the cross-section drawing for the aerated grit chambers given in Section 4.6.1 of the Consultant ACE report "Pretreatment Headworks at Daoura WWTP – Final Design Report – February 2019" prepared by the Consultant ACE for the CDR. The Consultant drawing shows a top concrete level of 10.45 m and a water level of 9.35 m. In case the adopted option is to cover these tanks, the lid would be about 1.1 meter (10.45-9.35 = 1.1 meter) above the water surface. The air volume above these tanks would be 1,430 m^3. This foul air must receive at least 10 air changes per hour resulting in a required air suction flow of 14,300 m^3/h.

For Phase 2, the ultimate air flow supplied by the air blowers would be 3,000 Nm^3/h since the Consultant ACE indicates in Section 4.6.2 of its report that the calculated air demand for Phase 2 is 2,877 Nm^3/h.

Therefore, an additional 17,300 m^3/h (14,300 + 3,000) of foul air, from the aerated grit chambers, would be feeding the OCU.

In case the adopted option is to provide a building enclosure, the air volume of the building space would need to be added as well. In this case, the required number of air changes could be reduced.

The capacity of the OCU, as specified by the Consultant, is 90,000 Nm^3/h. With reference to Figure 2, the Consultant ACE calculated a total inlet air flow of 76,445 m^3/h. The additional air flow from the aerated grit chambers needs to be accounted for. However, we do not assess that the indicated capacity of 90,000 Nm^3/h is not sufficient to cater for all the odor sources. We believe that the Consultant ACE may have over-estimated some air flows. We could not verify these air flow rates because such an exercise would require having the detailed drawings for the Daoura PTP to enable us see the plan and sectional views then calculate the air volumes. Such drawings were not made available to us.

1.3.4 Conclusion

The Daoura PTP OCU as described by the Consultant ACE should not be tendered for construction.

We have made this statement because we strongly believe that the proposed OCU system, the adopted inlet concentrations and the omission to service the aerated grit chambers would cause negative environmental impacts from high odors emissions. The transport, handling, storage and use of sulfuric acid would result in potential serious health hazards to the operators and workers at the Daoura PTP.

In what follows, we would assess odor emissions from the Daoura PTP that would be equipped with an OCU positioned at the same location indicated on the Consultant ACE plant layout drawing and having a capacity of 90,000 Nm^3/h.

1.4 DAOURA PTP – ODORS EMISSION SOURCES

For the Daoura PTP, the principal odors emission sources are the following:

- Inlet Pumping Station;
- Screening Building;
- Aerated Grit Chambers; and
- Effluent Pumping Station.

The main odorous compounds expected to be generated from the odors emission source are:

Table 2: Odorous Compounds from the Odor Emission Sources

Odorous Compound	Odor
Ammonia NH_3	Ammoniacal
Hydrogen Sulfide H_2S	Rotten eggs

1.5 BUFFER DISTANCES

In theory, the emitted odors can either be contained within a buffer zone around the wastewater treatment plant or collected and treated.

In what follows, the theoretical buffer zone concept is discussed.

According to International Practice, the radius of a buffer zone around an emission source would set a buffer zone around the wastewater treatment plant. The buffer distances [1] from some of the odors emission sources, for open-area construction, are as follows:

Table 3: Buffer Distance from Odors Emission Sources

Odors Emission Source	Buffer Distance (m)
Headworks	150
Primary sedimentation tanks	125
Aeration Tanks	150
Secondary sedimentation tanks	125
Tertiary filters	100
Sludge thickeners	300
Sludge storage tank	300

The buffer distances given in the previous table relate to open-area construction and are applicable in the absence of odor control units.

The buffer distance can be minimized by adopting lids, covers, gas wash installations…etc, by constructing the works within enclosed buildings and by installing odor control units.

In the case of the Daoura PTP, an odor control unit would be collecting and treating the odors emitted from the various odor emission sources. As such, the theoretical buffer distances given in the above table are not applicable since they relate to open-construction without odor control units.

In this EIA study, a more detailed analysis is carried out, through odors emission modelling, in order to quantify the magnitude of odors emissions from the Daoura PTP. Therefore, the emitted H_2S concentration isopleths (calculated in subsequent sections) would enable the definition of the required buffer zone.

1.6 ODORS EMISSION AND THRESHOLD CONCENTRATIONS

The expected odors emission concentrations for hydrogen sulfide and ammonia as well as the threshold limits for the same are given hereafter.

1.6.1 Odors Emission Concentrations

The wastewater reaching the Daoura PTP is considered to be septic due to the very high incoming average day flows of 227,500 m^3/d (Horizon 2020) and 325,000 m^3/d (Horizon 2050). The Daoura PTP would be servicing an extensive project area. The long travel distances in the wastewater collection and conveyance systems result in long residence times leading to the build-up of a high concentration of dissolved sulfide. For the Daoura PTP, the maximum hydrogen sulfide concentration would be expected at the headworks. As the incoming wastewater starts to receive air at the aerated grit removal tanks, the dissolved sulfide concentration would start to decrease which would result in lower H_2S concentrations after the aerated grit tanks.

1.6.2 Hydrogen Sulfide Emission Rates

The hydrogen sulfide gas emissions relate to the dissolved sulfide concentration in the raw wastewater. For the Daoura PTP, in the absence of measured raw wastewater characteristics we have to estimate the hydrogen sulfide concentration in the raw wastewater.

Basically, there are two approaches for estimating the hydrogen sulfide emission rates:

Approach No. 1: Mathematical Modelling using Software

The use of emissions software mathematical models to calculate emissions from wastewater process units provides a widely accepted method of calculation. The mathematical models used in the software are based on theoretical equations presented in various literatures. It is widely recognized that the preferred method for estimating emissions is the use of mathematical modelling. Such mathematical models incorporate detailed calculation procedures that account for pH, air and wastewater temperatures, Henry's law constant, liquid phase and gas phase equilibrium, air flow rate, wastewater flow rate, biodegradation rates, geometry,…etc.

Approach No. 2: Estimation

In this approach, the emission rates are estimated considering the fraction emitted (denoted by Fe) from the total amount present in the wastewater. The basic formula for this approach would be:

Emission Rate = Fe x Total Concentration in Wastewater x Wastewater Flow Rate

For the Daoura PTP, we have followed both approaches in order to estimate the hydrogen sulfide emission rates from the headworks that include all the defined emission sources.

In the first approach, we made calculations based on the Pomeroy/Parkhurst mathematical models. Following this procedure, the hydrogen sulphide concentration is calculated considering the biochemical oxygen demand, wastewater temperature, air temperature and the time of travel in the wastewater network.

In the second approach, we have calculated the hydrogen sulphide emission rates based on the fraction emitted method. Following this method, the hydrogen sulphide concentration is calculated considering the incoming sulphide concentration, the fraction emitted at the headworks, the air flows supplied to the aerated grit chambers, wastewater temperature and air temperature.

1.6.3 Hydrogen Sulfide Emission Concentrations

Two hydrogen sulfide concentrations are defined:

- Static Concentration; and
- Dynamic Concentration.

The Static Concentration at a process unit is calculated considering the prevailing air flow rate without the effect of air extraction from fans. The static concentration is calculated with the condition of having an air extraction fan turned off.

The Dynamic Concentration at a process unit is calculated considering the total air flow rate which includes the air extraction rates resulting from fans operation.

1.6.3.1 Hydrogen Sulfide Static Concentrations at Inlet of the Daoura PTP

The first estimate for the hydrogen sulphide concentration reaching the headworks of the Daoura PTP is made by applying the Pomeroy/Parkhurst mathematical models. Using this approach, we can calculate the expected dissolved sulphide concentration and the related hydrogen sulphide gas concentration.

The residence time in the wastewater collection and conveyance system is an important parameter in this calculation method. To accurately determine the residence time, all information related to the sewer lines would need to be taken into account including diameters, lengths, slopes and velocities. In the absence of such information, we have to make educated decisions. Knowing that the wastewater collection and conveyance system, leading to the Daoura PTP, is extensive, we estimate the residence time to be high. The maximum sulphide production would occur along the longest sewer route to the plant site. Considering a maximum travel distance of 12 km in this system, at a velocity of 0.75 m/s, the residence time would be 4.44 hours. For a minimum velocity of 0.60 m/s, the residence time would be 5.56 hours.

For the Daoura wastewater collection and conveyance system, the residence time could be as high as 6 hours. Therefore, we would calculate the expected hydrogen sulphide concentration reaching the Daoura PTP for residence times of 4, 4.5, 5.0, 5.5 and 6.0 hours. This sensitivity analysis approach would enable us make more educated decisions.

The calculations would be performed for summer weather conditions when the wastewater temperature and the air temperature are high. To define the maximum temperature during the summer season, we have obtained temperature data from the Beirut airport meteorological station. For the latest five years extending from the year 2014 until the year 2018, the mean value for the maximum recorded temperatures was found to be 33 ^{O}C for both the month of July and the month of August as given in Table 4 below.

Table 4: Maximum Recorded Temperatures – July and August

Year	**July Maximum Temperature (^{O}C)**	**August Maximum Temperature (^{O}C)**
2014	32.8	33.5
2015	39.2	38.0
2016	31.8	31.6
2017	31.0	31.1
2018	30.4	30.9
Average	**33**	**33**

The five day biochemical oxygen demand would be set at 369 mg/l as adopted by the Consultant ACE for the design of the plant.

We are further considering that the average sewer diameter for the whole wastewater collection and conveyance system is 400 mm.

Due to high residence times in the wastewater collection and conveyance systems, we estimate that the pH would be lower than 7.0. We would make sensitivity calculations at pH values of 6.7, 6.6 and 6.5.

The following main parameters are considered:

Wastewater residence time in the collection system:	4.0 – 6.0 h (sensitivity analysis)
Wastewater temperature in summer:	24 ^{O}C
Air temperature in summer:	33 ^{O}C
Biochemical oxygen demand (BOD_5):	369 mg/l
pH:	6.5 – 6.7 (sensitivity analysis)

Based on the above defined parameters, the calculated dissolved sulfide concentration and the hydrogen sulfide gas static concentration reaching the inlet works of the Daoura PTP would be as given in Table 5.

As noted in an earlier section, the 50/50 equilibrium between the distribution of hydrogen sulfide gas and the dissolved hydrogen sulfide is at a pH of 7.0. As the pH decreases, more Hydrogen sulfide gas would be emitted from the solution. This can be seen from Table 5 with an increase of emitted hydrogen sulfide gas at lower pH values.

Table 5: Inlet Dissolved Sulfide and Hydrogen Sulfide Gas Concentrations

Residence Time (h)	pH (-)	Dissolved Sulfide Concentration (mg/l)	Hydrogen Sulfide Gas Concentration (ppm)
4.0	6.7	1.10	217
4.5	6.7	1.24	244
5.0	6.7	1.38	271
5.5	6.7	1.51	298
6.0	6.7	1.65	325
4.0	6.6	1.10	233
4.5	6.6	1.24	262
5.0	6.6	1.38	291
5.5	6.6	1.51	321
6.0	6.6	1.65	350
4.0	6.5	1.10	248
4.5	6.5	1.24	279
5.0	6.5	1.38	310
5.5	6.5	1.51	341
6.0	6.5	1.65	372

The calculated inlet concentrations give a clear indication that the hydrogen sulfide gas (H_2S) static concentration at the inlet to the Daoura PTP could be on average about 350 ppm. The calculated inlet dissolved sulfide concentration is 1.65 mg/l.

To be conservative, we would consider in our analysis the following inlet concentrations:

Hydrogen Sulfide Gas (H_2S) inlet concentration: 400 ppm

Dissolved Sulfide inlet concentration: 1.80 mg/l

1.6.3.2 Hydrogen Sulfide Static Concentrations at Daoura PTP Headworks

In the absence of forced aeration at the inlet pumping station and the screens, the dissolved sulfide concentration would remain about 1.8 mg/l after passing through these process units. The concentration of hydrogen sulfide gas in the foul air above these units would be about 400 ppm. This condition would apply taking into consideration that no chemicals are dosed at the inlet works to alter the wastewater pH. The report by the Consultant ACE does not mention chemicals dosing at the plant inlet.

As the wastewater passes to the aerated grit chambers, the air blown from the blowers into the liquid volume of the aerated grit chambers would cause a reduction in the dissolved sulfide concentration and an emission of hydrogen sulfide gas above the surface of the tanks.
For estimating the dissolved sulfide fraction emitted to the atmosphere from the aerated grit chambers, and the resulting hydrogen sulfide gas concentration, calculations are performed using the software Toxchem. The following main parameters are considered:

Wastewater Average Day Flow Horizon 2020 :	227,500 m^3/d
Wastewater Average Day Flow Horizon 2050 :	325,000 m^3/d
Wastewater temperature in summer:	24 ^oC
Air temperature in summer:	33 ^oC
Biochemical oxygen demand (BOD_5):	369 mg/l
Total suspended solids (TSS):	431 mg/l
pH:	6.5 – 6.6 (sensitivity analysis)
Aerated grit chambers surface area Horizon 2020:	864 m^2
Aerated grit chambers surface area Horizon 2050:	1,296 m^2

The five day biochemical oxygen demand of 369 mg/l and the total suspended solids concentration of 431 mg/l are set as adopted by the Consultant ACE for the design of the plant.

The calculations results are given in Table 6.

Table 6: Hydrogen Sulfide Gas Emitted from the Aerated Grit Chambers

Design Horizon (-)	pH (-)	Air Blowers Flow (Nm^3/h)	Dissolved Sulfide Concentration (mg/l)	Dissolved Sulfide Fraction Emitted (%)	Hydrogen Sulfide Gas Concentration (ppm)
2020	6.6	2,000	1.80	9.77	614
2020	6.5	2,000	1.80	10.28	646
2050	6.6	3,000	1.80	10.21	611
2050	6.5	3,000	1.80	10.74	643

The calculated concentrations give a clear indication that the hydrogen sulfide gas (H_2S) static concentration emitted from the aerated grit chambers could be about 640 ppm. The calculated fraction emitted is around 10%, a result that we could have anticipated.

To be conservative, we would consider in our analysis the following emitted concentration from the aerate grit chambers:

Hydrogen Sulfide Gas (H_2S) from aerated grit chambers: 650 ppm

1.6.3.3 Hydrogen Sulfide Static Concentrations at the Effluent Pumping Station

Considering that about 10% of the dissolved sulfide concentration would be emitted from the surface of the aerated grit chambers, the wastewater flow exiting the aerated grit chambers would have a remaining dissolved sulfide concentration of about: 90% x 1.80 = 1.62 mg/l. This wastewater flow enters the effluent pumping station. The calculated hydrogen sulfide gas concentration in the effluent pumping station wet well would depend on the wastewater pH as given in Table 7.

Table 7: Hydrogen Sulfide Gas Emitted at the Effluent Pumping Station

pH (-)	Dissolved Sulfide Concentration (mg/l)	Hydrogen Sulfide Gas Concentration (ppm)
6.5	1.62	365
6.6	1.62	343
6.7	1.62	319
6.8	1.62	294
6.9	1.62	267
7.0	1.62	241

Due to the aeration in the aerated grit chambers, the wastewater pH would be expected to increase due to the reduction in carbon dioxide in the liquid volume. At the same time, residence time at the effluent pumping station could result in a decrease of the pH. We would consider that the pH could be between 6.7 and 6.9 with an average value of about 6.8. Therefore, the hydrogen sulfide concentration at the effluent pumping station would be around 294 ppm.

To be conservative, we would consider in our analysis the following emitted concentration from the effluent pumping station:

Hydrogen Sulfide Gas (H_2S) from effluent pumping station: 300 ppm

1.6.3.4 Hydrogen Sulfide Dynamic Concentrations

The Dynamic H_2S Concentration is calculated considering the emission rates and the total air flow rate inclusive of the air extraction rates resulting from fans operation.

The dynamic H_2S concentration conveyed by air ducts to the inlet of OCU is calculated as given in Table 8. The indicated air flow rates and number of air changes for the process units power bar screens, intermediate zone, inlet pumping station, coarse/fine screens building and the effluent pumping station are as indicated by the Consultant ACE. As such, these values are as calculated by the Consultant ACE and remain their responsibility. For the aerated grit chambers, we have explained in a previous section that the air flow emitted from the surface of these tanks would depend on the solution to be adopted for collecting and treating the foul air. The shown air volume considers the simpler solution of covering the tanks. Considering that the capacity of the proposed OCU is fixed at 90,000 Nm^3/h, we have allocated the remaining air flow of 13,555 m^3/h to the aerated grit chambers. This has resulted in the number of air changes (7.4) indicated in the table. The resulting number of air changes is acceptable since it is about 8 times.

Table 8: Dynamic Hydrogen Sulfide Gas Concentrations

Process Unit	Static H_2S (ppm)	Suction Air Flow (m^3/h)	Blower Air Flow (m^3/h)	Total Air Flow (m^3/h)	Air Changes (#/h)	Dynamic H_2S (ppm)	Air Flow Percent (%)	Flow Weighted Dynamic H_2S (ppm)
Power Bar Screens	400	2,700	0	2,700	10	40	3.00	1.20
Intermediate Zone	400	2,325	0	2,325	10	40	2.58	1.03
Inlet Pumping Station	400	22,270	0	22,270	10	40	24.74	9.90
Coarse/Fine Screens Building	400	44,550	0	44,550	10	40	49.50	19.80
Aerated Grit Chambers	650	10,555	3,000	13,555	7.4	88	15.06	13.26
Effluent Pumping Station	300	4,600	0	4,600	10	30	5.11	1.53
Total		**87,000**	**3,000**	**90,000**			**100**	**46.73**

The calculated flow weighted dynamic hydrogen sulfide gas concentration that would enter the OCU is 47 ppm.

To be conservative, we would consider in our analysis the following dynamic hydrogen sulfide gas concentration at the inlet of the OCU:

Hydrogen Sulfide Gas (H_2S) dynamic concentration at the inlet of the OCU: 50 ppm.

1.6.4 Ammonia Influent Concentrations

Beginning at the house connection to the main sewer line, nitrogen is mostly in the form of organic nitrogen. Through a process called hydrolysis, organic nitrogen begins conversion to ammonia or ammonium. The form of nitrogen, ammonia or ammonium, depends on pH and temperature. When the pH of the wastewater is acidic (< 6.9) or neutral (7.0), the majority of the nitrogen is in the form of ammonium (NH_4^+). When the pH increases over 8.0, the nitrogen is mostly in the form of ammonia (NH_3). Typically, by the time the wastewater enters the sewage treatment plant, most of the nitrogen would have been converted to ammonium.

The incoming liquid ammonia concentration to the headworks is calculated from the incoming total nitrogen (ammonium + ammonia) concentration and the wastewater pH.

The ammonia gas concentration is calculated from the liquid ammonia concentration by applying Henry's Law. The calculations are carried out as follows:

Total Nitrogen Concentration

The incoming total nitrogen concentration in the raw sewage, consisting of ammonium and ammonia is specified by the Consultant ACE to be 67.7 mg/l.

Liquid Ammonia Concentration

The liquid ammonia concentration is calculated from the incoming total nitrogen concentration and the wastewater pH as follows:

$$NH_{3liquid} = \frac{TN}{1+10^{(pKa-pH)}}$$

Where,

$NH_{3liquid}$:	liquid ammonia concentration (mg/l);
TN:	total nitrogen concentration (mg/l);
pKa:	acid dissociation constant of ammonium (-); and
pH:	hydrogen ion concentration (-).

The acid dissociation constant of ammonium pKa is given by the following model:

$$pKa = 0.0897 + \frac{2729}{(273.15 + T)}$$

Where,

T: wastewater temperature (ºC).

Ammonia Gas Concentration

The equilibrium ammonia gas concentration is calculated from the liquid ammonia concentration and Henry's Law unitless constant for ammonia. For ammonia, the Henry's Law unitless constant is given as:

$$H_{NH3} = \frac{239000}{(273.15 + T)} e^{\frac{-4151}{(273.15+T)}}$$

Where,

H_{NH3}: Henry's Law unitless constant for ammonia (-); and
T: wastewater temperature (ºC).

Therefore, the ammonia gas concentration is calculated as:

$$\mathbf{NH_{3gas} = H_{NH3} \,.\, NH_{3liquid}}$$

Where,

NH_{3gas}: ammonia gas concentration (mg/l);
H_{NH3}: Henry's Law unitless constant for ammonia (-); and
$NH_{3liquid}$: liquid ammonia concentration (mg/l).

In order to convert the ammonia gas concentration from mg/l to ppm, the following equation is used:

$$\mathbf{NH_{3gas}\ (ppm) = 4.815\ NH_{3gas}\ (mg/l)\ (273.15 + T_{air})}$$

Where,

T_{air}: air temperature (ºC).

Ammonia Concentration at the Headworks

Based on the above-described calculation methods, the ammonia gas maximum concentrations at the headworks are calculated considering the following basic data:

Wastewater Temperature:	24 ^oC;
Air Temperature:	33 ^oC;
Total Nitrogen:	67.7 mg/l; and
pH:	6.5 – 6.8 (sensitivity analysis)

The ammonia static concentration increases with the increase in the raw wastewater pH. In consideration to the long residence time in the sewerage system leading to the Daoura PTP, the pH is expected to be on the lower end. To be conservative, we have considered a maximum pH value of 6.8 to represent non-favorable conditions.

The calculated static ammonia gas maximum concentration, based on the above given, are:

NH_3 Maximum Static Concentration = 0.23 ppm.

Since the headworks would be serviced by the proposed OCU, the emitted static ammonia gas concentration would be duct conveyed via the extraction fan of the OCU. Considering the air changes and air flows (calculated in a previous section) provided by the operation of the air extraction fan of OCU, the ammonia gas dynamic concentrations could be calculated.

The calculated dynamic ammonia gas maximum concentrations to the OCU, based on the above given, are:

NH_3 Maximum Dynamic Concentration = 0.025 ppm.

1.6.5 Odors Emission Concentrations

For the Daoura PTP, the adopted concentrations of hydrogen sulfide and ammonia to the inlet of the odor control unit are as follows:

Hydrogen Sulfide (H_2S) Concentration to inlet of the OCU: 50 ppm

Ammonia (NH_3) Concentration to inlet of the OCU: 0.025 ppm

1.6.6 Threshold Concentrations

Odors annoyance from sewage treatment plants is recognized as a problem. International standards have been evolving with respect to the threshold concentrations for ammonia and hydrogen sulfide. The threshold concentration being the level at which the odor is detected by the recipients and is considered annoying and repelling.

At present, the United States Environmental Protection Agency (USEPA) sets the hydrogen sulfide threshold at 0.001 mg/m^3 (1 µg/m^3) [4]. This threshold is referred to by the USEPA as the Reference Concentration (RfC). This RfC is an estimate of a daily inhalation exposure of the human population (including sensitive sub-groups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

The World Health Organization (WHO) recommends that, in order to avoid substantial complaints about odor annoyance among the exposed population, hydrogen sulfide concentrations should not be allowed to exceed 0.007 mg/m^3 (7 µg/m^3 equivalent to about 0.005 ppm) with a 30-minute averaging time [4].

Upon examining the available air quality criteria from various international agencies, the adverse effects of ammonia on the upper respiratory system are the relevant end-point for establishing exposure limits. The USEPA sets the threshold for ammonia at 0.10 mg/m^3 (100 μg/m^3 equivalent to about 0.14 ppm) [5]. No threshold value is given by the WHO [5].

The USEPA threshold concentration for H_2S is considered very stringent when compared to the threshold set by the WHO.

Based on the above, the following threshold concentrations are adopted:

Table 9: Adopted Threshold Concentrations

Odorous Compound	**Threshold Concentration (μg/m^3)**	**Threshold Concentration (ppm)**
Ammonia - NH_3	100	0.14
Hydrogen Sulfide - H_2S	7	0.005

1.7 ODORS DISPERSION

To assess quantitatively the odors emissions, the Gaussian air dispersion model is adopted. The model permits the calculation of the concentration of an odorous compound at any distance from the emission source knowing the emission rate at the source.

1.7.1 Odors Dispersion Model

Considering the maximum downwind concentrations at ground level along the plume centerline, the applicable Gaussian air dispersion model is as follows [2]:

$$C_x = \frac{Q}{\pi \sigma_y \sigma_z u} \exp(-0.5(H/\sigma_z)^2)$$

Where,

C_x: concentration at distance x downwind (mg/m^3);
π: constant (3.1416);
Q: odor emission flow rate (mg/s);
σ_y: horizontal dispersion coefficient (m);
σ_z: vertical dispersion coefficient (m);
u: wind speed (m/s); and
H: plume height (m).

The plume height (H) is the sum of the vent stack height (h) and the plume rise (Δh). The plume rise (Δh) is calculated using the Carson-Moses model as follows:

$$\Delta_h = 0.35 \frac{V_{stack} D_{stack}}{u}$$

Where,

V_{stack}: stack exit velocity (m/s);
D_{stack}: stack diameter (m); and
u: wind speed (m/s).

For the prevailing meteorological and Daoura PTP site conditions, the horizontal and vertical dispersion coefficients are calculated from the following mathematical models [3]:

$$\sigma_y = a x^{0.894}$$

$$\sigma_z = c x^d + f$$

Where,

x: downwind distance (km);

The values of the coefficients a, c, d and f depend on the stability class and the downstream distance and are as follows.

Table 10: Dispersion Coefficients versus Stability Class

Stability Class	a	c	d	f
Distance < 1000 m				
A	213	440.8	1.941	9.27
B	156	106.6	1.149	3.3
C	104	61	0.911	0
D	68	33.2	0.725	-1.7
E	50.5	22.8	0.678	-1.3
F	34	14.35	0.740	-0.35
Distance ≥ 1000 m				
A	213	459.7	2.094	-9.6
B	156	108.2	1.098	-2
C	104	61	0.911	0
D	68	44.5	0.516	-13
E	50.5	55.4	0.305	-34
F	34	62.6	0.18	-48.6

1.7.2 Odor Control Unit Emissions Concentrations

The inlet and outlet concentrations as well as the downwind concentrations for the OCU are given hereafter.

1.7.2.1 H_2S Emissions from the OCU Outlet Stack

For the OCU, the expected inlet H_2S concentration was indicated previously as:

H_2S concentration to inlet of the OCU = 50 ppm.

For a guaranteed outlet H_2S concentration of 0.5 ppm from the discharge stack of the OCU, the required removal efficiency would be:

H_2S Removal Efficiency = (50-0.5)/50 = 99 %.

A high removal efficiency of 99% would be expected when the OCU is operating under optimum conditions.

For a close to optimum performance of the OCU with the removal efficiency being 98.5%, the outlet H_2S concentrations from the OCU stack could be 0.75 ppm.

For an average performance of the OCU with the removal efficiency being 98%, the outlet H_2S concentrations from the OCU stack could be 1.0 ppm.

In consideration to the above-mentioned conditions, we have contemplated to study three scenarios for the modelling of H_2S emissions from the outlet stack of the OCU defined as follows:

Scenario 1

In this scenario, optimum working conditions are assumed with an emitted mean H_2S concentration of 0.5 ppm.

Scenario 2

In this scenario, close to optimum working conditions are assumed with an emitted mean H_2S concentration of 0.75 ppm.

Scenario 3

In this scenario, average working conditions are assumed. In Scenario 3, taking into account the above mentioned conditions, we would assume an emitted H_2S concentration of 1.0 ppm to represent the mean under variable flow, temperature and removal efficiency conditions. This corresponds to a removal efficiency of: 98 %.

1.7.2.2 NH_3 Emissions from the OCU Outlet Stack

The expected inlet NH_3 concentration to the OCU was indicated previously as:

NH_3 concentration to inlet of the OCU = 0.025 ppm.

A comparison between the inlet NH_3 concentration (0.025 ppm) to the OCU and the adopted NH_3 threshold of 0.14 ppm, reveals that there would be no odor impacts related to ammonia emissions from the outlet stack of the OCU since the threshold is not exceeded at the inlet to the stack.

1.7.2.3 Meteorological Conditions

The main meteorological parameters required for odor dispersion modelling pertain to wind speed and direction. Normally, we use hourly data for several years of recordings. As a minimum a one year set of data consisting of hourly readings would be necessary. We have tried to obtain such data from relevant authorities in Lebanon but our efforts were not fruitful. The only data that was made available to us consisted of recorded monthly wind maximum speed, wind direction at the maximum speed, and some average wind speed recordings. The data was recorded by the meteorological station at the Beirut airport and the Beirut Golf Club.

As the summer season is the most critical with respect to odors emissions, we have looked at the data for the months of June, July, August and September. The wind data are given in Table 11 to Table 14. The tables include all the years for which wind data was recorded. For years not mentioned in the tables, no wind data was recorded. For the years 2013 until 2017, the average wind speed was not given in the original data. We have calculated the mean value of the ratio Maximum Wind Speed to Average Wind Speed for the years 2003 until 2012. We have adopted this mean ratio to calculate the average wind speed for the years 2013 until 2017 and such values are shown in italics.

The emitted odorous concentrations are at their maximum when the wind speed is lowest. At higher wind speeds, the concentrations get more diluted resulting in lesser odor impacts. Therefore, the minimum and average wind speeds are more of interest than the maximum wind speed.

The wind direction was recorded for the maximum wind speed. It is likely that a similar wind direction would be applicable for the average wind speed.

For the whole period of years, the average wind speed ranges from 1.69 m/s to 4.0 m/s. The mean value for the average wind speed ranges from 2.66 m/s to 2.93 m/s.

For the whole period of years, the wind direction ranges from 180 degrees to 330 degrees. The mean value for the average wind direction ranges from 223 degrees to 239 degrees.

The United Nations Development Programme (UNDP) sponsored the study “The National Wind Atlas of Lebanon” that was published in January 2011. Data retrieved from that study related to the average wind speed at Beirut Golf Club (closest to the Daoura plant site) is given in Table 15 and shown graphically in Figure 4. The indicated average values are calculated from a series of data covering a period of 11 years.

The average wind speeds, for the summer season, as given in the UNDP study are in agreement with the Beirut Airport data given in Tables 11 to 14.

Table 11: Wind Speed and Direction – June

Year	Maximum Wind Speed (m/s)	Average Wind Speed (m/s)	Wind Direction at Max. Speed (degrees)
2003	11.00	3.00	220
2004	12.50	3.00	220
2005	14.50	3.00	210
2008	13.00	3.33	220
2009	12.00	2.69	210
2010	12.50	3.40	210
2011	12.80	3.10	230
2012	10.60	2.80	230
2013	13.40	*3.28*	220
2014	15.20	*3.73*	240
2015	12.80	*3.14*	240
2016	7.90	*1.94*	231
2017	6.90	*1.69*	218
Average	**11.93**	**2.93**	**223**

Table 12: Wind Speed and Direction – July

Year	Maximum Wind Speed (m/s)	Average Wind Speed (m/s)	Wind Direction at Max. Speed (degrees)
2003	12.50	4.00	220
2004	10.50	3.00	220
2005	11.00	3.00	220
2008	10.00	2.73	320
2009	13.00	3.33	180
2010	12.00	2.90	220
2011	12.40	2.90	320
2012	12.00	2.80	240
2013	12.00	*3.14*	240
2014	13.30	*3.48*	240
2015	9.30	*2.43*	220
2016	7.90	*2.07*	242
2017	7.00	*1.83*	220
Average	**10.99**	**2.89**	**239**

Table 13: Wind Speed and Direction – August

Year	Maximum Wind Speed (m/s)	Average Wind Speed (m/s)	Wind Direction at Max. Speed (degrees)
2003	11.00	3.00	230
2004	13.50	3.00	220
2005	12.00	3.00	260
2008	11.00	3.21	220
2009	9.00	2.56	220
2010	11.00	2.80	220
2011	12.40	2.90	210
2012	10.00	2.70	240
2013	10.50	*2.71*	250
2014	13.50	*3.48*	220
2015	9.40	*2.42*	220
2016	7.20	*1.86*	250
2017	7.60	*1.96*	195
Average	**10.62**	**2.74**	**227**

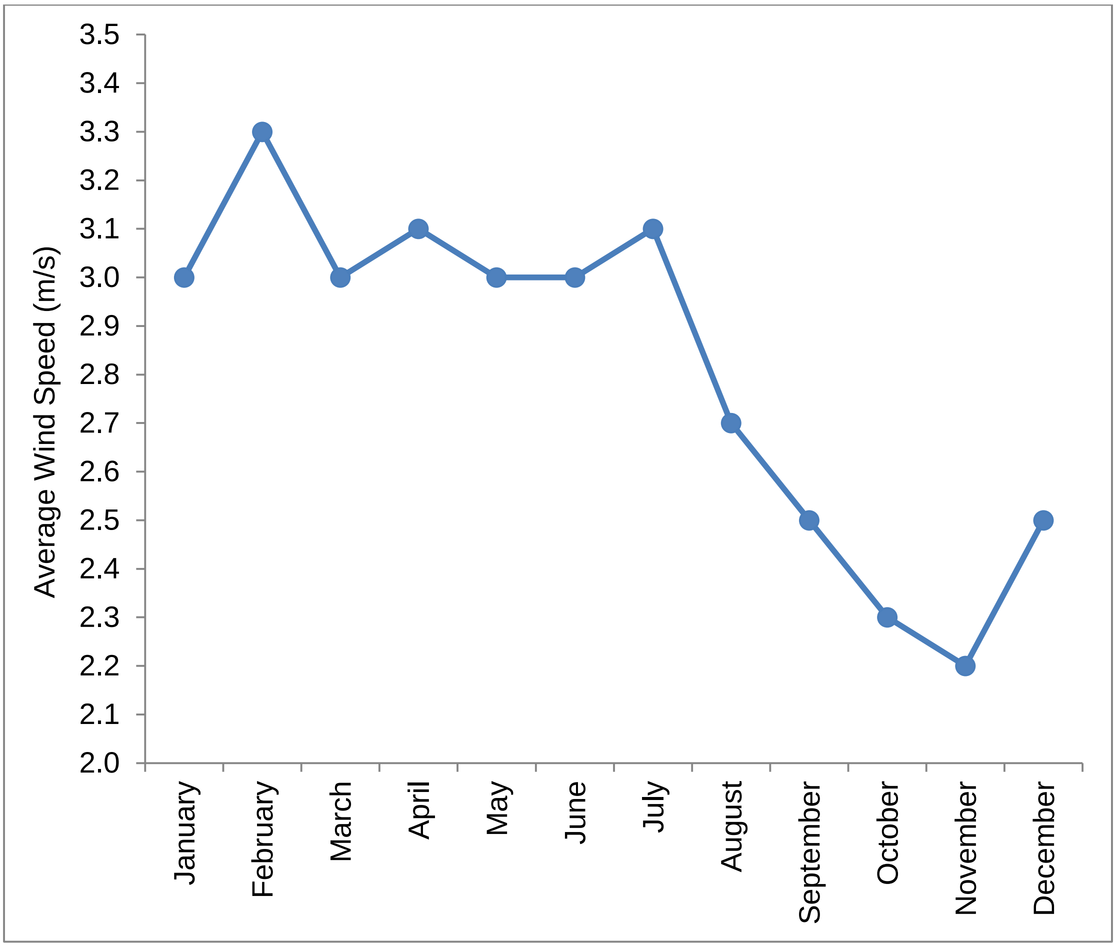
Table 14: Wind Speed and Direction – September

Year	Maximum Wind Speed (m/s)	Average Wind Speed (m/s)	Wind Direction at Max. Speed (degrees)
2003	11.50	3.00	330
2004	13.00	3.00	230
2005	12.00	3.00	220
2008	13.00	3.50	200
2009	18.00	2.83	180
2010	12.00	2.60	180
2011	13.30	2.40	240
2012	8.60	2.30	250
2013	12.20	*2.70*	260
2014	13.90	*3.08*	260
2015	12.10	*2.68*	240
2016	7.30	*1.62*	240
2017	8.60	*1.90*	184
Average	**11.96**	**2.66**	**232**

Table 15: Monthly Average Wind Speed – Beirut Golf Club

Month	Average Wind Speed (m/s)
January	3.0
February	3.3
March	3.0
April	3.1
May	3.0
June	3.0
July	3.1
August	2.7
September	2.5
October	2.3
November	2.2
December	2.5
Average	**2.8**

Figure 4: Monthly Average Wind Speed – Beirut Golf Club



Based on the extended time series data, the UNDP also published wind roses for several locations in Lebanon including Daoura. The UNDP wind rose for the Daoura site is given as Figure 5.

The UNDP wind rose shows prevailing winds from the South-West. In addition, the UNDP wind rose also shows potential winds coming from the North-East and the North-West. The winds that come from the South-East and South-West would cause the odors, emitted from the Daoura plant, to disperse above the sea. In this case, the emitted odors would not have impacts on the inhabited lands located to the south of the plant site.

For modelling odors emissions from the Daoura PTP, we are considering that the whole southern sector extending from East to West could be affected by the emissions when winds come from the North-East and the North-West.

Figure 6 is a schematic representation for the zone of interest. The center of the semi-circle is located at the emission source in the Daoura PTP. The zone of interest covers the two quadrants South-East and South-West. The northern quadrants North-East and North-West extend into the sea. Emissions along the northern quadrants would not have impacts on the inhabitants.

To account for variable wind speeds, we would study the odors emissions at variable wind speeds as presented in the next section. It can be stated that a representative average wind speed is about 3 m/s. Lower speeds would be considered for analysis and those speeds would denote minimum wind conditions.

The odor emission calculations would be performed over a 24 hour period including day time and night time.

Figure 5: Wind Rose for Daoura – UNDP

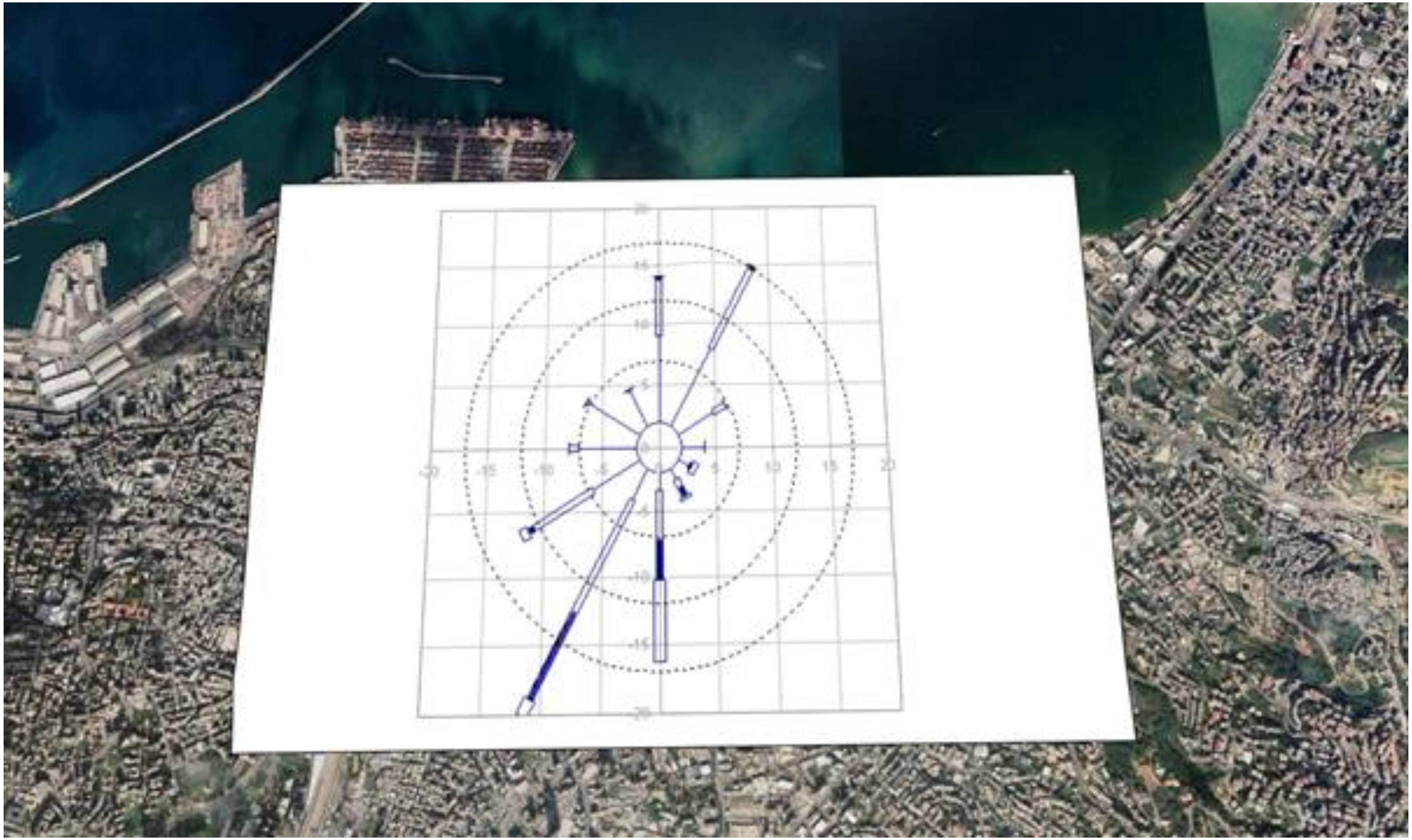


Figure 6: Zone of Interest

1.7.2.4 Basic Data for the OCU

For the modelling of odor emissions from the OCU, the following basic data are considered:

- An odor control system, OCU, is installed to treat the air from the headworks including the aerated grit chambers

- The outlet stack for the OCU has a diameter of 1700 mm

- The outlet stack for the OCU is located 6 meters above ground level

- The emitted hydrogen sulfide gas concentrations from the OCU outlet stack are

  Scenario 1: H_2S = 0.5 ppm
  Scenario 2: H_2S = 0.75 ppm
  Scenario 3: H_2S = 1.0 ppm

- Wind speed is considered low to average subject to a sensitivity analysis with the following wind speeds considered:

  Minimum Wind Speed = 2.0 m/s
  Moderate Wind Speed = 2.5 m/s
  Average Wind Speed = 3.0 m/s

- The dispersion calculations would be performed for the following scenarios:

  Scenario 1a: H_2S = 0.5 ppm, Wind Speed = 2.0 m/s
  Scenario 1b: H_2S = 0.5 ppm, Wind Speed = 2.5 m/s
  Scenario 1c: H_2S = 0.5 ppm, Wind Speed = 3.0 m/s

  Scenario 2a: H_2S = 0.75 ppm, Wind Speed = 2.0 m/s
  Scenario 2b: H_2S = 0.75 ppm, Wind Speed = 2.5 m/s
  Scenario 2c: H_2S = 0.75 ppm, Wind Speed = 3.0 m/s

  Scenario 3a: H_2S = 1.0 ppm, Wind Speed = 2.0 m/s
  Scenario 3b: H_2S = 1.0 ppm, Wind Speed = 2.5 m/s
  Scenario 3c: H_2S = 1.0 ppm, Wind Speed = 3.0 m/s

1.7.3 Downwind H_2S Concentrations from the Odor Control Unit

The downwind H_2S concentrations are calculated considering the defined inlet and outlet H_2S concentrations, the air extraction rate, the adopted dispersion model and the wind speed.

It is considered that the mean defined outlet concentration is occurring at every hour over a 24 hour period. As such, the dispersion calculations are considered to be within the 30-minute averages.

The resulting H_2S concentration isopleths for each scenario are given on the following figures.

Figure 7: H_2S Concentration Isopleths (μg/m³) – Scenario 1a – [H_2S 0.5 ppm, WS 2.0 m/s]

Figure 8: H_2S Concentration Isopleths (μg/m^3) – Scenario 1b – [H_2S 0.5 ppm, WS 2.5 m/s]

Figure 9: H_2S Concentration Isopleths (μg/m^3) – Scenario 1c – [H_2S 0.5 ppm, WS 3.0 m/s]

Figure 10: H_2S Concentration Isopleths (μg/m^3) – Scenario 2a – [H_2S 0.75 ppm, WS 2.0 m/s]

Figure 11: H_2S Concentration Isopleths (µg/m^3) – Scenario 2b – [H_2S 0.75 ppm, WS 2.5 m/s]

Figure 12: H_2S Concentration Isopleths (μg/m^3) – Scenario 2c – [H_2S 0.75 ppm, WS 3.0 m/s]

Figure 13: H_2S Concentration Isopleths (μg/m^3) – Scenario 3a – [H_2S 1.0 ppm, WS 2.0 m/s]

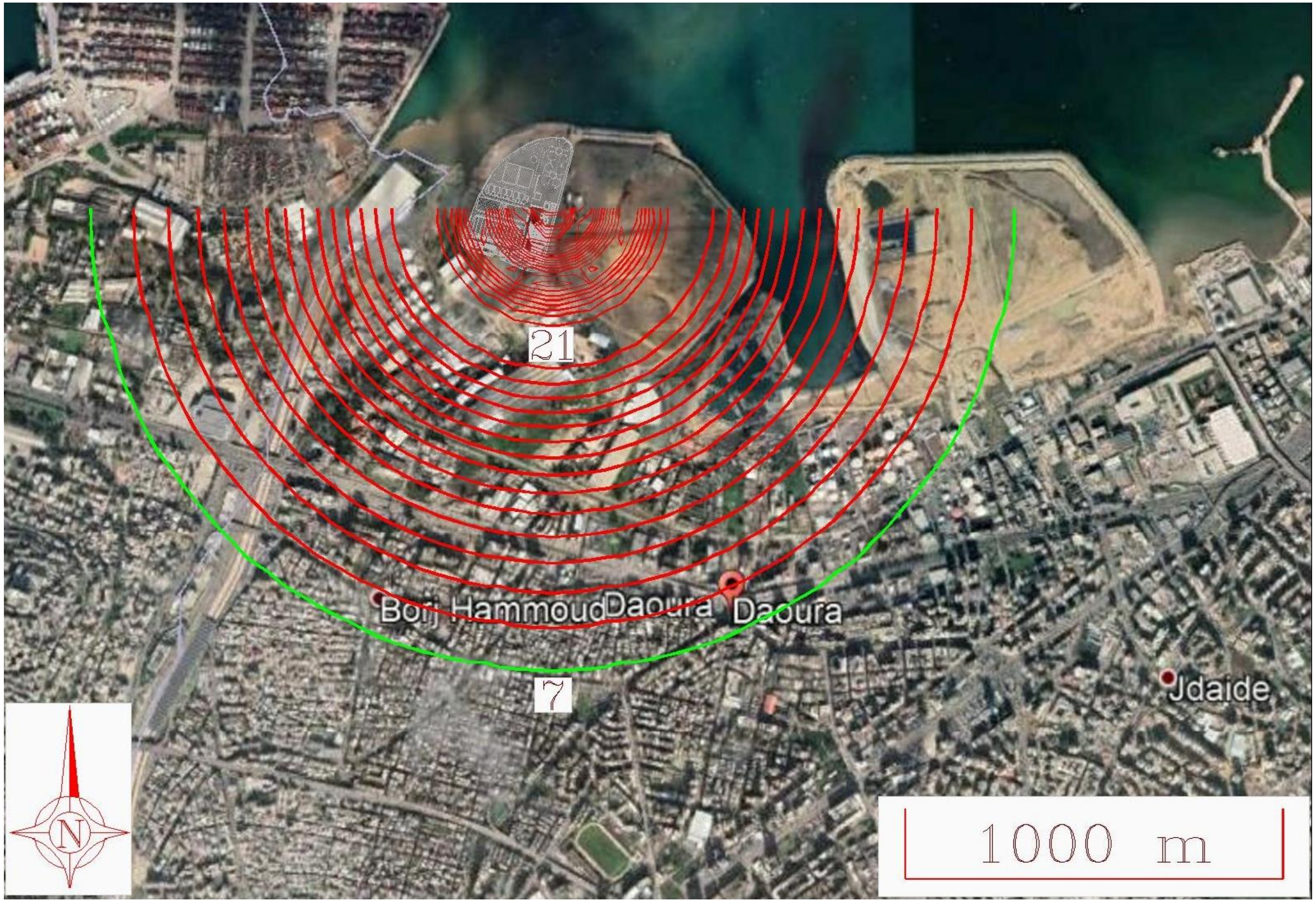


Figure 14: H_2S Concentration Isopleths (μg/m^3) – Scenario 3b – [H_2S 1.0 ppm, WS 2.5 m/s]

Figure 15: H_2S Concentration Isopleths (μg/m³) – Scenario 3c – [H_2S 1.0 ppm, WS 3.0 m/s]

1.7.4 Interpretation of Modelling Results

The H_2S concentration isopleths are developed over a 24 hour period which combines day time concentrations and night time concentrations. The maximum concentrations occur during the night. During the day, the solar radiation decreases the emitted concentrations. If we were to plot only the day time concentrations, the odor emissions impacts would appear lesser. However, we are considering that the night time is as important as the day time with respect to the potential impacts on the inhabitants. The inhabitants should not be negatively impacted from odor emissions at any time of the day.

The calculations show that, over a 24 hour period, the threshold H_2S concentration of 7 $\mu g/m^3$ would not be exceeded at the distances indicated in Table 16.

Table 16: Distance to Threshold H_2S Concentration

Scenario	Distance from OCU (m)	Distance from Daoura PTP southern boundaries (m)
Scenario 1a	710	510
Scenario 1b	610	410
Scenario 1c	530	330
Scenario 2a	990	790
Scenario 2b	860	660
Scenario 2c	760	560
Scenario 3a	1,230	1,030
Scenario 3b	1,060	860
Scenario 3c	950	750

The northern limits of the inhabited areas, to the south of the Daoura PTP, are located at a distance of about 925 meters from the OCU. The zone extending from 700 meters to 925 meters from the OCU, includes the Daoura highway and mixed developments of commercial and industrial facilities. Industrial facilities are located within a zone that extends from the OCU to a distance of 700 meters to the south.

Based on the results given above, under favorable operating conditions (case of Scenario 1c), the H_2S emissions would stay below the threshold of 7 $\mu g/m^3$ at a distance of 530 meters from the OCU. At minimum wind speed of 2.0 m/s, the threshold is not exceeded at a distance of 710 meters from the OCU. The H_2S threshold would be exceeded inside the industrial zone under minimum wind speed conditions. The inhabited zone, located at 925 meters from the OCU, would not be negatively impacted by the odor emissions.

Under less favorable operating conditions, but still close to optimum (case of Scenario 2c), the H_2S emissions would stay below the threshold of 7 $\mu g/m^3$ at a distance of 760 meters from the OCU. At minimum wind speed of 2.0 m/s, the threshold is not exceeded at a distance of 990 meters from the OCU. The H_2S threshold would be exceeded inside the industrial zone, the mixed development zone, the Daoura highway and a small portion of the inhabited zone under minimum wind speed conditions. The inhabited zone, located at 925 meters from the

OCU, would not be negatively impacted by the odor emissions under average wind speed conditions ranging from 2.5 m/s to 3.0 m/s.

Under average operating conditions (case of Scenario 3c), the H_2S emissions would stay below the threshold of 7 µg/m^3 at a distance of 950 meters from the OCU. At minimum wind speed of 2.0 m/s, the threshold is not exceeded at a distance of 1,230 meters from the OCU. The H_2S threshold would be exceeded inside the industrial zone, the mixed development zone, the Daoura highway and an appreciable portion of the inhabited zone under minimum wind speed conditions. The inhabited zone, located at 925 meters from the OCU, would be slightly negatively impacted by the odor emissions under average wind speed of 3.0 m/s.

In all the studied scenarios, the H_2S emissions threshold of 7 µg/m^3 would be exceeded inside the boundaries of the Daoura PTP. This would negatively impact the operators and workers of the plant.

1.8 CONCLUSION AND RECOMMENDATIONS

The odors impacts assessment carried out for the Daoura PTP revealed the following:

Ammonia Emissions

The threshold concentration for ammonia gas would not be exceeded at the outlet stack of the odor control unit.

No odor impacts are foreseen related to ammonia gas emissions.

Hydrogen Sulfide Emissions

The hydrogen sulfide emissions were assessed subject to stringent parameters including high summer temperature, low wind speeds and highest hydrogen gas emitted concentrations.

Under favorable operating conditions, the emitted odors would not have negative impacts on the inhabited areas south of the Daoura PTP.

Under average operating conditions, the emitted odors would have negative impacts on the inhabited areas south of the Daoura PTP and the people travelling along the Daoura highway. The impacts would extend up to a distance of about 1,000 meters from the Daoura PTP southern boundaries.

The operating staff of the Daoura PTP, would be exposed to hydrogen sulfide concentrations exceeding the threshold of 7 µg/m^3. A maximum concentration of about 40 µg/m^3 (equivalent to about 0.03 ppm) could be emitted around the location of the odor control building under unfavorable operating conditions.

Based on the summer wind data given in Tables 11 to 14, the prevailing wind rose during the summer season is shown as Figure 16. The sector that would receive the emissions, most of the time, remains the one facing the prevailing wind directions that range from 220 degrees to 240 degrees. Figure 17 shows the most potential zone that would be affected by odor emissions during the summer period. For generating Figure 17, we have considered incoming winds from directions of 200 degrees to 260 degrees and favorable operating conditions with emitted H_2S of 0.5 ppm and the most typical low wind speed of 2.5 m/s (Scenario 1b).

Figure 16: Wind Rose – Summer Season

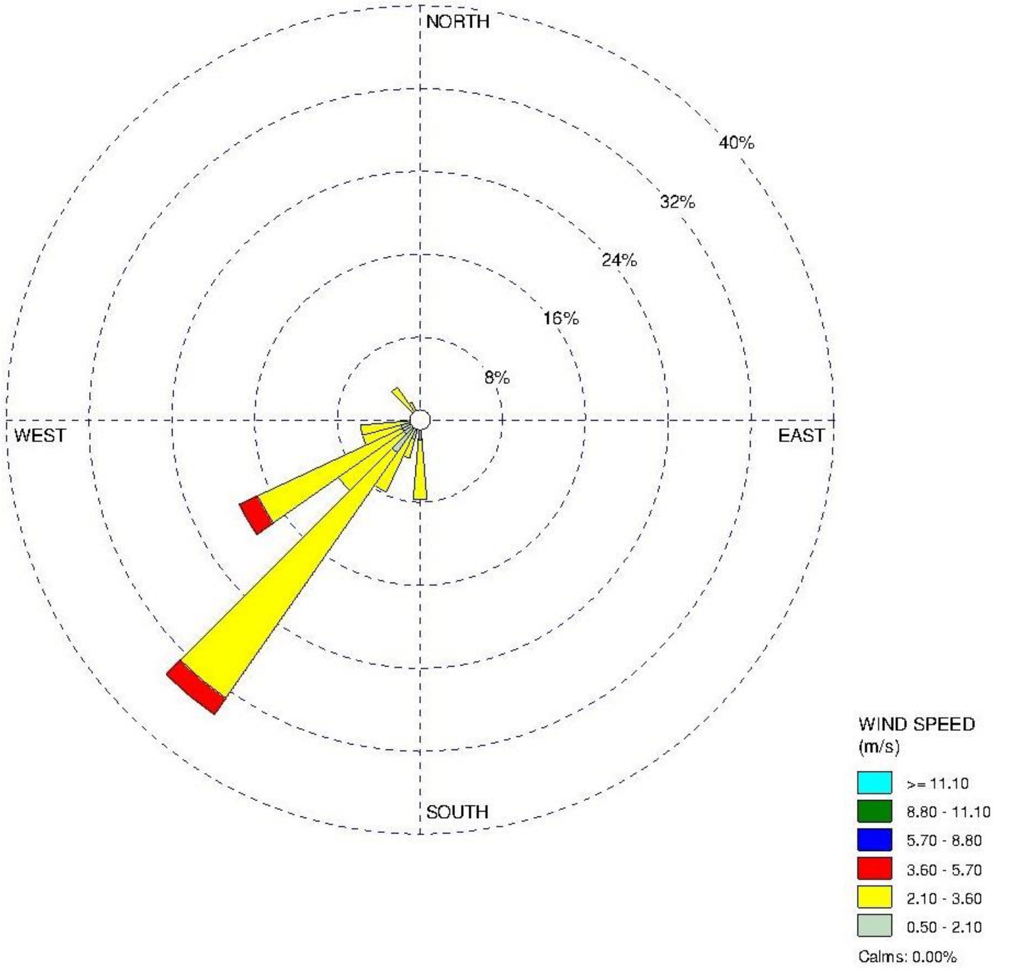


Figure 17: H_2S Concentration Isopleths ($\mu g/m^3$) – Scenario 1b – [H_2S 0.5 ppm, WS 2.5 m/s] – Prevailing Wind Direction

We have assessed that odor emissions from the Daoura PTP could be of serious importance due to potential negative impacts under less favorable, or even average operating conditions, and subject to winds incoming from the northern sectors.

In that respect, we recommend the adoption of a multi-barrier approach for odor control. Adopting a multi-barrier approach would require implementing measures for odor control that would result in the emission of the least amount of hydrogen sulfide mass flux from the outlet stack.

With reference to what we have discussed in the previous section regarding day time and night time concentrations, we are including Figure 18 that was generated for the day time extending from 6 am until 19 pm. This figure is included to give an idea about odor emissions during the day time which are expected to be of lesser impact than those during the night hours. For generating Figure 18, we have considered less favorable operating conditions with emitted H_2S of 0.75 ppm and the lowest wind speed of 2.0 m/s (Scenario 2a).

During the day hours, the H_2S emissions would stay below the threshold of 7 $\mu g/m^3$ at a distance of 250 meters from the OCU. The H_2S concentrations, over a 24 hour period of analysis, for the same scenario was previously given in Figure 10. A comparison shows that during the night, the threshold of 7 $\mu g/m^3$ is exceeded up to a distance of 990 meters from the OCU whereas during the day, the threshold would not be exceeded after a distance of 250 meters from the OCU.

While we have concluded that it is important to foresee measures to minimize odors emissions, it must be reckoned that during the day time hours, the odors emissions cause lesser impacts than during the night hours.

In case proper measures are implemented to minimize odor emissions, following the recommendations given below, it could be possible to release from the odor control unit outlet stack a hydrogen sulfide concentration of 0.25 ppm. Such an outlet concentration could correspond to reducing the dynamic hydrogen sulfide concentration to 25 ppm through various measures that involve reducing the ambient static hydrogen sulfide concentration. In addition, the OCU removal efficiency would have to be 99%. For the conditions of having the removal efficiency at 99% and the dynamic hydrogen sulfide concentration at 25 ppm, the outlet hydrogen sulfide concentration would be 0.25 ppm. It would not be an easy target to achieve all the time. Nevertheless, with this target met, the calculations reveal that the hydrogen sulfide threshold of 7 $\mu g/m^3$ would not be exceeded at 40 meters from the outlet stack. Therefore, at an emitted hydrogen sulfide concentration of 0.25 ppm, there would be no adverse impacts from odor emissions.

For minimizing odors emissions, the following measures are recommended:

- With reference to the report "Pretreatment Headworks at Daoura WWTP – Final Design Report – February 2019" prepared by the Consultant ACE for the CDR, the cover page of this report shows a 3D view of the proposed Daoura wastewater treatment plant. Looking at the 3D view, we notice the complete absence of trees along the boundaries of the plant. We recommend planting trees along the boundaries of the proposed plant with a maximum spacing of 3 meters. Besides the positive visual impacts, the trees would help absorb odors emissions and would act as a natural barrier for odors emissions containment.

Figure 18: H_2S Concentration Isopleths (μg/m^3) – Scenario 2a – [H_2S 0.75 ppm, WS 2.0 m/s] – Day Time Hours

- The release of hydrogen sulfide gas from the liquid wastewater can be minimized by increasing the pH of the wastewater. The chemical equilibrium between the hydrogen sulfide gas and dissolved sulfides versus pH was previously given in Figure 1. This EIA strongly recommends the provision of a chemical dosing station to increase the pH of the influent wastewater to the Daoura PTP. This would result in an increase of the wastewater pH which in turn would lower the hydrogen sulfide gas emissions. Accordingly, the ambient static hydrogen sulfide gas concentration would be reduced. Chemicals used for this purpose include lime [$Ca(OH)_2$], caustic soda (NaOH) or magnesium hydroxide. The handling and preparation of either lime or caustic soda would be easier than magnesium hydroxide.

- The odor emissions from the aerated grit chambers must be captured and treated. This would require covering the tanks or providing a building enclosure around the tanks. The OCU capacity must be adequate to accommodate the air flow from the aerated grit chambers.

- The OCU capacity of 90,000 Nm^3/h should not be increased further because an additional increase would result in higher emitted hydrogen sulfide mass flux.

- The OCU stack must be at least 6 meters high from the ground level. Additional height is recommended, if possible, subject to applicable building codes and structural stability considerations.

- The tender documents for the Daoura PTP should specify the required outlet H_2S concentration from the OCU without necessarily indicating the required removal efficiency. In addition, the tender documents must specify that the ambient static hydrogen sulfide concentration would be on average 500 ppm.

- This EIA recommends that information about exposure to hydrogen sulfide be provided for the operating staff of the Daoura PTP. The workers doing regular cleaning, maintenance and operational tasks near the plant works should always wear at least disposable protective masks.

- A notice is required to warn the wearing of masks for operators, workers and/or visitors who intend to be near the plant works for prolonged periods of time.

- This EIA recommends the continuous monitoring on a daily basis of hydrogen sulfide emissions at the emission sources and within the plant boundaries. Measured values are to be compared to the threshold concentrations. Corrective measures and action would be required in case the measured values exceed the threshold concentrations.

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APPENDIX I: GRIEVANCE REDRESS MECHANISM

PRETREATMENT HEADWORKS AT DAOURA-BURJ HAMMOUD WASTEWATER TREATMENT PLANT GRIEVANCE REDRESS MECHANISM

The Council for Development and Reconstruction (CDR) has developed a grievance mechanism, which aims to receive and resolve concerns and grievances among affected communities in relation to the Daoura-Burj Hammoud waste water treatment plant (WWTP). The grievance mechanism seeks to resolve concerns promptly, using an accessible and transparent consultative process. The purpose of this leaflet is to describe how you are able to make a grievance, how we record the information about the grievance, our investigation procedure, and how you will hear back from us with a proposed response and resolution.

Any person, group or other type of stakeholder affected by the project can contact us and raise a grievance. However, the grievance must be related to any activity associated with the Burj Hammoud headworks.

During the construction phase, you can submit an oral or written grievance note to the concerned municipalities (i.e. The Municipality of Burj-Hammoud can be reached out at the following contact number: 01/260155 and on the following email address : info@bourjhammoud.com) which can facilitate the grievance between the complainant and the CDR, the Project Management Unit at the CDR is the division to which grievance notes are received, recorded, and processed. The Project Management Unit at CDR can be reached on the land line phone number +961-1-980096 or by email on infocenter@cdr.gov.lb.

If the complaint is not resolved, contact the concerned governmental institutions depending on the aspects of the complaint e.g. contact the ministry of environment for a grievance relating to an environmental issue (contact details : +961-1-976532 or +961-1-976555 Ext. 515 ; webmaster@moe.gov.lb).

During the operation phase, you can also submit an oral or written grievance note to the concerned municipality which can facilitate the grievance between the complainant and the CDR (within a period of 5 years from project implementation)or the BMLWE (future operator of the WWTP), the Project Management Unit at the CDR and BMLWE is the division to which grievance notes are received, recorded, and processed. Similarly, the Project Management Unit at BMLWE can be reached on the land line phone number +961-1-386760 or by email on info@ebml.gov.lb.

Similarly if the complaint is not resolved, contact the concerned governmental institutions depending on the aspects of the complaint e.g. contact the ministry of environment for a grievance relating to an environmental issue.

Grievances can be submitted through the website, email, or in person. Any written and/or verbal complaint will be recorded by the contacted person, and potentially other representatives. The following information shall be requested from you:

- Your name, community's name or occupation, and your preferred contact details (landline phone number, mobile number, email) (optional);
- The date, time, place where the complaint was received and means of submission (i.e. paper grievance form, website grievance form, verbally, phone, etc); and
- Description of complaint which may include any third parties (such as a construction contractor);

The information you provide will be recorded in a grievance log. However, you are not obliged to provide your name and can place your complaint anonymously if you do not wish to disclose your identity.

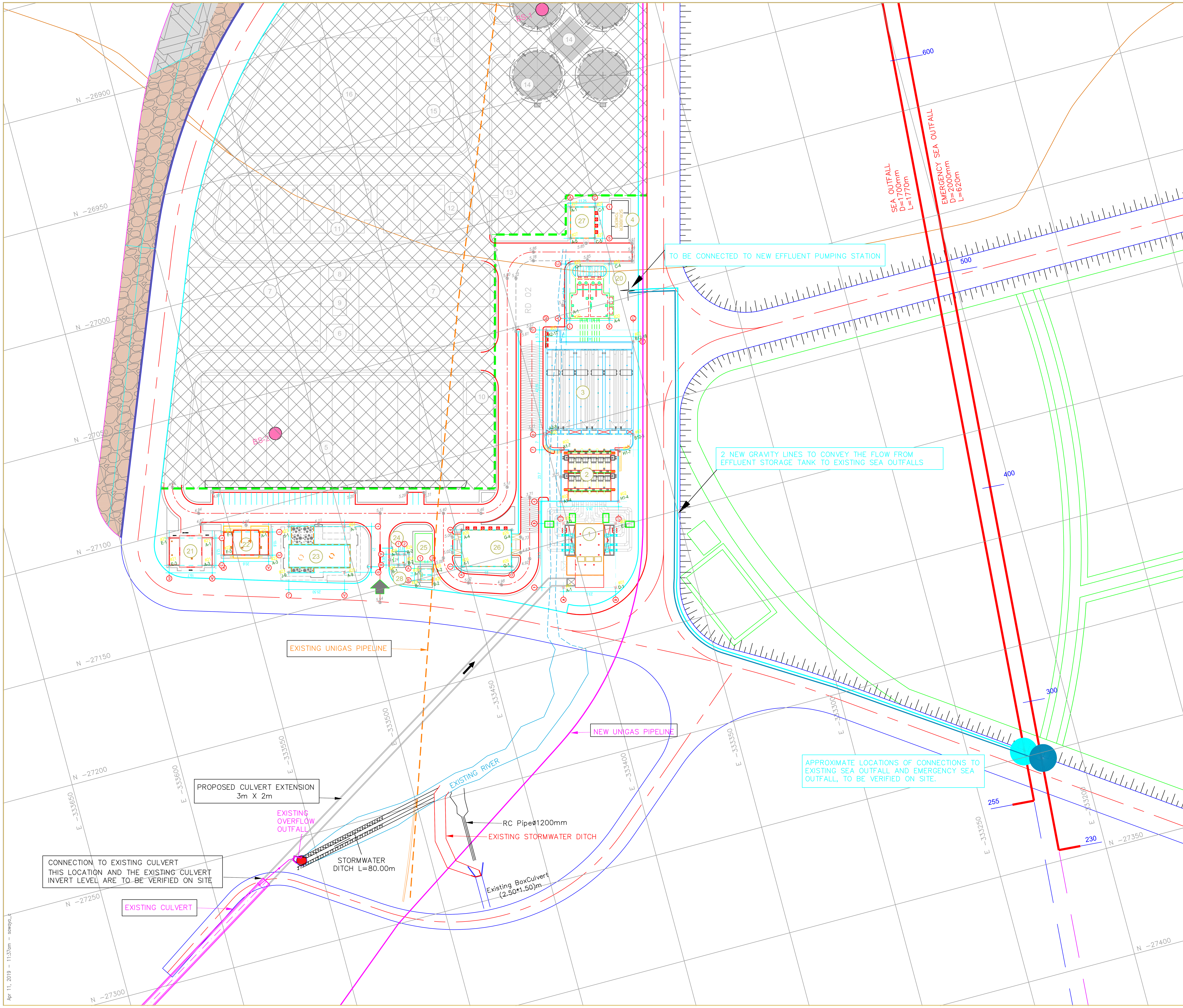
After you have submitted a complaint, you may be contacted for more details about the grievance. When your grievance has been placed and details about your complaint have been recorded, discussions and investigations about your grievance might take place with other Projects personnel and other parties, as applicable. During this process, the significance of the grievance will be assessed and investigated. And updates about the grievance will be provided to you during the investigation.

A response to the grievance shall be developed within 15 working days after receiving the complaint and it should be in the form of writing. You will be notified about the proposed action taken to resolve the grievance and provide any clarifications required.

If you are not satisfied with the final response or if you feel that further action is needed or if you believe that the problem has not been resolved by the response, the grievance will re-assessed, or you can submit a grievance complaint to the concerned governmental institutions depending on the aspects of the complaint.

APPENDIX J: PROJECT MAPS

Appendix J1: Daoura-Burj Hammoud WWTP Layout



NOTES:

1. ALL DIMENSIONS ARE IN METERS.
2. ALL LEVELS ARE IN METERS.
3. ALL AREAS ARE NET AREAS.

LEGEND:

1. INLET PUMPING STATION
2. SCREENING
3. GRIT AND GREASE REMOVAL
4. ODOR CONTROL SCRUBBERS
5. PRIMARY SEDIMENTATION TANKS
6. FLOW DISTRIBUTION CHAMBER
7. MBBR REACTORS
8. FLOW DISTRIBUTION CHAMBER
9. WASTE SLUDGE PUMPING STATION
10. BLOWER STATION
11. DENSE SLUDGE CLARIFIERS
12. CHEMICAL BUILDING
13. SLUDGE THICKENING BUILDING
14. DIGESTERS & DIGESTER SERVICE BUILDING
15. SLUDGE DEWATERING BUILDING
16. DRYER
17. GAS HOLDERS
18. BIOGAS COGENERATION PLANT
19. FLARES
20. EFFLUENT PUMPING STATION
21. WORKSHOP
22. LABORATORY BUILDING
23. ADMINISTRATION BUILDING
24. GUARD HOUSE
25. DIESEL TANKS
26. SUBSTATION
27. SUBSTATION
28. WATER TANK AND PUMP ROOM

SETTING OUT POINTS

Bldg. ID	Axis Intersection	Easting	Northing
#01	E-3	-333378.793	-27148.510
#01	A-3	-333401.886	-27142.359
#01	D-1	-333386.333	-27176.823
#01	A-1	-333409.428	-27170.671
#02	H1-7	-333368.862	-27116.280
#02	A1-7	-333394.470	-27109.459
#02	A1-4	-333400.569	-27132.361
#02	H1-4	-333374.962	-27139.180
#03	A2-17	-333386.875	-27054.720
#03	B12-16	-333349.587	-27070.137
#03	A2-8	-333399.190	-27100.958
#03	B12-8	-333360.538	-27111.253
#20	C-1	-333368.520	-27028.351
#20	A-1	-333374.929	-27052.413
#20	A-4	-333357.439	-27057.071
#20	C-4	-333351.030	-27033.010
#21	A-1	-333558.952	-27107.405
#21	E-1	-333577.989	-27102.335
#21	E-3	-333581.206	-27114.413
#21	A-3	-333562.170	-27119.484
#22	F-3	-333555.946	-27116.321
#22	F-1	-333553.218	-27106.078
#22	A-1	-333533.312	-27111.380
#22	A-3	-333536.040	-27121.623

SETTING OUT POINTS

Bldg. ID	Axis Intersection	Easting	Northing
#23	A-9	-333504.494	-27138.154
#23	J-9	-333529.120	-27131.595
#23	J-1	-333523.715	-27111.302
#23	A-1	-333499.089	-27117.862
#24	A-1	-333478.502	-27136.501
#24	B-2	-333477.071	-27142.005
#24	A-2	-333475.797	-27137.222
#24	B-1	-333479.776	-27141.285
#26	A-1	-333452.093	-27149.409
#26	G-1	-333429.868	-27155.329
#26	G-4	-333425.544	-27139.095
#26	A-4	-333447.769	-27133.175
#27	A-1	-333361.532	-27003.156
#27	C-5	-333354.367	-27019.967
#27	A-5	-333365.238	-27017.071
#27	C-1	-333350.661	-27006.052
#28	A-2	-333465.117	-27146.826
#28	B-2	-333466.507	-27152.044
#28	B-1	-333471.918	-27150.603
#28	A-1	-333470.529	-27145.385

REV. N°.	DATE	BY	DESCRIPTION	CH'KD	APP'D

REVISIONS

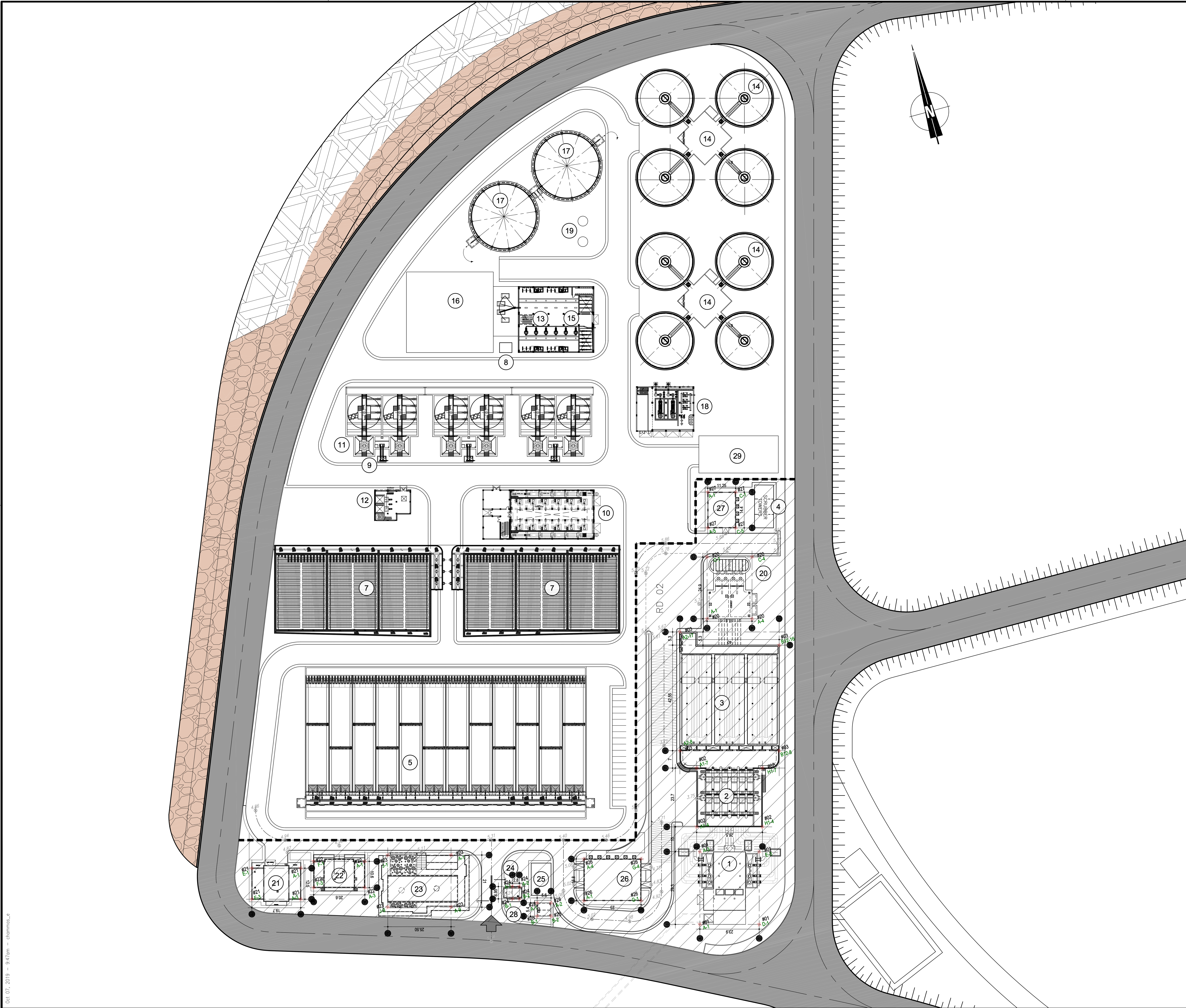
CLIENT
REPUBLIC OF LEBANON
COUNCIL FOR DEVELOPMENT AND RECONSTRUCTION

المكتب الهندسي الاستشاري - ايس ش م ل بيروت
ASSOCIATED CONSULTING ENGINEERS SAL BEIRUT

PROJECT CONCEPTUAL DESIGN FOR THE INTEGRATED WWTP (PRELIMINARY AND SECONDARY) AND UPDATE OF THE DETAILED DESIGN FOR THE PRETREATMENT HEADWORKS AT BOURJ HAMMOUD

TITLE PRETREATMENT HEADWORKS – GENERAL LAYOUT PLAN EXISTING CULVERT AND PROPOSED CULVERT EXTENSION

DESIGNED	CHECKED	PROJECT N°.	SHEET	DRAWING N°.	REV.
C.S.	E.D.	L1803	1 OF 1	NBT-PLAN-02	–
DRAWN	APPROVED	DATE	SCALE		
C.S.	N.F.	APR. 2019	1/800		



NOTES:

1. DRAWINGS ARE INDICATIVE FOR TENDER PURPOSES ONLY.
2. ALL DIMENSIONS ARE IN METERS.
3. ALL LEVELS ARE IN METERS.
4. DIMENSIONS OF CIVIL STRUCTURES SHALL BE CONFIRMED BY THE DETAILED STRUCTURAL DESIGN.
5. SIZES OF THE EQUIPMENT ARE TYPICAL; THEY SHALL BE UPDATED IN THE DETAILED DESIGN ACCORDING TO THE MANUFACTURER'S INFORMATION.
6. R.G.L.= ROUGH GRADING LEVEL. THE FINAL GROUND / ASPHALT LEVEL IS TO BE DETERMINED BY THE CONTRACTOR DURING EXECUTION OF THE PROJECT.
   WL = WATER LEVEL.
   FCL = FINISH CONC. LEVEL.
   FL = FINISH LEVEL.

LEGEND:

1. INLET PUMPING STATION
2. SCREENS BUILDING
3. GRIT AND GREASE REMOVAL TANKS
4. ODOR CONTROL SCRUBBERS
5. PRIMARY SEDIMENTATION TANKS
6. - - - - -
7. MBBR REACTORS
8. ODOR CONTROL UNIT
9. WASTE SLUDGE PUMPING STATION
10. AERATION BLOWER STATION
11. DENSE SLUDGE CLARIFIERS
12. CHEMICALS BUILDING
13. SLUDGE THICKENING AND DEWATERING BUILDING
14. DIGESTERS & DIGESTERS SERVICE BUILDING
15. - - - - -
16. SLUDGE DRYER (OPTIONAL)
17. BIOGAS STORAGE TANKS
18. BIOGAS COGENERATION PLANT
19. FLARES
20. EFFLUENT PUMPING STATION
21. WORKSHOP
22. LABORATORY BUILDING
23. ADMINISTRATION BUILDING
24. GUARD HOUSE
25. DIESEL TANKS
26. SUBSTATION
27. SUBSTATION
28. WATER TANK AND PUMP ROOM
29. CHLORINATION BUILDING (OPTIONAL)

REV. N°.	DATE	BY	DESCRIPTION	CH'KD	APP'D

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REPUBLIC OF LEBANON
COUNCIL FOR DEVELOPMENT AND RECONSTRUCTION

المكتب الهندسي الاستشاري - ايس ش م ل بيروت
ASSOCIATED CONSULTING ENGINEERS SAL BEIRUT

PROJECT TITLE

CONCEPTUAL DESIGN FOR THE INTEGRATED WWTP
(PRELIMINARY AND SECONDARY)
AND UPDATE OF THE DETAILED DESIGN FOR
THE PRETREATMENT HEADWORKS
AT BOURJ HAMMOUD

DESIGN STAGE : CONCEPTUAL DESIGN
OF THE INTEGRATED BOURJ HAMMOUD WWTP–PART B
DWG. TITLE : SITE PLAN
--

DESIGNED	CHECKED	PROJECT N°.	SHEET	DRAWING N°.	REV.
C.S.	E.D.	L1803	1 of 3	NBT-W-SP01	–
DRAWN	APPROVED	DATE	SCALE		
E.CH.	N.F.	SEPT. 2019	1/500		

Oct 07, 2019 - 9:47am - chammas_e
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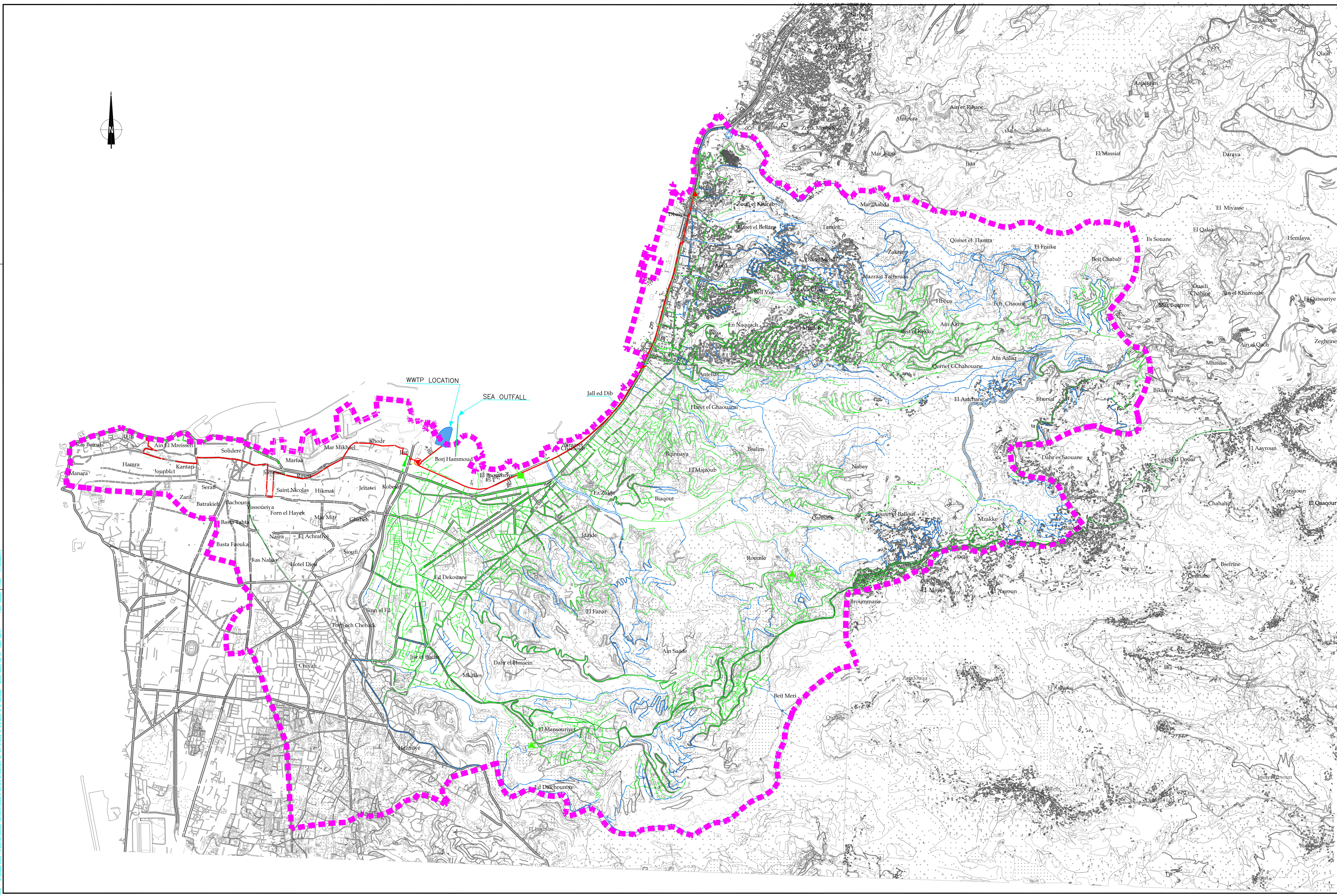
Appendix J2: Coverage Area of the Daoura-Burj Hammoud WWTP



REV. N°.	DATE	BY	DESCRIPTION	CH'KD	APP'D

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COUNCIL FOR DEVELOPMENT AND RECONSTRUCTION

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ASSOCIATED CONSULTING ENGINEERS S.A.L. BEIRUT

PROJECT
CONCEPTUAL DESIGN FOR THE INTEGRATED WWTP (PRELIMINARY AND SECONDARY) AND UPDATE OF THE DETAILED DESIGN FOR THE PRETREATMENT HEADWORKS AT BOURJ HAMMOUD

TITLE
WWTP WATERSHED AREA

DESIGNED	CHECKED	PROJECT N°.	SHEET	DRAWING N°.	REV.
E.D	E.D.	L1803		A–001	
DRAWN	**APPROVED**	**DATE**	**SCALE**		
S.A	–	OCT.2018	N.T.S.		

APPENDIX K: EDTO OUTFALLS REHABILITATION REPORT

CDR

REPUBLIC OF LEBANON
COUNCIL FOR DEVELOPMENT AND RECONSTRUCTION

European Investment Bank

ACE

Rehabilitation and Recommendation Report

September 2010

ED-263-R03-10
Revision 0A

Greater Beirut Northern Scheme
for Wastewater Collection Sewer Lines
and the Pretreatment Headworks
at Doura and Sea Outfall Rehabilitation

Inspection and Survey of Sea Outfall
Contract No. 17057

EDESSA

EDT Offshore

Rehabilitation and Recommendation Report

September 2010

ED-263-R03-10
Revision 0A

Greater Beirut Northern Scheme
for Wastewater Collection Sewer Lines
and the Pretreatment Headworks
at Daoura and Sea Outfall
Rehabilitation

Inspection and Survey of Sea Outfall
Contract No. 17057

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REHABILITATION AND RECOMMENDATION REPORT
INSPECTIOB AND SURVEY OF DAOURA SEA OUTFALL

PREPARED FOR THE CDR

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ED-263-D11: Sacrificial Anode System – Cable Connection Detail

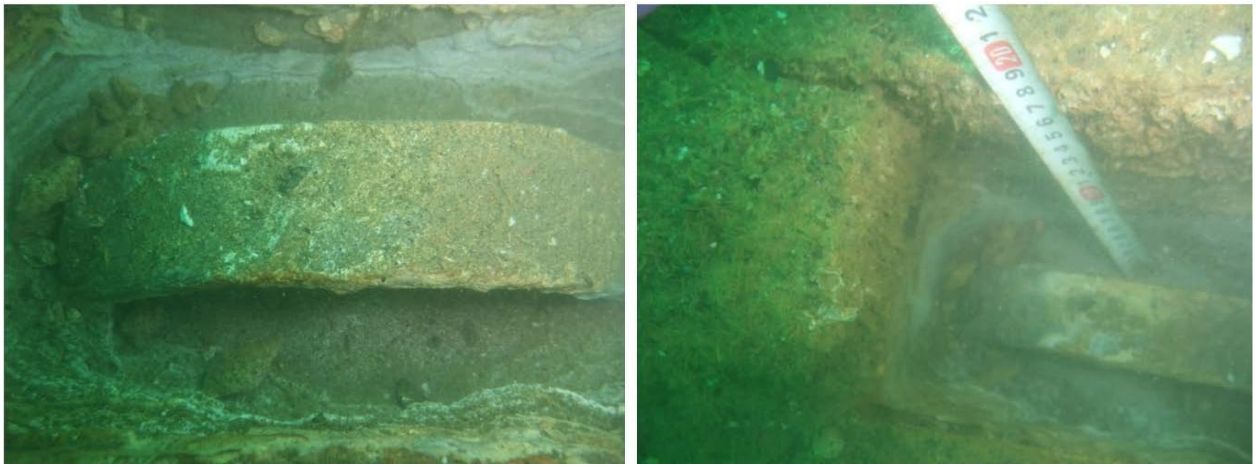
EXECUTIVE SUMMARY

EDT Offshore Limited (EDTO) has been awarded from the Council for Development and Reconstruction (CDR) the inspection and survey of the Daoura Outfalls. Two marine Outfall Pipes were installed in the mid 1980's along the northern shore of Beirut at a location between the Bourj Hammoud Dump Site and the Beirut River outlet. The pipes were never commissioned and understood to be sealed at both ends at the time of construction. The main Outfall Pipe is 1,777 m in length and has an internal diameter of 1,700 mm. The second pipe is an emergency Overflow Pipe. Its length is 620 m and its internal diameter 2,000 mm. The pipes are made of steel and are covered with an outer concrete skin of 210 and 270 mm respectively. A conditional assessment report and a geotechnical report were submitted by EDTO under separate cover. This report focuses on the recommendations and rehabilitation aspects of the pipes.

Regardless of the extent of damage identified as part of this survey, the pipes are located in a relatively unsuitable area. Their location is not compatible with the natural setting and ongoing activities in the area. Indeed, a number of mooring points for fuel supply vessels are located over and adjacent to the pipes. Marine traffic is extensive and is likely to increase with the expansion of the Beirut Harbor. The area being sheltered, it is used during storm events for emergency sheltering of vessels. In addition, extensive fishing activities take place in the area. Fishing nets were found stuck on almost every diffuser on the Outfall and Overflow Pipe.

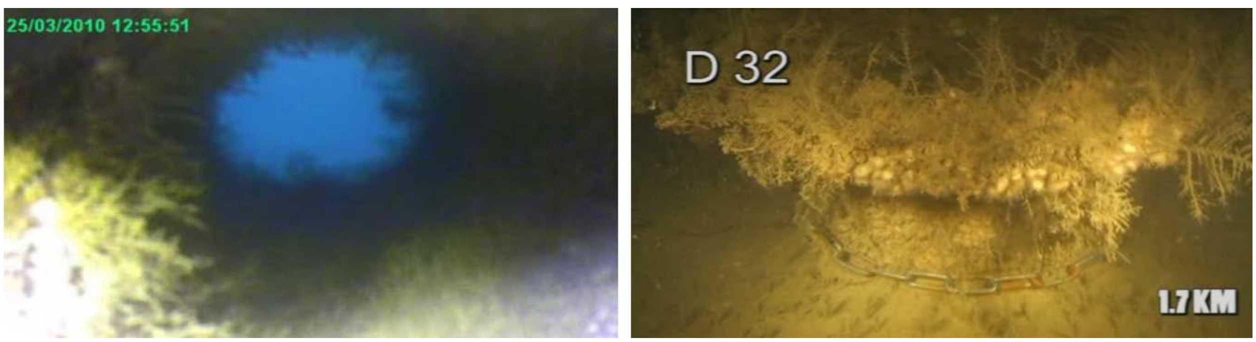
In addition to the above, the pipes are located at proximity to the Bourj Hammoud Dump Site. Significant quantities of waste and debris have covered the pipes on the inshore section. The presence of the Beirut River is also contributing to the deposition of sediments over the pipes and the modification of the coastline. The area has been a repository of very fine sediments since geological times. All these factors contribute to having a severe impact on underwater visibility and working conditions, a point that should be emphasized and made known to any contractor either working in the area or planning to submit a proposal for any work related to inspection, repairs or ongoing maintenance of the Outfall Pipes.

The pipes were protected against corrosion with a sacrificial anode system that is now fully consumed. The following plates clearly show the bracket where the zinc was casted. Traces of light grey are the only evidence of the zinc that was installed. The pipes have therefore been suitably protected for the first 20 years by such zinc. However, in the absence of such anode material, the pipes are now exposed to the element and ***will rust at an accelerated rate*** *as the efficiency of the pipes coating after 25 years is now severely degraded. The installation of an impressed current system is not recommended at this stage for a number of practical reasons outlined in this report. In order to salvage the pipes while it is still possible, the installation of a cathodic protection system consisting of sacrificial anodes is of the utmost urgency.*



Sacrificial anodes fully consumed on pipes

In addition, a number of damages were also noted on the Outfall Pipe. These typically included diffusers that have been severed by anchors or trawling activities. In total, 14 diffusers have been severed either at the pipe crown or at the level of the horizontal flange. The absence of such diffusers is enhancing marine growth inside the Outfall Pipe that is degrading the internal coating. It is also allowing the ingress of oxygen inside the Outfall Pipe that will accelerate the internal corrosion of the pipe. Closing of the diffusers is a very high priority in order to avoid such accelerated degradation of the Outfall Pipe.



Marine growth inside (left) and outside (right) Missing Diffusers

Furthermore, a number of damages to the concrete pipe surround were noted between Chainages 900 and 1,000 caused by a large chain and fuel pipes crossing the Outfall Pipe as well as possible impacts of anchors or buoy sinker blocks. The damage is spreading along the pipe through the rusting of the exposed steel that is breaking up the concrete cover, exposing more reinforcing steel to seawater. Remediating the concrete is also a priority activity in order *to limit the spread of the damage. If not promptly repaired, the entire concrete cover could be destroyed and the steel pipe could be exposed to direct corrosion.*

Extensive damage to the concrete cover of the pipe

EDTO has insisted on the need to implement these emergency measures that would protect the pipes from accelerated degradation. These emergency measures were not authorized for budget reasons despite the fact that the accelerated degradation will only result in more repairs and the need to remobilize a Contractor through a new tender procedure where financial mark-ups will be higher than the Variation Order mark-ups.

In addition to the emergency repairs, a number of additional investigations are required. These could not be conducted as part of this contract for budget reasons. These additional investigations include the dredging of the sediments over the pipe in the navigation channel in order to assess the extent of the concrete damage and the cleaning of the internal parts of the pipes from debris and sediments in order to complete the internal inspection of the pipe.

Geotechnical soil improvement and pipes replacement are discussed in this report as required in the Terms of References. However, these activities are not considered justified and required at this stage.

REHABILITATION AND RECOMMENDATION REPORT

INSPECTION AND SURVEY OF DAOURA SEA OUTFALL

PREPARED FOR THE CDR

1. INTRODUCTION

EDT Offshore Limited (EDTO) is pleased to submit to the Council for Development and Reconstruction (CDR) this report presenting the recommended additional investigation and rehabilitation of the Outfall and Overflow Pipes located in Daoura, along the northern coastline of Beirut. This report has been prepared in accordance with the scope of work outlined in the Tender Documents and our proposal submitted on July 17, 2008.

EDTO has been awarded from the CDR the inspection and survey of the Daoura Outfall. The project is fully funded by the European Investment Bank (EIB). The works conducted by EDTO were supervised by Associated Consulting Engineers (ACE). Daily and monthly reports, compiled by EDTO, were submitted to ACE in order to document progress detailing the various activities that took place as the works developed during the period of the project.

The scope of the current contract is to prepare a condition inspection and survey of the two pipes and to make further recommendations for further inspection and measures to repair or rehabilitate the pipes before full commissioning.

This report is the third of three reports prepared by EDTO to be presented to CDR in accordance with the requirements of the awarded contract. The detailed list of reports is as follows:

- Condition Assessment Report
- Geotechnical Report
- Rehabilitation and Recommendation Report

1.1 PROJECT DESCRIPTION

Two marine Outfall Pipes were installed in the mid 1980's along the northern shore of Beirut at a location between the Bourj Hammoud Dump Site and the Beirut River outlet. The project was designed by ACE and executed at the time by the Société Nationale d'Entreprises (SNE) under the supervision of ACE for the Comité Executif des Grands Projets de Beyrouth. The pipes were never commissioned and understood to be sealed at both ends at the time of construction.

It is known that these submarine Outfall Pipes were installed during the prevailing civil war and were never visited or investigated throughout the post-construction period. The land and marine regions concerned were considered to be un-secure and their location remains critical at present, particularly with regard to difficult access and to site conditions. The sites consist of open and un-protected land and sea areas where the pipes have the potential to be subjected to possible damage from machines onshore, solid waste dumping (on and offshore), fishing marine craft of various sizes and the continuous mooring of large oil cargo marine vessels in navigational channels that are situated over the pipelines.

The following is a general technical description of the two pipes based on the design parameters as detailed in the original construction Contract Specification or as surveyed by EDTO as part of this project.

Sea Outfall Pipe:

Material:	Welded Steel
Reported Wall thickness:	15.88 mm
Nominal inside diameter:	1,700 mm
Length as surveyed by EDTO:	1,777 m
Reinforced Concrete External Coating Thickness:	210 - 222 mm
Number of diffusers:	36@10 m centers
Spacing between Diffusers 12 and 13 as surveyed by EDTO:	5m
Diffuser internal diameter:	approx. 223 mm

Overflow Pipe:

Material:	Welded Steel
Reported Wall thickness:	15.88 mm
Nominal inside diameter:	2,000 mm
Length as surveyed by EDTO:	620 m
Reinforced Concrete External Coating Thickness:	270 mm
Number of diffusers:	26 @ 5m centers
Diffuser internal diameter:	approx. 407 mm

1.2 SITE LOCATION

The general location of the site is on the northern coastline of Beirut immediately to the west and northwest side of Bourj Hammoud Dump Site and east of the Beirut River outlet. The site limit to the south is bounded by the north wall of DEMCO steel and is situated on land reclaimed from the sea in the early eighties. The zone in which the condition survey took place is limited to a corridor approximately 10 m to the west of the Outfall Pipe and 10 m to the east of the Overflow Pipe extending northwards into the sea some 1,777 m in length (See Plate 1).

Plate 1: General Site Location

2 SITE CONSTRAINTS

The information presented in this section should be shared with any contractor planning to submit a proposal for any type of work related to the pipes.

The pipes are located in an area where two types of major constraints give cause for concern. These constraints are both man-made and natural in form. Man-made constraints are considered to be the most critical to the two pipes. They include:

- The presence of a number of mooring points for marine vessels supplying fuel to Lebanon,
- The presence of intense marine traffic in and out of the Beirut Harbor,
- The site is a sheltering haven for marine vessels during storm events,

- The site is an active fishing ground essential to the local community,
- The presence of the Bourj Hammoud waste dump site,
- The discharge of effluent and other pollutants into the site area by rivers and brooks.

Specific natural constraints are related to:

- Excessive sedimentation
- Very soft seabed conditions
- Very poor visibility
- Exposure to weather fronts from the North

EDTO considers these constraints to be quite critical for the safe and ongoing operation of the pipes as sewer outfalls.

Plate 2: Man-made and natural constraints in the vicinity of the pipeline spread

2.1 MOORING POINTS

There are at least 20 large permanent mooring buoys fixed in the vicinity of the pipeline spread, the location of nine of which is considered to be extremely critical. These buoys are cylindrical, made of steel, considerably large and used by tankers and other large vessels while unloading fuel, gas or waiting to enter the harbor.

Plate 3: Steel cylindrical buoy used by tankers for off loading fuel

A number of smaller conical buoys are also located in the area. These tend to be used by small-scale marine craft and fishermen or otherwise to locate the fuel supply hoses.

It is recommended to conduct a full survey of the mooring buoys in the area of the pipes. The position of the buoys, the anchoring blocks and their anchors should be surveyed. Buoys that are no longer in use should ideally be removed in order to reduce the congestion in the area. Coordination with the Ministry of Transport should be sought in order to investigate the possibility of relocating some of these mooring points. Contacts should also be made with the Ministry of Transport and other relevant authorities requesting them not to authorize the installation of new mooring locations in the area of the pipes and to coordinate with the CDR such requests.

Plate 4: Fuel offloading with smaller conical buoys nearby

Some of the mooring buoys observed on-site are not new and seem to have been present at the time of construction of the pipes with no apparent action undertaken by the affected parties to either relocate the pipes or alternatively move the buoys to avoid a conflict of interest. Is should be noted that a number of such buoys are shown on the as-built drawings prepared by SNE in 1985.

The majority of marine craft moored at these locations are substantial in size with the capacity to supply large quantities of fuel and gas to onshore storage and handling depots.

As can be seen in Plate 6, several of these permanent buoys are of some concern based on their location, the size of the vessels observed, the length of the mooring cable attachments and the methods that are likely to have been adopted to anchor such buoys on the sea bed. Such anchoring methods can commonly consist of sinking steel or concrete wedges and weights of up to 20 tons with heavy chain designed to gain a secure foothold on the seabed. The form, location and number of these anchors and their resting relationship to the Outfall Pipe lines alignments are currently unknown.

Plate 5: Fuel tanker vessel moored directly over the Outfall Pipe line

EDTO has determined a critical radius of 300 m based on the existence of vessels 175m in length having been observed in the area of the pipeline spread. Such vessels have been observed to utilize mooring cables in excess of 125m length in order to complete maneuvers and secure attachments to the buoys allowing discharge of cargo. Despite the presence of these mooring buoys, heavy ships anchors are still dropped and dragged as an additional mean of mooring. Plate 6 shows the critical buoys colored in red based on the possible impact of anchors on the pipes within the 300 m radius around the buoys.

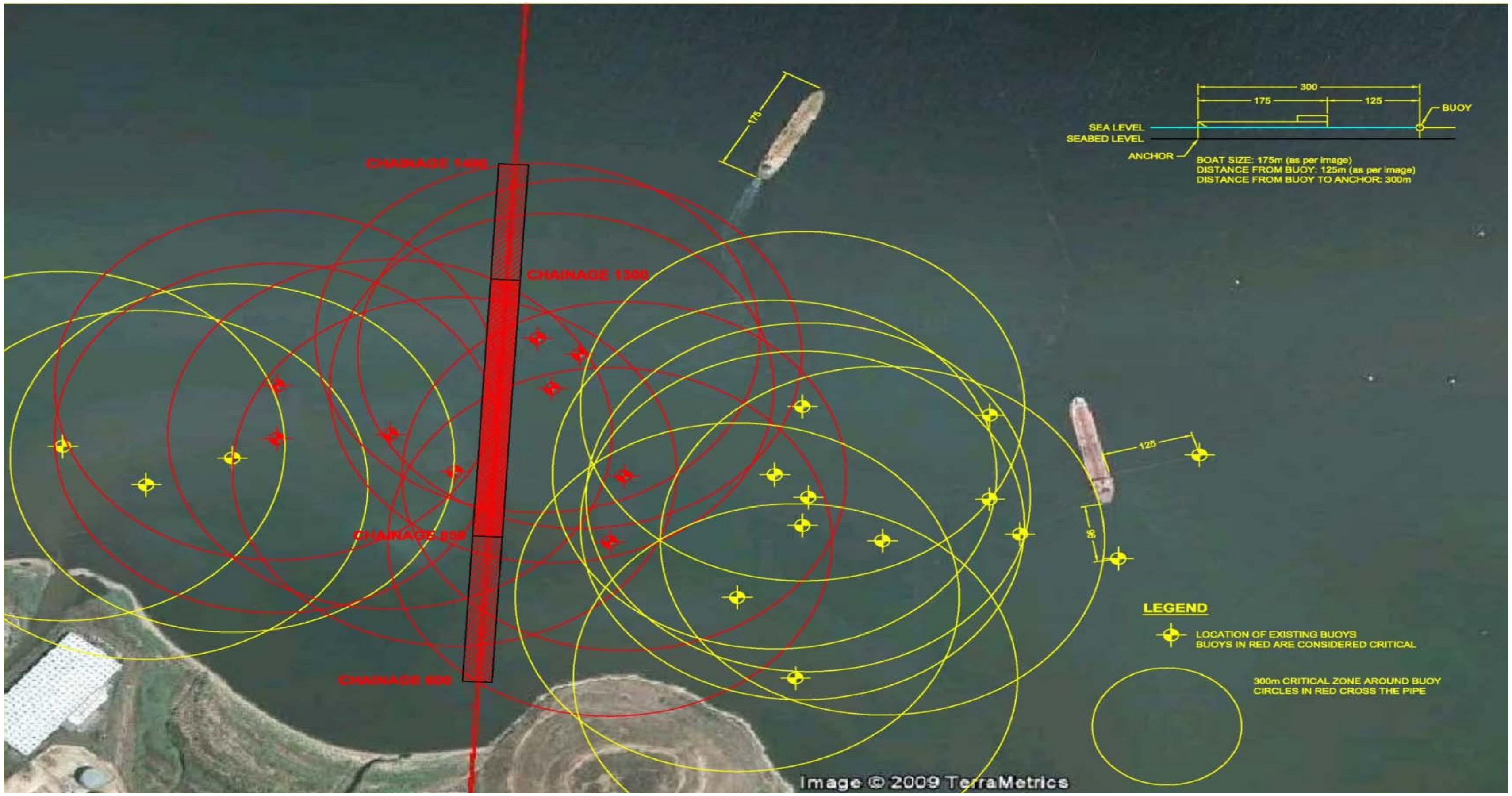


Plate 6: Critical buoys affecting the pipes

As was presented in the condition assessment report, the results of the side scan sonar have identified a multitude of anchor impact craters on the seabed adjacent to and along the length of the Outfall and Overflow Pipe line spreads. Furthermore, some ‘direct hit’ damage observed during divers’ inspection of the pipes could be attributable to anchor drops on the pipes themselves.

EDTO considers this situation to be of the utmost concern and in the long term, potentially highly detrimental to the lifespan of the pipe. As long as the pipes and the mooring points remain at the same location, the long term integrity of the pipes will continue to be under threat ratifying EDTO in their belief that the pipes or the mooring points should ultimately be relocated.

Plate 7: Mooring buoy located over the pipes with fuel supply vessel off-loading cargo in the background

The inspection survey revealed that three suspected refueling lines have been identified as crossing the exposed section of the pipe. At least one of these lines is known to be regularly active. Ideally, these refueling lines should be relocated. However, the fuel importing companies involved may be reluctant to entertain the concept of such relocation and may insist on the pipes being relocated instead.

2.2 MARINE TRAFFIC AND EMERGENCY MOORING

As indicated earlier, the pipes are located at the entrance of the Beirut Harbor. The Beirut Harbor is the busiest harbor along the eastern coast of the Mediterranean. Plans are underway for its expansion with the construction of a new quay and expanding the container facility.

Plate 8: Large container vessel passing next to the pipes location while leaving Beirut Harbor

In addition, because the area where the pipes are located is relatively sheltered from major southwesterly winds, vessels use this area as an emergency mooring location during major storm events. It is virtually impossible to ask vessels seeking shelter during a storm or large vessels maneuvering in and out of the Beirut Harbor not to cross the area of the Outfall Pipe. However, such heavy traffic and emergency mooring over the pipeline spread are likely to continue and to increase the risk for the pipes to incur further damage in the future.

In short, the pipeline spread is located in the middle of an extremely active navigational channel, used continuously, 24 hours-a-day, by ocean-going ships of many thousand tons in size which require to drop and weigh anchor during maneuvers as standard procedure every time they come and go.

EDTO firmly believes that as an absolute minimum, the Sea Outfall and Overflow Pipes should be highlighted on the most up-to-date admiralty charts of Beirut. Precautions should be taken and measures made in order to improve the awareness of all affected mariners and to ensure that no vessel is allowed to throw its anchor within a minimum 50 m safety distance of the pipe.

Throughout the duration of the inspection survey, which extended over a period of ten months, the aforementioned ocean-going marine craft were instrumental in destroying temporary marker buoys installed by the EDTO dive team, essential in order to carry out their external inspections of the Outfall and Overflow Pipes on numerous occasions. The re-establishment of destroyed temporary marker buoys resulted in a minimum of 60% increased dive time for the team to complete their inspections. Even with close and regular coordination with the Beirut Port Pilot, the dive team, on several occasions had to abort their operations on-site due to marine traffic mooring or maneuvers in some cases while the divers were literally still working underwater.

2.3 INSTALLATION OF SPECIAL MARK BUOYS

In an a profound effort to counter the problem from the present time and in the longer term, four 'Special Mark' cylindrical buoys have been installed by EDTO with the approval of the CDR and the Ministry of Transport towards the end of this inspection survey project. The buoys were installed along the length of pipeline strategically located to demarcate the 'hot zones' where the pipe, exposed on the sea-bed, has been known to suffer most damage. The buoy design and installation was carried out in close coordination with the Lebanese Ministry of Transport (MOT), specifically the Chief of Light Houses Maintenance & Aids to Navigation Section and MEDCO whose buoys are the closest pipelines.

The buoys are equipped with explosion proof yellow lights. The furthest buoy from the shore is equipped with a three nautical miles light. The lights on the three others are rated as being visible from two nautical miles. The final installation location of each buoy has been passed formally by EDTO to the MOT through the CDR in order for the MOT to ensure the location of the pipes and the buoys are clearly indicated on the admiralty charts of the area for the benefit of all affected parties. The Engineer (ACE) represented the Client (CDR) at the relevant meetings with the MOT at CDR's Engineer desire.

The location of the buoys is presented in Plate 12. The coordinates of the buoys and the specifications of the lights are presented in the following table. In this table, the coordinates are provided in International UTM WGS84 format (to be used by international organizations) and in Lebanese coordinates.

On August 21, 2010, the Ministry of Transport informed the United Kingdom Hydrographic Office of the presence and coordinates of the pipes and the buoys in order for them to add them on the admiralty charts of the region.

Table 1: Location and Specification of Special Mark Buoys

Buoys	UTM Coordinates	Lebanese Coordinates	Light Intensity	Light Flickering Frequency
B1	E= 735,517 N= 3,754,659	X = -333,166 Y = -26,716	2 nm	FL(4)10s
B2	E= 735,514 N= 3,754,760	X = -333,164 Y = -26,615	2 nm	FL(4)10s
B3	E= 735,500 N= 3,755,385	X = -333,140 Y = -25,991	2 nm	FL(4)10s
B4	E= 735,503 N= 3,755,847	X = -333,110 Y = -25,530	3 nm	FL(4)10s

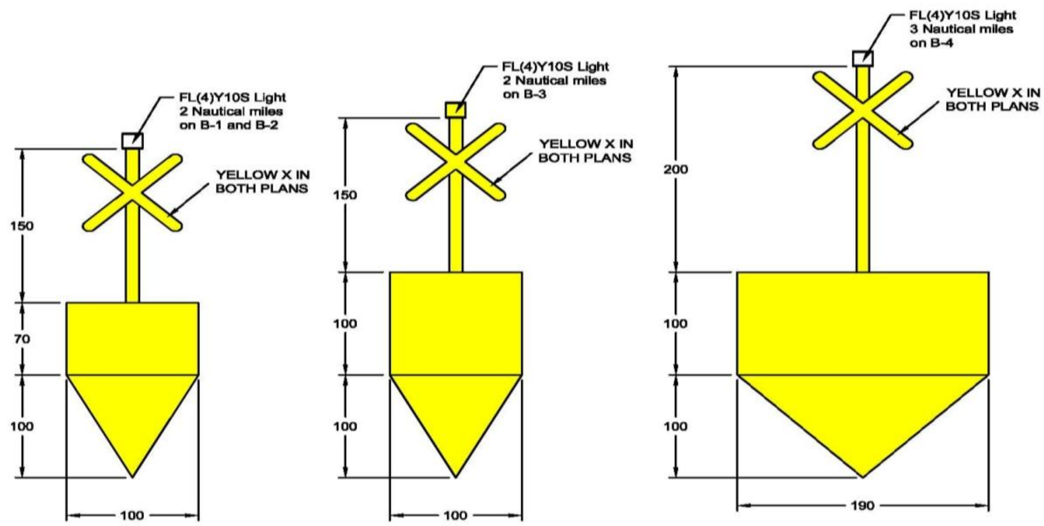


Plate 9: Design of the 'Special Mark Buoys' as agreed with the MOT

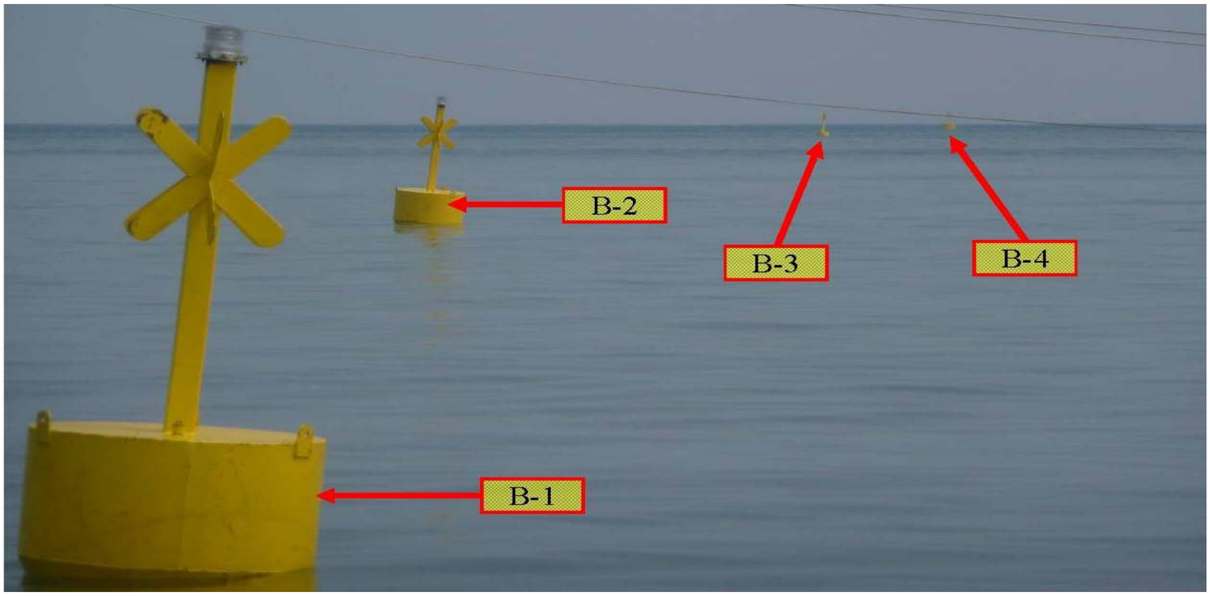


Plate 10: Deployed Special Mark Buoys

Plate 11: Welding the screws holding the lights on Buoys B-3

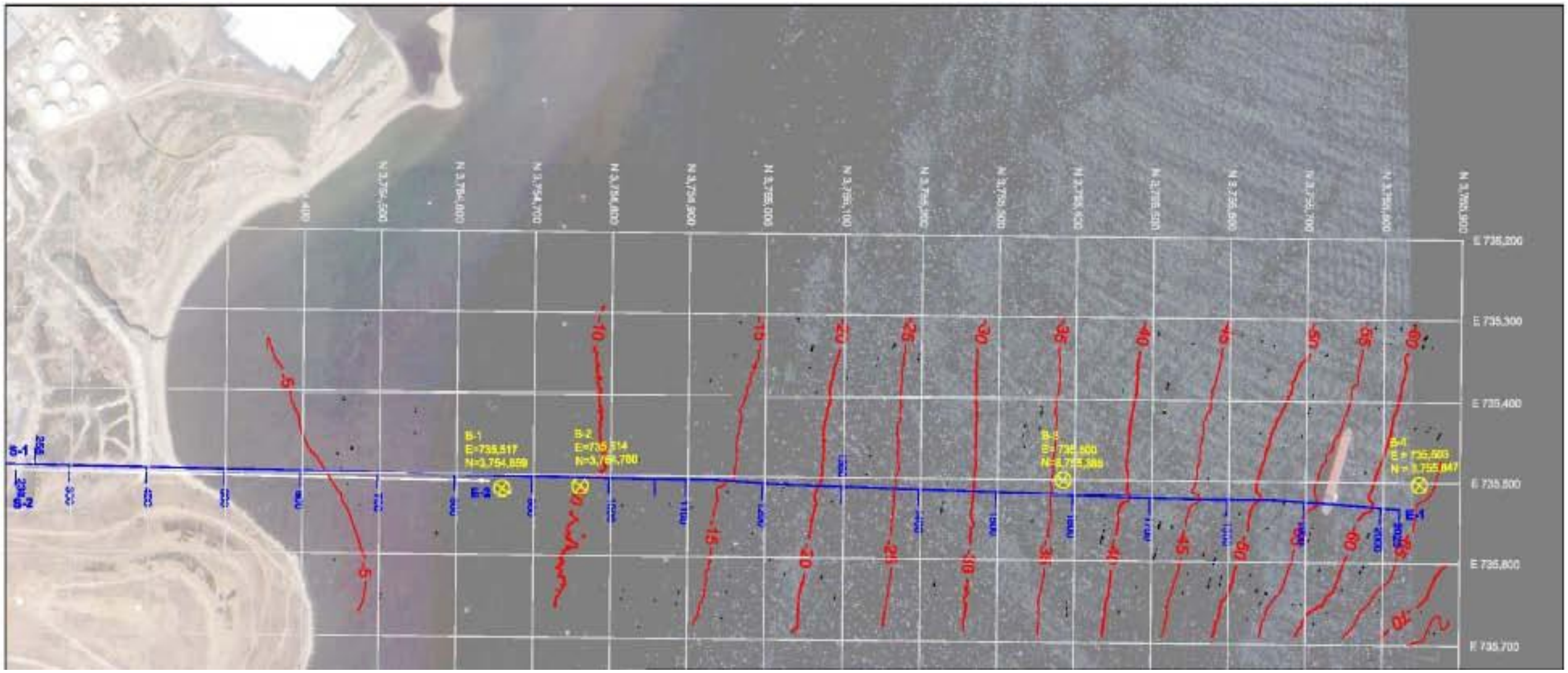


Plate 12: Location of the Four Special Mark Buoys installed by EDTO

2.4 FISHING ACTIVITIES

The presence of the fishing harbor to the east of the Bourj Hammoud Dump Site and the calm sea conditions actively encourage regular fishing activities in the vicinity of the pipeline spread easily accessible from the harbor.

Plate 13: The fisherman's harbor viewed eastwards from Bourj Hammoud Dump Site

Once the pipes are operational, fishing activities may be even more intense based on the increase of the organic load discharged in the water.

Almost all the diffusers on the Sea Outfall and several on the Overflow pipes have fishing net and line debris entangled on them. Such nets are likely to affect the performance of the diffusers once the pipes are commissioned. In addition, our survey has indicated that 14 of the 36 diffusers on the Sea Outfall Pipe have been broken either by anchor dropping or as a result of fishermen attempting to recover their fishing nets snagged on diffusers.

Once the pipes are operational, EDTO recommends that the appropriate authorities move to restrict fishing activities to areas out-with the pipeline spread. However, as the local fishermen depend on working this stretch of water for their livelihood, this will be a major challenge for any authority to overcome.

2.5 PRESENCE OF THE BOURJ HAMMOUD DUMP SITE

The presence of the Bourj Hammoud Dump Site is likely to have had a substantial impact with the deposition of waste, debris and sediments over the pipes as a consequence of waste side-slope failures into the sea. In addition, as is explained in the Geotechnical Engineering Report, the western extent of the dump site is, at one specific location visible on the surface, less than 10 m distant from the alignment of the Overflow Pipe creating lateral pressure build-up. The consolidation of the loose sediments under the dump site is an additional consideration with the potential to induce long term pipes settlement.

2.6 NATURAL CONSTRAINTS

Natural site constraints include excessive sedimentation over the pipes as a direct result of the Beirut River outflow and its effect on the ever changing coastline. Such sedimentation is likely to increase with the recent and future construction activities set to expand the extent of the Beirut Harbor even further.

As is discussed in the Geotechnical Engineering report, the seabed conditions are very poor with sediments consisting of very loose soils that are amenable to excessive settlement and liquefaction during seismic activity events.

2.7 VISIBILITY

The extremely poor visibility conditions that exist underwater are likely to make future inspection of the pipes difficult and at certain times of the year, virtually impossible.

2.7.1 GENERAL

EDTO confirms that underwater visibility is likely to be at its best during late summer and early fall. This is due to a combination of calm sea condition and minimal river flow. Even under such ideal conditions, the underwater visibility was found to be minimal. Visibility deteriorates progressively through the winter and towards early spring as the snow melts, leading to larger quantities of suspended and dissolved solids being transported and discharged by the nearby Beirut River.

An added complication to be considered within the site is the existence of the Bourj Hammoud Landfill Dump Site situated immediately adjacent to the east side of the Overflow Pipe. Experience gained by EDTO’s local partners EDESSA on local coastline landfills such as those at Saida and Normandy dumpsites would suggest that, as each winter progresses and storm events become more frequent, failure of exposed waste side slopes leads to worsened underwater visibility.

Added to the Beirut River and Bourj Hammoud Dump Site factors is the known discharge of effluent, storm water and other pollutants into the site area via at least two local raw sewerage discharge brooks emerging from adjacent industrial areas.

2.7.2 PROJECT FINDINGS

Rarely during the external inspection phase of the project (from October 2009 until mid May 2010) did underwater visibility improve beyond 30 cm in 10 m making the actual locating of the pipes during external inspection fully dependant on:

- The accuracy of as-built coordinates extracted from the contract documents,
- Continuous GPS positioning,
- Divers 'touch and feel' senses in the water.

Bathymetric and Side Scan Sonar Surveys would eventually improve awareness of the precise pipes location, however visually locating the pipes was always dependant on the divers' ability to see ahead of them underwater in order to attach temporary buoy markers, conduct inspections and ultimately to take still photographs and video footages.

Continuous storm events during the winter months together with repetitive loss of temporary buoy markers by fishing and large shipping vessels during maneuvers was to prove a continuous challenge for the dive team to face up to, requiring the pipes to be searched for again and buoys to be reestablished on numerous occasions while underwater visibility deteriorated to absolute zero at times as the works moved through the winter months.

Such poor visibility will be faced by every future contractor or operator whose responsibilities entail any form of underwater work or inspection of the pipes.

2.7.3 CONTRIBUTING FACTORS

Contributory factors affecting underwater visibility during the external inspection phase of the works included:

Wind direction:

While the site is relatively sheltered against weather systems from the southwest, the Beirut River outflow, slumping waste sediments from the adjacent dumpsite and other effluent discharges in the vicinity of the site were found to be influenced by wind direction, swell and under currents with the following patterns emerging:

- **Wind from the North:** River sediments would typically be directed over both the Sea Outfall and Overflow Pipes. With strong winds emanating from the north, stormy sea surface conditions would prevail across the site, making the area dangerous for the maneuvering of all marine craft sizes.

- **Wind from the West:** River sediments would typically be directed over the Outfall Pipe at depth with limited influence on the Overflow Pipe other than disturbance of waste sediments adjacent to the landfill. With strong wind emanating from the west, stormy surface conditions would prevail above the Sea Outfall at depth making vessel maneuvering hazardous in that area. The sea would be much calmer in-shore at the Overflow Pipe location.

- **Wind from the South**: River sediments would typically affect the Sea Outfall at depth. Coastline sediments including those from the Dump Site would typically affect visibility inshore at both pipes locations. With strong wind emanating from the south, stormy surface conditions would prevail on approach of the site from the north. The sea would be much calmer in-shore.

- **Wind from the East**: This is considered a rarity but seen to be the most favorable site conditions, whereby river sediments are picked up and encouraged more westwards and to the northwest away from both pipelines. The Outfall Pipe can be affected by slumping waste sediments from the landfill. Generally, calm surface conditions would prevail across the site.

Sediment disturbance

Even during limited periods when the wind is from the east and visibility is relatively good, marine life especially large fish who have their habitat in, around the pipes and in the loose sediments and mud would stir the fine seabed surface deposits while fleeing from divers instantly creating a zero visibility situation forcing divers to abort inspection until the disturbed sediments settle again which could take several hours and in the hope that the fish have not returned and the weather/wind direction had not changed.

Divers themselves very quickly learnt that any physical contact with the seabed resulted in again a zero visibility situation as well as exposure to danger by the suction effect of the sludge deposits.

2.8 DIVING HAZARDS

The EDTO diving team, led by renowned head technical diver Tony Haddad, adhered to the foremost international technical diving standards currently applicable worldwide.

The diving environment in the vicinity of the site is like no other location along the coastline of Lebanon for the primary reason that visibility most of the time is at absolute zero due to a combination of factors as was well documented above. No matter how advanced the lighting technology adopted underwater, divers invariably depended on touch and feel to orientate themselves literally having to touch their dive partners to know where they were. On numerous occasions dives had to be aborted because a diver could not locate his partner rendering any further work unsafe to proceed with.

Without the ability to visually communicate with each other in deep waters, zero visibility impaired the divers' ability to assess by sight the job in hand and any unseen hazards that could affect their health and welfare when executing their duties. Over the period of the pipelines external inspection, such potential and actual hazards during diving activities included:

- Large container marine vessels moving in and out of the Beirut Harbor via the pipeline spread without notice,
- Large fuel supply ships mooring over the pipeline spread at short or without notice attaching mooring lines to buoys and dropping anchors,
- Local fishermen trawling nets in the zone of the pipelines,
- Rapid weather change and underwater currents,
- Oral intake of suspended solids and pollutants from effluent and the landfill,
- 'Quicksand' effect of waste and sediment sludges on the sea-bed,
- Handling polluted sediment sludges during dredging and sampling,
- Jellyfish and octopus attacks,
- Abrasion injuries due to barnacle and razor sharp incrustation on diffusers and the pipelines,
- Collision with submerged solid elements such as metal units, reinforcing bars, concrete and other landfill wastes together with diffusers, marine chains and anchors,
- Entanglement in buoy ropes, old nets, ropes, gut fishing lines etc draped around diffusers,
- Panic when any of the above occurs

EDTO is pleased to report that no injuries to divers occurred throughout the duration of the project which we believe is due testament to the professionalism and responsible approach adopted by the management team and operatives involved.

3 RECOMMENDED ADDITIONAL INVESTIGATIONS

The scope of the investigation as presented in the Terms of References (TOR) for the inspection survey was quite extensive given the limited amount of information available to the Consultant relating to the installation and lifespan of the pipes since 1985. However, based on the findings of the survey, a number of additional investigations are recommended to be conducted at various stages in order to provide a more complete assessment of the pipes conditions. These additional investigations were not done as part of this contract since they required dredging of sediments above and inside the pipes which could not be performed at this stage due to budget limitations.

3.1 DREDGING IN NAVIGATION CHANNEL

3.1.1 JUSTIFICATION

A large portion of the pipes is covered by quarry run, natural sediments or dump site debris. Therefore, inspection of the pipes exterior was only possible where they were visibly exposed or where trial pits were excavated in order to effect exposure. Ideally, it would be preferable to remove all quarry run and sediments from over the pipes in order to fully inspect them. However, since the actual steel pipes are not damaged, and since the excavation of trial pits on land has proven to be useless in terms of visibility and dangerous in terms of risking damage to the pipes during the removal of the quarry run, it is preferable to limit the area to be exposed to the minimum required from a technical viewpoint.

Plate 14: Excavation of trial pits on land

As such, where quarry run was placed as a cover to the pipes in the early eighties, EDTO recommends not removing such material at this stage as any removal and reinstatement of such material could be more dangerous to the pipes integrity.
Sediment removal to expose the Outfall Pipe is highly recommended through the navigational channel and the zones identified in Plate 6 as critical due to the proximity of steel buoys and mooring points where damage to the concrete protection of the pipe has already been noted. Sediment removal is also required in order to reveal the extent of the damage that the external coating of the pipe has suffered until now. It should be noted that damage to the concrete would rapidly spread along the pipe if not promptly repaired. The exposed steel would rust and as the rust expands under the sound concrete, the concrete cover would typically break apart, exposing yet more steel that will in turn rust as well.

Dredging should only be initiated if a budget is available for remedial works as silts will continue to accumulate in the dredged zones eventually covering the pipe once again. If the concrete coating repair budget is not available, then it would be preferable to postpone such dredging and inspection activities until such a time as when the repair works could run concurrently as part of the same contract.

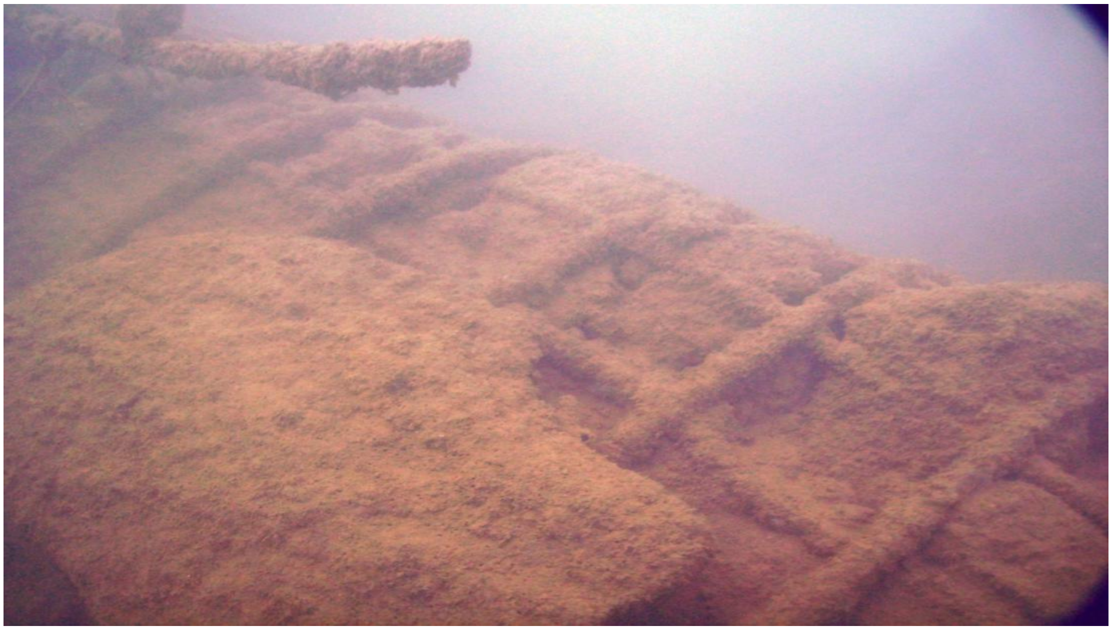


Plate 15: Exposed damaged reinforcement bars following dredging activities

3.1.2 SPECIFICATIONS

Dredging of the sediments to expose the pipe crown and sides shall be carried out manually and with care using air lifting techniques ensuring minimum risk of causing damage to the pipe. The deployment of other larger scale mechanical dredgers e.g. ‘cutter suction’ or ‘bucket’ type marine dredging plant and equipment typically used in open channel dredging activities shall not be used as they could cause significant damage to the pipe itself and current resting conditions.

The reasoning behind dredging is to expose the pipe in the navigational channel identified as critical based on the presence of a number of mooring buoys in a ‘hot’ zone’, where concrete coating damage to the pipe was noted to be quite extensive and where evidence of numerous impacts were detected following the side scan sonar survey.

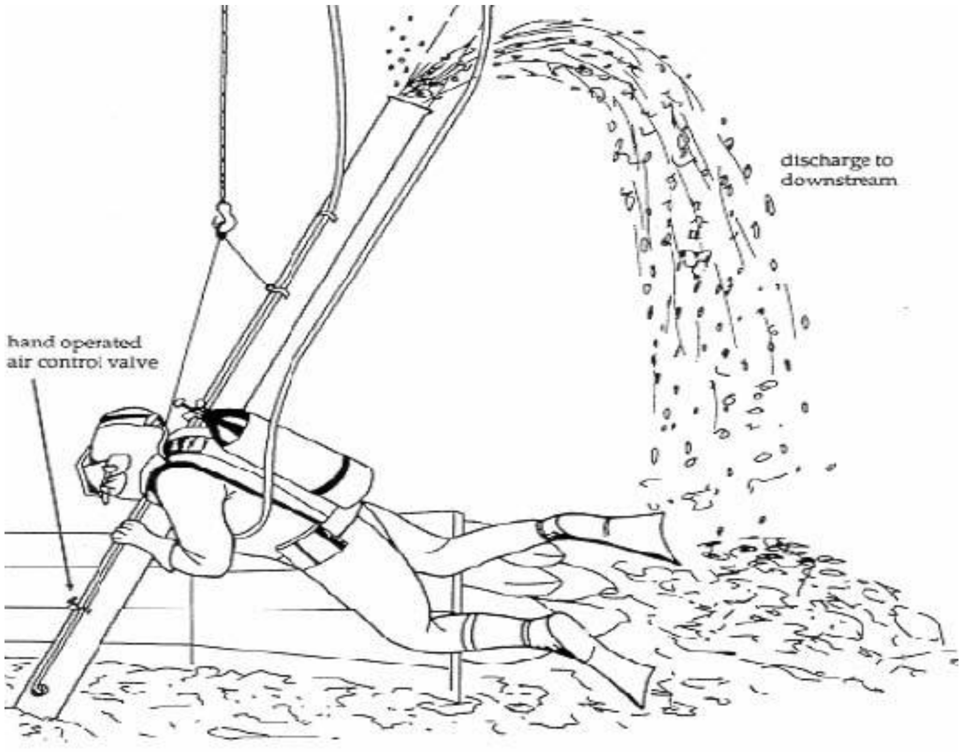


Plate 16: Air-lifting technique

Dredging conducted by air lifting techniques shall expose a wedge of at least 1 m by 1 m adjacent to the pipe and down to an elevation below half bore (Plate 17) without undermining the pipe's resting position, in order to allow the detailed inspection of the pipe by ROV or by divers. Photos and videos of the dredged area shall be provided for the Engineer's review in order to assess if additional repair to the concrete is required. Any pipe damage uncovered by dredging shall be quantified accurately by the dive team using measuring tapes and by any other means necessary where applicable.

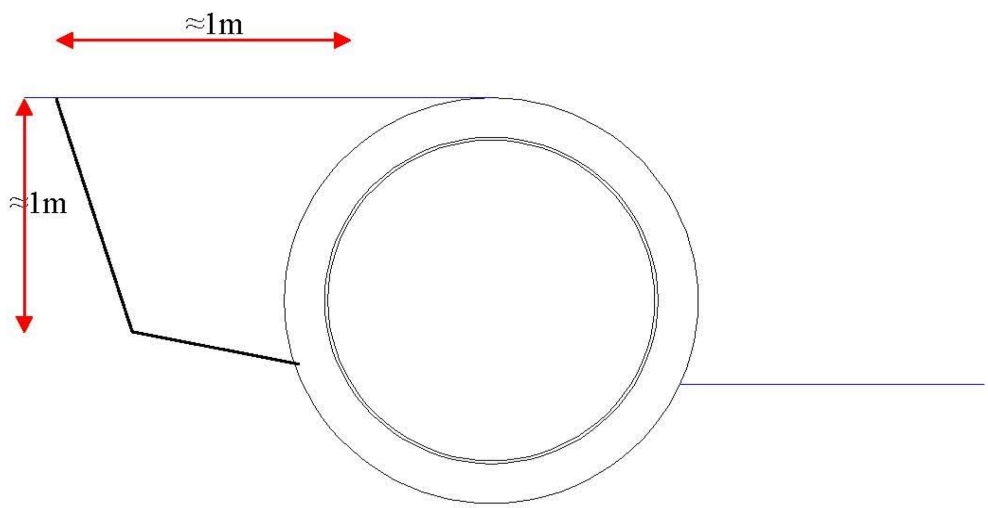


Plate 17: Dredged wedge alongside the pipe

Health and safety consideration to the diving team shall be properly provided.

The air lifting technique was successfully adopted on a small scale by EDTO to excavate trial pits at specific locations and to dredge a 36 linear meter channel along the Outfall Pipe length in the vicinity of trial pit excavation TP17. Larger compressors and additional dredging teams would be required in order to achieve a more optimal daily production rate.

Plate 18: Dredging by air lifting techniques on-going

Plate 19: Air lifting nozzle

3.1.3 QUANTITIES

Based on the findings of the inspection survey, EDTO recommends as a minimum, exposure by dredging of the Outfall Pipe in the navigational channel between Chainage 850 and 1300. In the event that extra budget can be secured, dredging of the deeper portion where extensive sediment coverage was discovered, should be given due consideration (between Chainage 1300 and 1620). However, any prospective contractor should be made aware that dredging in this chainage zone would be considerably more challenging due to the significant thickness of sediments to be removed and the increased water depth limiting diving time.

Dredging shall expose the pipe surrounds to below half bore while taking care not to undermine the pipe. Although this activity is relatively straightforward between Chainage 900 and 1220, more extensive excavation work would be required north of Chainage 1220 where the pipe is completely buried and exposing the pipe surrounds would require a large surface area to be dredged at the top to ensure safety. Where seabed materials require to be excavated to depths in excess of one meter, side slopes must be battered back to 1 vertical, 2 horizontal to allow safe working conditions for the dive team. Should side slopes fail due to near vertically inclined excavation, there would be no early warning for divers working in the excavation as the works will be carried out in absolute zero visibility conditions.

The recommended area to be dredged is approximately 450 m.

3.2 DEBRIS REMOVAL FROM INSIDE THE PIPES

3.2.1 JUSTIFICATIONS

Because of the presence of large debris inside the pipes and due to budget constraints related to the removal of such debris prior to flushing, cleaning and flushing of the pipes were not done as part of this contract. This vital activity will be done as part of additional works and investigations. The cleaning of the pipes should be executed prior to commissioning the pipes and will form part of a new contract. This contract should, but without limitation, include:

- Removal of the upstream and downstream end connection pieces of the two pipes,
- Removal of large, heavy and dense debris without damaging the pipes and internal coating,
- ROV survey to document the proper removal of the critical debris and the suitability of the flushing of the pipes,
- Flushing of the pipes,
- ROV survey to document proper flushing of the pipes from remaining debris and sediments and confirmation of the soundness of the pipes sections that was covered by sediments.
- Closing of the pipes (unless of this activity is done immediately prior to commissioning of the pipes),
- Preparation of an inspection and survey report.

Various debris of variable sizes were noted inside the Outfall and Overflow Pipes. Removal of the debris will have to be carried out in order to inspect the bottom portion of the pipes. Debris extraction will be required prior to commissioning the pipes. Such removal must be undertaken in a careful manner and in such a way as to avoid causing damage to the pipes walls.

Plate 20: Large debris inside the Outfall Pipe

3.2.2 SPECIFICATIONS FOR REMOVAL BY DIVERS

Provided that proper Health and Safety Procedures are implemented by the Contractor, the Engineer could authorize a dive team to enter the Outfall Pipe over a maximum length of 300 m from the inlet end connection piece and typically at the deep end a maximum length of 50 m from the pipe outlet. In the case of the Overflow Pipe , the distance from the inlet connection piece shall be the same. The distance from the outlet end-connection piece can be increased to 100 m. Any deviation from these guidelines will have to be supported by a thorough health and safety plan and may be refused by the Engineer.

Although one solution could be the creation of openings in the pipes that would be re-instated upon completion of the debris removal, this approach is not recommended as it would almost defeat the entire purpose of safeguarding the pipes that are currently intact. Such openings are likely to become weak points if repairs, which are subject to human error, are not expedited properly with the potential for leaks to occur in the future.

Entering the pipes from the diffusers is not an option as the diffuser internal diameters are too small for a diver with his gear to safely enter the pipe. The diffuser opening would have to be enlarged, once again, defeating the purpose of protecting the pipe.

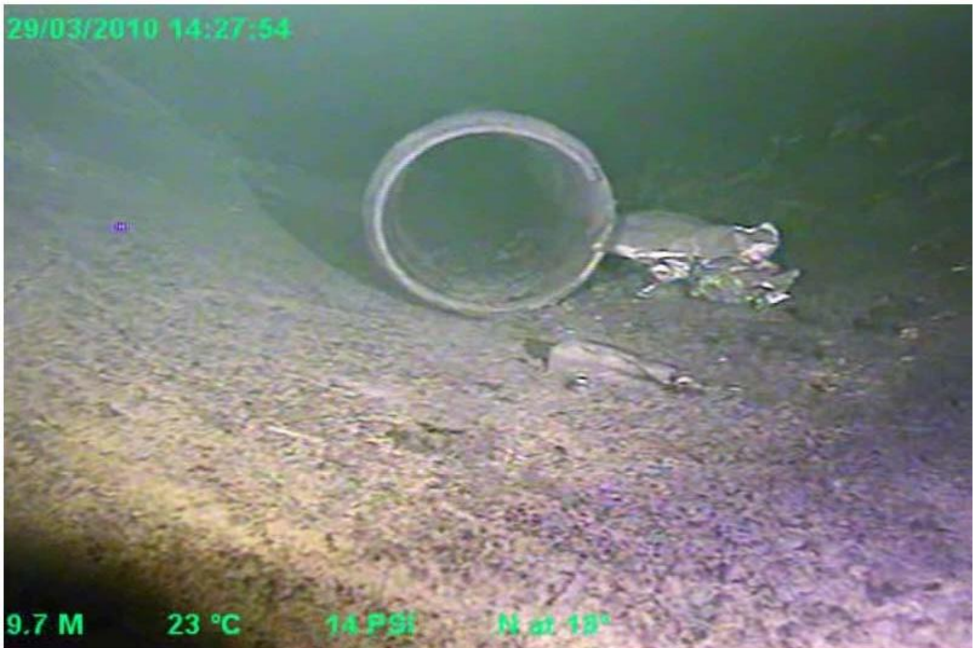


Plate 21: Debris inside the Overflow Pipe

Therefore in conclusion, the dive team, while respecting all Health and Safety requirements, could physically remove the debris located at the extremities of the pipes manually by hand, with ropes or assisted by purpose-built trolleys, sleds and inflatable buoys.

Other methods shall be required for the removal of debris beyond 300 m inside the pipes from the shore and 50 or 100 m inside the pipes from the outlet end. These typically would entail the removal of large debris by ROV and the removal of smaller debris by flushing. These techniques are detailed in the following two sections.
An inspection of the pipes inlets upon opening them will be required as some debris could fall during the removal of the temporary end plate installed at the pipes end connection piece. These would have to be removed manually by divers.

3.2.3 SPECIFICATIONS FOR REMOVAL BY ROV

Removal of debris by ROV is an option that shall be considered especially for debris that cannot be accessed by divers. The ROV can safely enter the pipes from one end to the other. Depending on the bulk and weight of the debris to be salvaged, if equipped with a manipulator arm, the ROV could either pick up foreign objects and bring them out; or pick them up and place them on a trolley to be pulled back from the shore. It could, alternatively, attach ropes around larger or heavier debris that could be recovered. All these operations are similar to salvage operations. They are time consuming, delicate and tedious. However, they would have to be done for the larger and hazardous debris that should not be flushed as the flushing of such debris would damage the internal pipes surface during flushing.

Only ROV operators with proven experience in the field shall be charged with manipulating the arm in order to safely remove the large and heavy debris from inside the pipe.

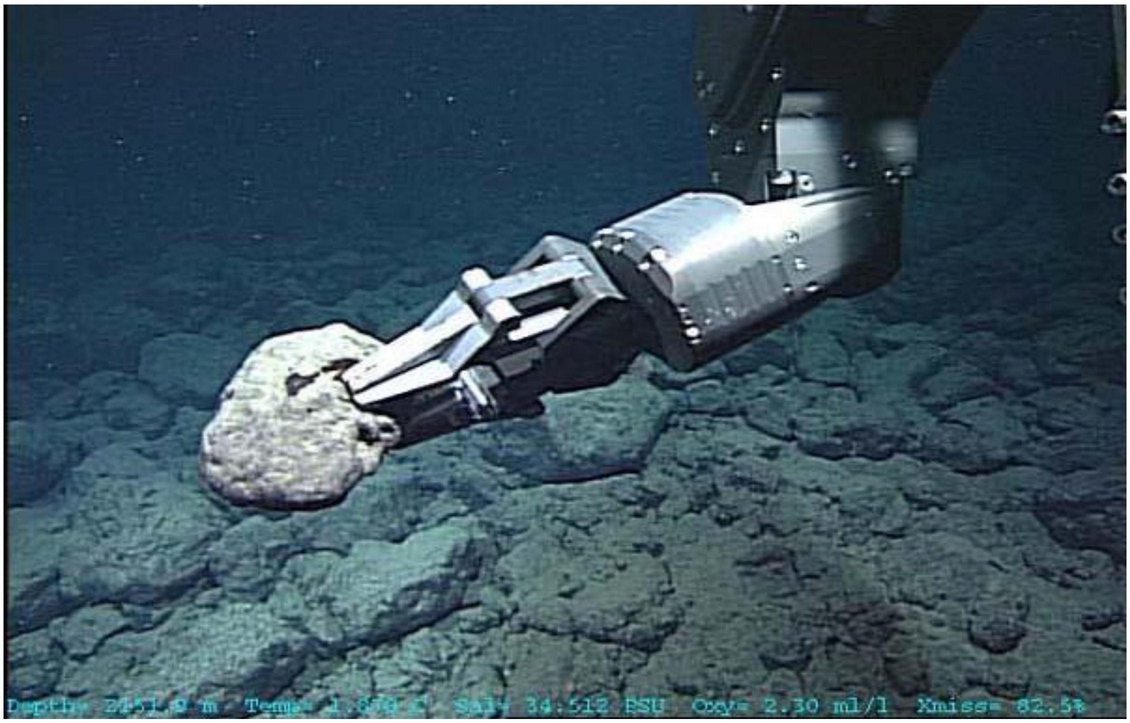


Plate 22: ROV Manipulator Arm

3.2.4 SPECIFICATIONS FOR REMOVING DEBRIS BY FLUSHING

Some larger debris although bulky could be harmless and easily flushable. Such objects could consist of bags, rags, hard hats, tires, etc. These items could be flushed safely with no risk of harming the pipes internal walls. On the other hand, small but heavy and dense debris and boulders could be quite harmful especially to the coal tar epoxy pipe lining if flushed directly inside the pipe.

The recommended approach is to limit the “salvage” operations to removal of the heavy and dense debris and to assess with the approval of the Engineer which debris could be safely flushed along with the sediments.

Flushing of the pipes shall not be authorized until a full video of the internal pipes conditions is provided by the Contractor in order to confirm the proper removal of all debris that could cause damage to the pipe. A full method statement shall be submitted to the Engineer for approval prior to such flushing.

3.2.5 QUANTIFICATION OF BULKY DEBRIS REMOVAL

Based on our ROV survey, the following critical debris were identified as having to be removed prior to flushing of the pipes.

Table 2: List of Debris Requiring Special Handling - Outfall Pipe

Chainage	Type of debris with description
250	Large debris: boulders of around 50 cm
423	Boulders of around 30 cm
470	Two concrete blocks of around 10 x 50 cm
473	Wood plank of around 30 cm x 100 cm
476	Two concrete blocks of around 10 cm x 50 cm Section of pipes Wood planks
507	Concrete block
642	Construction debris
1817	Concrete/boulder block

Table 3: List of Debris Requiring Special Handling - Overflow Pipe

Chainage	Debris Type and Description
230	Rubble and boulders
232	Steel pole
346	Boulder
381	Boulder
435	Metallic debris of around 30 cm
477	Concrete block of around 40 cm
482	Metallic piece
600	Metal piece of around 1 m
611	Pipe about 25cm in diameter and about 2m in length
833	Large sedimentation pile
840	Large concrete block

3.3 SEDIMENT REMOVAL FROM INSIDE THE PIPE

3.3.1 JUSTIFICATION

The main problem with the clearing of the pipes is related to the presence of large debris and the need to open the outlet end of the pipes in order to allow for the flushed sediments to be removed.

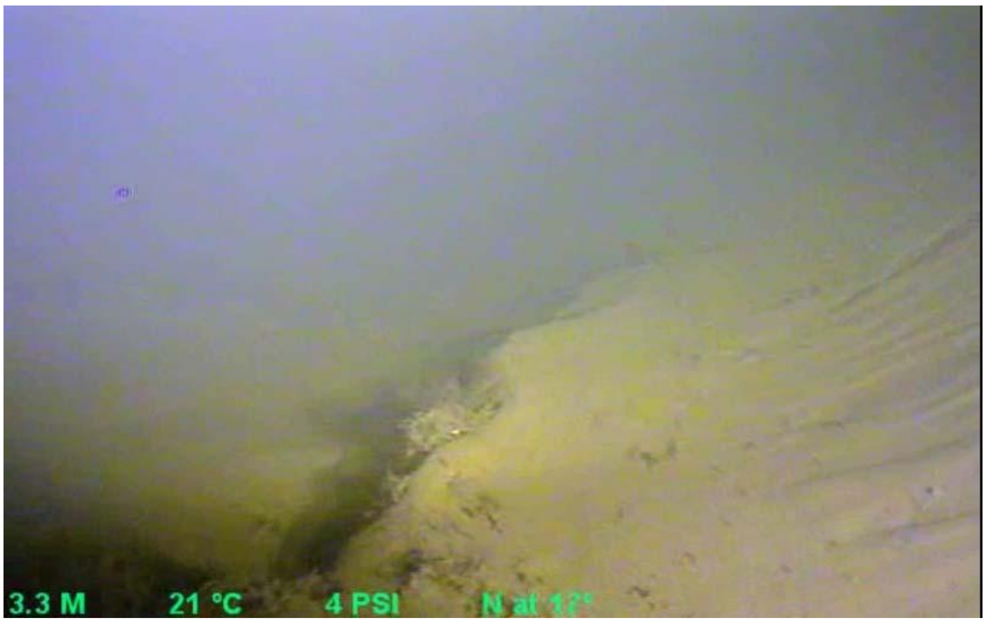


Plate 23: Extensive sediment deposits inside the Overflow Pipe

The main requirement and reasoning behind flushing the sediments is to inspect the bottom part of the pipes that were covered with such sediments and to remove accumulated debris and sediments prior to commissioning of the pipes. The decision to flush the pipes has to be weighed with the cost of such an exercise and the fact that once the wastewater treatment plant is commissioned, flushing of the pipes will take place in any case based on the high flow generated from the wastewater treatment plant.

One option could therefore be to limit internal cleaning to removal of the denser debris and to wait for the wastewater treatment plant to be operational before conducting an ROV survey of the pipes at a later stage once operational flushing is underway. On no occasion shall flushing of the pipes be carried out before the larger debris has been safely removed from the pipe. Flushing the pipes before the debris are removed could damage the pipes as the denser elements would ricochet against the pipes walls and could subject the inside of the pipes to some severe damage.

It should be noted that foreign element items such as concrete blocks, boulders, steel rods, pipes sections and rings have been identified inside the pipes during the internal inspection. Flushing these items over a distance of up to 1.7 km could result in significant damage to the internal pipes walls and coating or in clogging of the pipes.

EDTO does not recommend relying only on opening diffusers to release the flushed water and sediments. Based on the density and volume of the sediments found inside the pipes, the sediments under pressure through flushing could accumulate and be compacted inside the pipes and either block or create a sediment plug in diffusers that will prove to be very difficult to remove in the future.

With this concern in mind, EDTO believes that the end connection pieces at each pipe outlet should be removed to ensure that flushed sediments are comfortably discharged via the outlets into deeper water by-passing diffusers and maintaining their open status for use in the manner for which they were designed. The end plates would then be re-installed before the operational stage of the pipes enabling diffuser units to discharge in directions as intended by design. The removal of such end plates will require the dredging of the sediments from around these plates.

3.3.2 SPECIFICATIONS

Prior to flushing the pipes, the end piece connections at the downstream end of the pipes shall be removed. The removal of the end connection pieces will require the dredging of sediment from around the end connection pieces as the pipes are currently partially buried at their deep end.

Dredging Around the End Connection Pieces
The dredging zone required shall extend a sufficiently safe distance around the pipes in order to minimize the risk of caving in and in order to ensure that the flushed sediments can be dispersed beyond the pipes outlets. Dredging shall extend below the invert level of the pipes or as necessary in order to provide access for the removal of all bolts from the end connection piece and to minimize any penetration of sediments once the end connection piece will be reinstated. The Contractor must take care when conducting this activity, so as not to over-dredge and undermine the resting position of the pipes outlet.

Dredging is likely to be required over an area of 50 square meters centered along the pipes alignment and beyond as necessary to clear the areas so providing adequate access for divers to operate while removing and eventually re-fitting the outlet end-connection pieces.

Removal of the End Connection Pieces

The removal of the end connection pieces shall be carried out with care as it shall be re-installed after flushing and inspection activities are completed. If the end pieces are damaged during their removal, then replacement units shall be fabricated new for old. In both cases, the connection between the end piece and the pipes flange should be well sealed and to the satisfaction of the Engineer. In the event of damage to the existing plate or nut and bolt connections during removal of the end plates, the cost of replacing these items will without reservation be borne by the Contractor.

The Contractor is hereby informed of the likely difficulties that will be experienced in removing the end connection piece because of the presence of the old towing bracket which remains in place at the pipes outlet and the presence of assorted chains, cables and ropes that are entangled between the towing bracket and the first diffuser.

Flushing of the Pipes

Flushing shall not be done without the prior approval of the Engineer. The Contractor shall confirm that the remaining sediments and debris will not damage the pipes during flushing. The sediments identified inside the pipes are likely to be silty with gravel. The Contractor shall be responsible for mobilizing the appropriate pumping plant and equipment that will allow the effective flushing of the pipes and the removal of such sediments during the flushing operation. Flushing of the pipes shall be done in such a way as to remove at least three times the volume of the water already in the pipes.

The volume of the Outfall Pipe has been estimated to be in the order of 4,000 m^3 and the Overflow Pipe around 2,000 m^3. As such, the pumped volume of water from the Outfall Pipe shall be a minimum of 12,000 m^3 and the Overflow Pipe 6,000 m^3 minimum respectively.

Once the downstream end connection piece of the pipes have been removed, a pump with a minimum capacity of 1,000m^3/hr should be used to flush the pipes. The diameter of the supply pipe shall be 8 inches or larger.

It is recommended to use compressed air in order to assist the flushing. The pressure of the compressed air shall be greater than 7 bars in order to reach the end of the pipe and counteract the static pressure of the seawater at 63m depth. In order for the flushing to be effective, the inlet structure shall be perfectly sealed with a steel plate covering the full cross section of the pipe inlet. This end plate shall be fitted with holes to allow the connection of the pump and the compressed air. Any leak between the end plate and the pipe will result in water flowing out of the pipe at the inlet structure.

Flushing of the Overflow Pipe may not necessitate the use of compressed air as the pressure at the outlet of the Overflow Pipe is only 2 bars (less than 10m of water). Furthermore, there is less sediments in the Overflow Pipe than in the Outfall Pipe.

Water for flushing the Outfall Pipe shall be taken from the Overflow Pipe. Water for flushing the Overflow Pipe shall be taken from the Outfall Pipe. Otherwise, significant pressure drop would result from bringing the water from the sea.

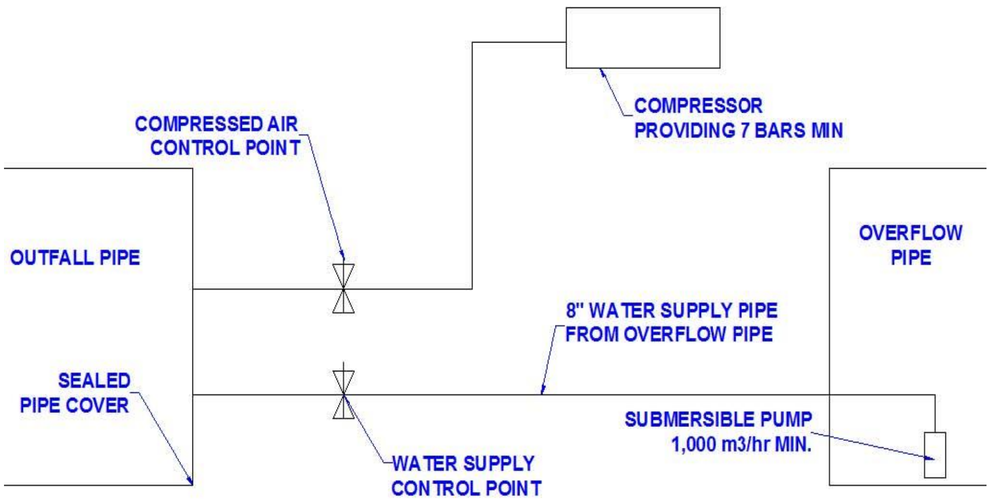


Plate 24: Flushing Diagram for Outfall Pipe

The Contractor shall be responsible to ensure that the system adopted will successfully flush all sediments from inside the pipes and properly expose the bottom part of the pipes for inspection.

Reinstatement of the End Connection Pieces

In the event that pre-operational flushing has taken place, once all debris has been removed and flushing of the pipes completed, the Contractor shall document the completion of these tasks by conducting a thorough ROV survey. Upon approval of the completion of the works by the Engineer, the Contractor shall reinstate the end connection piece at the downstream end of each pipe as per the original design.

The Contractor shall also install a new plate at the pipes inlet structures. The steel cover at the inlet structure is regarded as temporary and will be removed once the wastewater treatment plant is commissioned and the pipes commissioned. As such, the specifications of such a cover are not as critical as the permanent end plate to be re-installed at the downstream end and shall consist of 5 mm thick steel plate secured in position by at least eight bolts.

3.4 ROV SURVEY AFTER CLEANING

3.4.1 JUSTIFICATION

An ROV survey was conducted by EDTO of the interior part of the two pipes during the conditional assessment contract. Sediment deposits and debris were noted inside both pipes covering a portion of the bottom section of the pies. Therefore, EDTO's inspection of the pipes was limited literally to the visible internal surfaces, i.e. the parts not covered with sediments or debris.

In order to gain a full understanding on the pipes conditions including surfaces that are currently covered by sediments, EDTO recommends conducting two new ROV surveys inside each pipe; one after the debris have been removed (i.e. prior to flushing the sediments) and one after such sediments have been flushed from inside the pipe. The objective of the first ROV survey is to make sure that all debris that could cause damage to the pipes during flushing have been successfully removed. The objective of the second ROV survey is to document the proper flushing of the pipes and to assess the presence of any damage to the pipes in the part that was buried under the sediments.

3.4.2 SPECIFICATIONS

The specifications for the additional ROV survey can be similar to those of conditional assessment project as prepared by ACE. However, the focus will obviously be on the internal bottom part of the pipes in order to document the conditions of the areas that were previously covered by sediments or debris. In addition a brief scan of the internal upper section should take place to ensure no damage to surfaces has taken place as a result of Contractor's dense and heavier material removal.

The Contractor shall carry out an internal inspection of the entire length of each pipe, namely the sea Outfall and the Overflow Pipes and determine the full condition of the pipes after sediment and debris removal. The survey shall confirm the proper and complete removal of debris and sediments and shall document the conditions of the pipes interior especially for the part that was previously covered by sediments and debris.

Internal inspection of the pipes shall be done by sending an ROV equipped with low lux directional CCTV and adequate lighting. The survey shall be carried out from the shore end of the pipes and therefore the tether of the ROV shall be long enough to reach the end of each of the pipes (620 m for the Overflow Pipe and 1,777m for the Outfall Pipe). The ROV shall be rated to reach depths in excess of 65m.

The navigation of the ROV shall be managed remotely from the shore control station. The control station shall allow the navigation of the unit inside the pipes and the control of the lights and the control and change in orientation of the camera.

It shall provide real-time display of the camera vision and record at least the following information:

- Video display
- Water depth
- Water temperature
- Water pressure
- Compass direction, and
- Date and time for Chainage synchronization

Chainage shall be added to the video through time synchronization of the ROV tether deployment and the internal clock of the navigating ROV.

3.4.3 QUANTITIES

The quantities to be surveyed are 1,777m for the Outfall and 620 m for the Overflow Pipe. A sufficient number of videos shall be produced in order to cover all internal and cleaned surfaces of the pipes.

4 PIPES REPAIR

4.1 CATHODIC PROTECTION

4.1.1 JUSTIFICATION

The steel of the pipes was found to be in good structural condition and with minimal visible signs of rust evident on surfaces accessible for inspection. This has been most likely possible due to a high quality internal lining and external coating of the pipes together with the provision of sacrificial anodes in the form of zinc blocks. According to the SNE as-built drawings, zinc anodes were provided at approximately every 12 m on each of the two pipes. They were placed in dedicated openings in the concrete coating reaching the exterior of the pipes. The dimensions of these anodes openings are as follows:

Outfall Pipe:

- Length: 19.5 cm at the top and 24.5cm at the bottom
- Width: 9 cm at the top and 14 cm at the bottom
- Depth: 20.5 cm
- Anode Weight: 38 kg
- Number of Anodes: 143
- Total weight of Zinc: 5,434 kg

Plate 25: Typical sacrificial anode in the concrete coating of the Overflow Pipe now partially filled with silts

Overflow Pipe:

- Length: 27.5 cm at the top and 32.5 cm at the bottom
- Width: 8 cm at the top and 13 cm at the bottom
- Depth: 26.5 cm
- Anode Weight: 60 kg
- Number of Anodes: 53
- Total weight of Zinc: 3,180 kg

The exposed zinc anodes were found to be consumed. Therefore, the pipes are no longer considered to be suitably protected against corrosion and have become dependent solely on the protection provided by the internal lining and external coating which, although still in good structural condition, would typically lose its corrosion protection properties over time.

EDTO has attempted to estimate how long the sacrificial anodes installed on the pipes have lasted in order to estimate the duration that they have been in place with no protection. It is difficult to calculate an exact date at which the zinc is likely to have been consumed as such consumption rate depends on a number of factors and data not available for review at this stage including:

- Degree of purity of the zinc
- QA/QC procedures on the installation of the zinc anodes
- QA/QC procedures on the installation of the internal and external coating and the concrete
- Sea, mud and fill resistivity

Based on a number of scenarios developed by EDTO, it can safely be assumed that the zinc applied to the pipes is unlikely to have lasted more than 20 years.

Suitably protecting the pipes against corrosion is therefore extremely critical at this stage. This is considered by EDTO to be one of the most urgent rehabilitation measures affecting the on-going lifespan of the pipes as any future degradation would be accelerated in the absence of an appropriately re-instated cathodic protection system.

In addition to protecting the pipe, protection of the exposed reinforcing steel of the concrete surrounding the pipes is also critical. This steel can either be protected by implementing the concrete repairs presented in Section 4.4 or by including such steel in the dimensioning of the cathodic protection system.

Cathodic protection is an electrochemical means of corrosion mitigation. The process minimizes the anodic dissolution of a metallic structure by reducing the electrical potential energy difference between the anodic and cathodic sites on the surface of a metal when placed into a conductive electrolyte. Cathodic protection could be provided either through sacrificial anodes which was the method used previously or by impressed current:

- **Sacrificial anodes** provide a metallic source that is typically consumed by corrosion before steel by providing a source of cathodic protection current due to the higher electrical potential energy of the anode versus the structure intended for protection. This is considered to be the simplest method prior to commissioning at a time when the pipes are not in operation and without the benefits of regular maintenance. Sacrificial anodes are usually made of an alloy of magnesium, zinc, or aluminum. Once the pipes are connected to the wastewater treatment plant, an impressed current system could then be recommended.

- **Impressed current Cathodic Protection** (ICCP) systems adopt anodes of a type that are not easily dissolved into metallic ions, but rather sustain an alternative reaction, oxidization of the dissolved chloride ions. Power is supplied by an external power unit. Impressed current systems require continuous operation, follow-up and maintenance managed from a manned station by dedicated technicians responsible for monitoring the pipes during the operational phase.

The advantages and disadvantages of each of the two aforementioned systems in the context of the Daoura outfall are detailed in the following sections and summarized in the following tables.

Table 4: Advantages and Disadvantages of Sacrificial Anode System for the Daoura Outfalls

Advantages	Disadvantages
Almost No Maintenance Required	Offshore Installation Required
More Secure option	
No external power sources needed	
Easy Operation	

Table 5: Advantages and Disadvantages of ICCP for the Daoura Outfalls

Advantages	Disadvantages
Permanent System	Security Concerns
No Offshore Installation Needed	High Maintenance
	Difficult to operation without a functional plant
	Issues with electric supply
	Generator would be required

As such, EDTO's recommendation is to re-instate at the earliest stage possible cathodic protection to the pipes in the form of an effective sacrificial anodes system in order to safeguard the continued lifespan of the pipes in the interim period prior to the introduction of the wastewater treatment plant. The amount of anode material would be optimized based on the anticipated date at which the plant is expected to be commissioned and therefore an impressed current installed. Anode material geometry and quantities and anode locations would be to the extent possible in line with the original design intent. It shall provide sufficient protection until such a time as when the wastewater treatment plant would be operational. At that stage, an impressed current system could be installed in a more feasible way.

The proposed design is based on data available and reasonable assumptions made. Optimization of the design could be achieved based on a focused field survey that would be aimed at quantifying some of the assumptions made.

Proprietary sacrificial anode systems are available on the market. These cannot be specified in such a report. However, the Client should welcome such systems as long as they meet the overall design objective of the project.

Based on discussions with the Engineer and the CDR, two options will be developed for the sacrificial anode system. One is for the sacrificial anodes to last 3 years and the second is for the sacrificial anode system to last 5 years.

During this period, sufficient data would be collected on the actual performance of the cathodic protection system in order to allow to properly dimension at a later stage an ICCP that would be suitable for the period when the pipes are in operation with water flowing within them. The period of monitoring will also allow us to quantify potential losses resulting from the proximity of the Bourj Hammoud dump site and any metal object or structure in contact with the pipe.

Dimensioning an ICCP system at this stage will have to be based on a number of assumptions. If these assumptions are too conservative, then the price of the ICCP would be too high. If on the other hand, the assumptions are too aggressive, then the system may not operate properly and may have to be replaced. Regardless, and in order to meet our contractual obligations, a design for ICCP will be provided in this report.

Furthermore, dimensioning the ICCP at this stage would result in a system that will be obsolete and too small once the pipes are commissioned. On the other hand, dimensioning the ICCP based on future demand will result in an overdesign, over consumption and increase in operation and maintenance budgets until such a time when the pipes are commissioned.

The ICCP presented in this report is for a 25 year design life. It is based on assumptions that could be made as a result of our knowledge of the pipe. Alternatively, a dedicated study should be conducted in order to quantify such parameters such as:

- Voltage along the pipes and the response of the pipes to electrical induced current,
- Current drain along the pipe,
- Electric continuity and resistance of the pipe,
- Test the continuity of reinforcing steel,

- Confirm the absence of contact between the pipes and the reinforcing steel,
- Soil resistivity,
- Water and mud resistivity.

4.1.2 SACRIFICIAL ANODE SYSTEM

Areas

The Outfall Pipe is 1,777m long with a diameter of 1,700 mm. The area of the pipe is about 9,490 m^2. The Overflow Pipe is 620 m long with a diameter of 2,000 mm. The area of the Overflow Pipe is 3,895m^2.

Pipes Coating

According to the SNE as-built drawings and contract specifications, both pipes were coated externally with hot bitumatic enamel fiber-glass L.R. 8 tissue and 6 mm average thick bitumatic impregnated thermoglass. The external pipes joints are protected with servi-wrap primer with servi-wrap HD cold applied tape. Furthermore, the Outfall and Overflow Pipes have an external reinforced concrete coating of 21 and 27 cm respectively – a thickness which was to be varied on site by the Contractor to suit negative buoyancy. The concrete is in place mainly for the provision of structural protection to the pipes together with also partial protection against corrosion as chlorides can find their way through the concrete.

Internally, the pipes have been lined with coal tar epoxy of average thickness 0.5 mm. The conditional inspection has revealed that the internal coating remains in good structural condition. With the exception of areas where the external concrete cover is damaged (or where the pipes are buried and no inspection of the pipes exterior was possible), the visible external protection of the pipes was found to be generally in sound condition.

It should be noted however, that the internal lining and external factory applied coating's resistance decreases greatly with age and directly affects structure-to-electrolyte resistance. As such, we propose to consider minimal the electric resistance offered by the coating material.

As the sea Outfall Pipes are already 25 years old, the need for future replacement of the pipes may be accelerated by the continued degradation of the coating conductivity resulting in a direct acceleration of the pipes degradation in the future. As such, further delay in the proper protection of the pipes by cathodic protection will certainly result in accelerated degradation of the pipes when compared with past degradations. Furthermore, assuming that the cathodic protection sacrificial anode system is reinstated, further delay in the commissioning of the pipes may lead ultimately to the need for eventual pipes replacement in the event that the recommended pre-commissioning sacrificial cathodic protection reinstatement expires due to continued delay.

Material in Contact with the Pipes

The first 200 m of the pipes are buried in saturated fill materials. The salt content of the groundwater at the inlet of the pipes was found to be zero probably due to groundwater being heavily charged following the winter months. However, the salinity is expected to increase to seawater salinity as we approach the sea and on-shore as groundwater elevations decrease through the dry summer months. As such, EDTO has assumed that at various times during the year, the entire pipes lengths are in contact with salty water.

During the ROV internal inspection, water inside the Outfall Pipe was found to be of lower salinity for the first 1,000 m and salty thereafter throughout the remaining length through the zone of missing diffusers. The water at the inlet and inside the Overflow Pipe was found to have an elevated salt content from the day that it was exposed. However, since the Outfall Pipe is open at depth in the sea and both pipes are open on-land, EDTO has assumed that for the next five years, salty water will be present inside both pipes.

By design, the reinforcing steel of the concrete covering the pipes does not seem to be in electrical contact with the pipe. As such, the pipes and reinforcing steel are considered distinct for the purpose of cathodic protection. Should the reinforcing steel be in contact with the pipes, then significant current will be drained towards the reinforcing steel.

Although the Bourj Hammoud dump site is only a few meters away from the pipes, we have not assumed that any metallic waste would be in direct contact with the pipes.

Current Density

Since salt water is generally considered to be in overall contact with the pipes, the current density (amount of current required per square foot of steel to be protected) required to change the structure potential to -1.08 V will be taken as 30 mA per square meter.

Electric Continuity

Since all pipes welds appear to be intact following inspection by ROV, it is not critical to install zinc anodes in each of the existing 12 m spaced openings. This will avoid having to dredge or remove quarry run from over a large portion of the pipes. As mentioned in the conditional assessment report, over 1,000 m of the Outfall Pipe is currently covered either by quarry run fill material or under sediments. Similarly, over 550 m of the Overflow Pipe is covered with either sediments or quarry run.

Both pipes are therefore considered to be structurally continuous. This is an important aspect as any discontinuity in the pipes in any shape or form would have required the installation of anodes on each separated section as a short term fix until structural continuity of the pipes could be fulfilled by repair. The electrical continuity of the pipes in their current form will facilitate the distribution of the anodes in sections of the pipes that are readily accessible and not buried under sediments or fill materials. Electric continuity could be confirmed through a separate survey.

Type of Anodes

Zinc was used as the original anode material. EDTO has been requested to provide a cathodic protection system in line with the previous design that was implemented. There are several grades of zinc that can be used as sacrificial anodes. In the case of the pipes and their current critical status, a higher grade zinc is considered to be essential; otherwise, there is a risk that the sacrificial anodes will have a lower corrosion potential and therefore the steel of the pipes may start rusting in parallel with the poorer quality sacrificial anode. Alternatively, other anode material could be considered.

The natural corrosion potential of iron is about -0.55 to -0.85 volts in seawater. The selection of the material for the anode must have a more negative corrosion potential for the net difference (driving potential) to be optimized. Below are a few examples of natural corrosion potentials of suggested anode metals in seawater:

- Zinc -1.2 volts
- Alloy Magnesium: -1.55 volts
- High-Manganese Magnesium: -1.75 volts

Low quality zinc or other low quality alloys would have a corrosion potential too close to that of the pipes and would thus be ineffective. We have assumed in our analysis the use of zinc anodes.

Calculation Model

As discussed with the CDR, the original approach is to install sufficient sacrificial anodes for the pipes to be cathodically protected for a period of three to five years at which time the headworks are expected to be operational allowing a more permanent cathodic protection facility to be introduced in the form of an impressed current system.

Using a current density of 30 mA per square meter and a coating efficiency based on the age of the pipes being in the water for 25 years, the current requirement was estimated to be in the order of 32 mA per linear meter of pipe for the Outfall Pipe.

Assuming zinc anodes with -1.2V corrosion potential are used and adopting a steel corrosion potential of -0.85V for the pipe, the total resistance is calculated to be about 11Ω per linear meter of pipe (for the Outfall Pipe) assuming a very low electrical resistance provided by the coating itself based on its aging.

Dimensioning of the Anodes based on 5 years protection

The amount of zinc required to provide protection for the interim period of a further 5 years was calculated as 2.6 Tons for the Outfall Pipe that can be distributed into strings of anodes connected to the accessible anode brackets located on exposed lengths of the pipe. A similar analysis of the Overflow Pipe resulted in the requirement to provide 1 Ton of zinc distributed into strings of anodes connected to the accessible anode brackets of the pipe.

Unless special mat anodes are provided, a maximum number of anode brackets should be exposed in order to distribute the zinc anodes as uniformly as possible on the pipes in accordance with the initial design.

- Outfall Pipe: The Outfall Pipe is currently completely buried from Chainages 255 to 884 and from Chainages 1220 to 1620. Therefore, only 748 m of the pipe is accessible. Even within this distance, most of the anode brackets located in the void left by the degraded zinc are covered by sediments, so removal of these sediments exposing the surviving bracket will be required.

  As anode brackets are positioned on the pipe at regular 12 m intervals, this computes to 62 brackets being potentially accessible for use following localized cleaning of sediments. We would also recommend adding an additional zinc anode at the inlet structure of the pipe (bringing the total number of accessible anode locations on the Outfall Pipe to 63). As such, the 2.6 tons of zinc would have to be distributed into 41 kg anode strings to be connected at 63 locations.

- Overflow Pipe: The Overflow Pipe is currently completely buried from Chainages 230 to 795. Therefore, only the last 50 m of the pipe are accessible. Even within this distance, most of the anode brackets are covered by sediments, so localized cleaning of the sediments exposing the surviving brackets will be required.

  As anode brackets are situated on the pipe every 12 linear meters, this computes to four brackets being potentially accessible (plus one at the inlet structure). As such, the 1 ton of zinc would have to be distributed into 200 kg anode strings connected at 5 locations. In order to spread the load further over a longer length of pipe, additional brackets could be exposed in order to distribute the zinc over at least 10 locations in total with 100 kg at each location. This would entail a limited length of dredging to be carried out in order to expose the currently buried as-built anode locations.

The anodes do not have to be manufactured in a way to fit the openings originally designed for cathodic protection. Anodes of various shapes and sizes are readily available on the international market. Their shapes may be optimized for current production. The anodes will have to be connected to each in order to achieve the required weight of the string of anodes. They would be placed or buried alongside the pipes and will be connected by means of an electric wire on the pipe mounted brackets to be exposed as shown on Drawing ED-263-D-11.

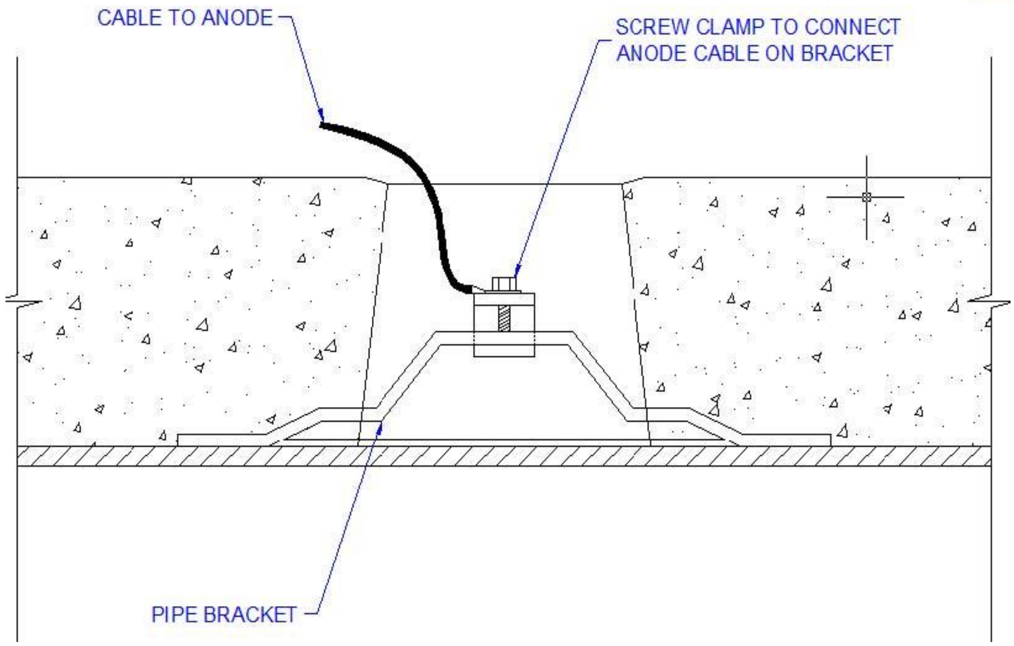


Plate 26: Connection of the anode cable to the pipe

Alternatively, where possible, some of the anodes could be connected to the uncoated section of diffusers. The connection on the brackets can either be by means of welding or special clamp. The estimated locations of the anodes are shown on Drawing ED-263-D10.

Dimensioning of the Anodes based on 3 years protection

The amount of zinc required to provide protection for the interim period of a further three years was calculated as 1.6 Tons for the Outfall Pipe that can be distributed into strings of anodes connected to the accessible anode brackets or diffusers located on exposed lengths of the pipe.

A similar analysis of the Overflow Pipe resulted in the requirement to provide 650 kg of zinc distributed into strings of anodes connected to the accessible anode brackets or diffusers of the pipe. Unless special mat anodes are provided, a maximum number of anode brackets should be exposed in order to distribute the zinc anodes as uniformly as possible on the pipe.

- Outfall Pipe: Based on the same principle as outlined earlier for the five years duration and a total of 63 anodes, the 1.6 tons of zinc would have to be distributed into 25 kg anode strings to be connected at 63 locations. This size the anode could fit inside the space provided on the pipe. However, anodes available on the market may have different shape and would require connection using cables as presented in Drawing ED-263-D-11.

- Overflow Pipe: Based on the same principle as outlined earlier for the five years duration and a total of ten anodes manufactured, the 650 kg of zinc would have to be distributed into 65 kg anode strings connected at each location. This would entail a limited length of dredging to be carried out in order to expose the currently buried as-built anode locations.

4.1.3 SPECIFICATIONS

The cathodic protection anodes shall be sized in order to ensure that they have the right shape and surface area allowing the discharge of enough current to protect the structure and appropriate weight to last the desired lifetime when discharging this current. Design and installation of the cathodic protection system shall be in accordance with good marine practice in corrosion protection and in compliance with the latest revisions of the following Codes & Standards:

- API RP 17B: American Petroleum Institute
- API RP 17J
- API RP 5L
- ASTM A 36: American Society of Testing of Materials
- DNV RPB 401: Det Norske Veritas
- DNV RP-F103

Anodes shall be made of high grade zinc or equivalent (Al-Zn-Mg) alloy suitable for the protection of steel in a buried/submerged marine environment. They shall not have any mercury content. The potential of the sacrificial alloy material shall be -1.08V or more negative and referred to a silver/silver chloride reference electrode. The Electro-chemical efficiency of anode material shall be minimum 2500 AH/kg after four (4) days of operation as per DNV RP B 401.

The anodes shall be free from mechanical defects like cracks, shrinkages, excessive flash, surface projections, laminations, cold laps, surface slag, etc. as consistent with good casting practice. All anodes shall be delivered with material certificate from the Vendor stating batch identification number and chemical analysis.

Anode to steel insert shall be checked for electrical continuity. The resistance between the connector and the body of the anode shall not exceed 0.005 Ω.

Anode installation procedures shall be submitted for the approval of the Engineer prior to mobilization. Welding shall be conducted in accordance with qualified procedures. All surviving brackets on the pipes shall be visually inspected by an independent dive team to assure that they have been properly cleaned prior to welding.

All connections are to be inspected by an independent dive team. This inspection shall ensure a firmly attached bond and electrical continuity.

4.1.4 QUANTITIES

If the anodes are installed concurrently with the installation of the diffuser covers or the actual diffusers, some saving could be achieved by installing the anode material on the diffuser or the diffuser plate above water. This would save the installation cost under water of the anode.

4.1.5 IMPRESSED CURRENT SYSTEM

Designing an Impressed Current Cathodic Protection (ICCP) is more critical than designing a sacrificial anode system. Indeed, factors of safety and assumptions inherent to sacrificial anode systems and the relative low cost of the material compared to the installation cost usually result in overdesigns of such systems at almost the same price.

On the other hand, overdesigning ICCP systems results in major increase in capital and operating costs; as such, it is important to collect more field data to properly design an ICCP system. Data collection for ICCP could be provided by the monitoring of the performance of a sacrificial anode system. Alternatively, it should include a number of field investigations including but not limited to the following:

- Water and soil resistivity survey,
- Monitoring pipeline electric potentials both on-shore and offshore,
- Current drainage survey recording pipeline potential both on-shore and offshore
- Extent of current loss in the ground due to the proximity of the Bourj Hammoud Dump site.
- Site investigation to location a suitable location for the ground bed other cathodic protection equipment.

In the absence of such data, the design presented in the following section is based on assumptions that can be made at this stage. In the event that the Engineer and the CDR decide to install an impressed current system for the outfall and Overflow Pipes, we strongly recommend that either a sacrificial system is installed and monitoring of the performance of the system is done to allow an optimization of the ICCP or that a field investigation be conducted in order to collect such information prior to completing the detailed design of the system.

ICCP systems require the on-going supply of electricity, the safeguarding of the equipment and the monitoring of the system components. Even if electricity is supplied by the Lebanese grid, a backup generator would still be required as power cuts are frequent. It will be difficult to quantify the operating cost of the facility as such a budget will be highly dependent on the fuel budget required to operate the generators.

Land ownership would first have to be resolved as permanent installations will have to be installed above and below ground. Access to the site should be unhindered for the site operatives. Access is currently controlled by the Municipality of Bourj Hammoud, who seems to be unsupportive of the project in its current form. This issue would have to be resolved in case ICCP is to be installed and operated.

The safeguarding of the equipment usually means the provision of a guards as the generator and other components could easily be stolen. Finally, the monitoring of the system components requires technical presence at least once a week to ensure that all components are operating properly and to conduct the required preventive maintenance and repair tasks inherent to such a system. Full-time presence on-site is likely to be required since a power generator will have to be provided and operated at least on a part-time basis. ICCP would be suitable once the wastewater treatment plant is built and operative staff and electricity are available on a full-time basis.

The operator of the ICCP will also be faced with technical problems emanating from the sea. Indeed, in case of any accidental collision damage with the pipes by a vessel anchor where a diffuser could be removed or the concrete cover could be damaged, the current demand of the pipes would increase drastically. This will result in a voltage drop that may not be compensated by the system. As such, the operator cannot be held liable for maintaining a set protection level of the pipe.

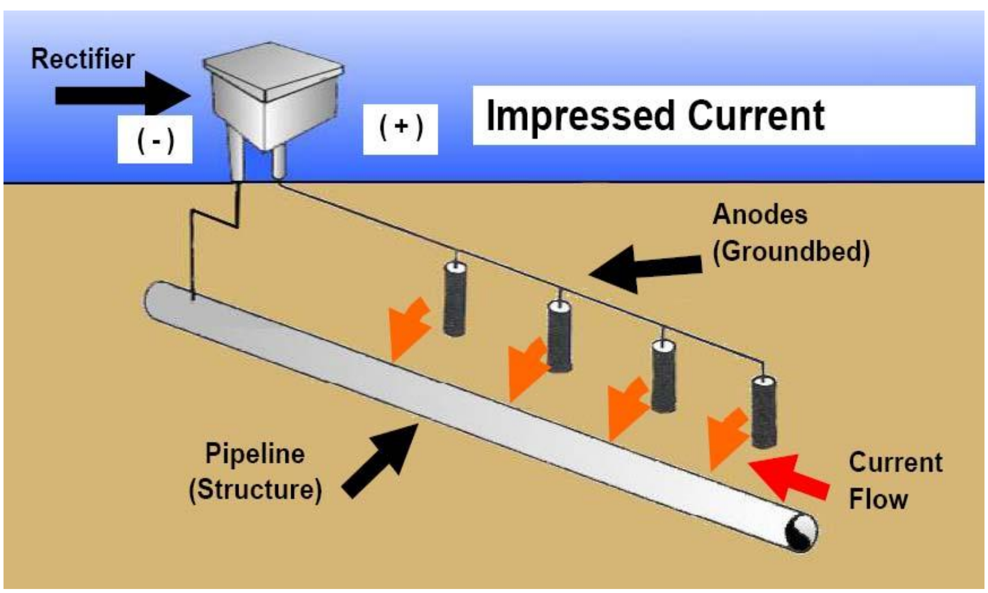


Plate 27: Operating Principle of ICCP

Although capital cost of the ICCP could appear low when compared to sacrificial

anodes, it is important not to underestimate the operating and maintenance costs of such systems that most of the time result in the tilting of the economic feasibility towards sacrificial anodes. ICCP have higher operating and maintenance cost. They are inherently more prone to failure or operating errors (switches inadvertently turned off). The system needs to be monitored frequently and yearly services are usually required. Due to the lack of available AC power and monitoring / maintenance, EDTO strongly feels that an ICCP system is not applicable at this stage.
Unlike sacrificial anodes that rely on direct contact of the anodes with the pipes, ICCP relies on the transfer of the electrical current through the ground (Plate 27). As such, the current efficiency is highly dependent on the nature of the fill in the vicinity of the pipe. Presence of metallic objects will create stray current diverting electricity from the pipe.

We have identified a number of critical areas that will result in negative interference with the ICCP system. These are presented in Plate 28; they include general waste deposits in the open area around the pipes, the presence of the Bourj Hammoud Dump to the immediate east of the site that includes large amounts of demolition waste, the presence of DEMCO steel yard to the immediate south of the pipes and the presence of debris in the sea.

Plate 28: Known interference with the ICCP

In addition the presence of a mooring steel chain and three steel fuel pipes crossing over the Outfall Pipe could attract current and divert a portion of the ICCP away from the pipes.

For all the reasons outlined herein, EDTO does not recommend the installation of a cathodic protection system based on impressed current technology at this stage. The design presented in the following pages have been presented at the insistence of the Engineer and the Client.

Dimensioning

Since the ICCP system will be a permanent system to be used when the pipes are in use. The dimensioning of the system has included the addition of the headworks piping system leading to the wastewater treatment. The actual equipment within the future wastewater treatment plant are considered to be electrically isolated from the pipes.

The ICCP system further considers that the pipes are open and that sewerage water is flowing inside them.

Design Life

The design life for the impressed current cathodic protection system shall be 25 years.

Current Drains

The outfalls must remain electrically isolated from foreign metallic structures such as earthing/grounding systems; concrete rebar etc to ensure no protection current is drained to nearby structures. Electrical isolation protection must also be installed for shock protection during any high voltage electrical interference (lightning strikes etc).

During the construction of the new proposal wastewater treatment plant, effective isolation flanges are required to be installed onto the outfalls to ensure no electrical current drain path is connected to the site earthing system.

At all isolated flanges, Isolating Spark Gaps will be installed which provide lightning equipotential bonding, in case of lightning strikes affecting the outfalls.

Design Current Densities

The outfalls are considered to be in 4 sections when considering the current densities required to provide adequate cathodic protection:

1. Onshore Sections
2. Offshore Sections buried
3. Offshore Sections non-buried depth <30m
4. Offshore Sections non-buried depth >30m

The following table details the current densities adopted required as per DNV standard B401.

Table 6: ICCP Current Densities

Pipeline Section	Current Density Required (mA/m^2)
On-shore buried	25
Off-shore buried	25
Offshore Sections non-buried depth <30m	170
Offshore Sections non-buried depth >30m	140

Design Temperatures

On completion of the wastewater plant, when the outfalls are in operation they are not expected to operate at temperatures greater than 40°C.

Cathodic Protection Potentials

The effectiveness of the cathodic protection systems is determined by the potential shift of the protected structure from its naturally occurring corrosion potential. The following "instant off" or IR free potentials should apply in the cases. The IR free potential value for protection of onshore pipelines shall be in line with DNV RP-F103 or other applicable standards.

- Steel in soil -0.850 to -1.200 Volts versus $Cu/CuSO_4$ reference electrode
- Immersed steel -0.800 to -1.150 Volts versus Ag/AgCl reference electrode

Soil Conditions

Soil data for the onshore and offshore sections of the outfalls has been taken from the geotechnical report submitted under separate cover by EDTO. Soil data was supplemented by a resistivity survey conducted in August 2010. The resistivity of the soil has been measured up to 100 m (groundbed studies) and also at the depth of the pipes burial, offshore soil samples and water samples were collected and their resistivity measured.

The resistivity's recorded during the site survey show that that surface of the soil is highly resistant. With increasing depth, the resistivity decreases markedly until around 50 m depth. This decrease of resistivity with depth is related to a shallow water table as the location is very near to the shoreline. The onshore section of the outfalls are buried in the water table thus are continuously submerged by saturated soil.

Local Conditions

Local infrastructure was inspected to evaluate possible adverse effects on the cathodic protection system of the outfalls. It was noted that three steel oil transport pipelines cross the main outfall around Chainage 1000. It was noted also that these pipelines are resting on the concrete coating of the outfall, so no electrical shorts are currently present. These MEDCO operated oil pipelines are likely to be protected by a sacrificial cathodic protection system. Monitoring of these MEDCO pipelines will be required before and after commissioning of the new ICCP system.

Coating Breakdown

The Outfall Pipe lines are currently 25 years old, and require a permanent cathodic protection solution for the next 25 years. Therefore, the current coating breakdown ratio is based on a 25 year old pipe. The coating breakdown in 25 years will be calculated using a 50 year life of the coating (50 years after installation).

It has been assumed that the new section of outfalls, which is required to be installed between the existing inlet flanges and the new water treatment plant, will be coated with a high quality coating.

Initial Current Requirements

The current required to achieve adequate cathodic protection depends on the environment to which the structure requiring protection is exposed to. Increased levels of H+, aeration, agitation and temperature can lead to increased current requirements. Therefore, if a structure is buried, it is less exposed and would require less current per meter squared when compared to a structure which is submerged in seawater. Initial current requirement was calculated to be in the order of 50 Amps.

Maintenance Current Requirements

The initial current demand is required to fully polarize the outfalls if they become de-polarized, this initial current is much larger than a polarized current (maintenance current) as the deposits caused by cathodic protection (which act as a barrier to reactants) have to be reformed. The ICCP system has to be able to provide the outfalls with the initial current in case the system is left de-energized for a large period of time. Once the deposits are present, the required current is substantially reduced. Maintenance current requirement in 2010 was calculated to be 16 Amps. The maintenance current requirement in 2035 was calculated to be in the order of 32 Amps based on a further natural deterioration and breakdown of the electric conductivity of the pipes coatings.

It should be noted that systems are dimensioned based on Maintenance current requirements. Therefore, power cuts should not occur during the lifetime of the project as significantly larger currents would be required to reinitiate the system.

Current Attenuation

When cathodic protection current is provided to the outfall, current from the soil/seawater flows towards the outfall from the groundbed. The current flow along the outfall and the potential change are greatest at the drain point (nearest point between the outfall and the groundbed). The decrease in voltage and current away from the drain point is due to the attenuation.

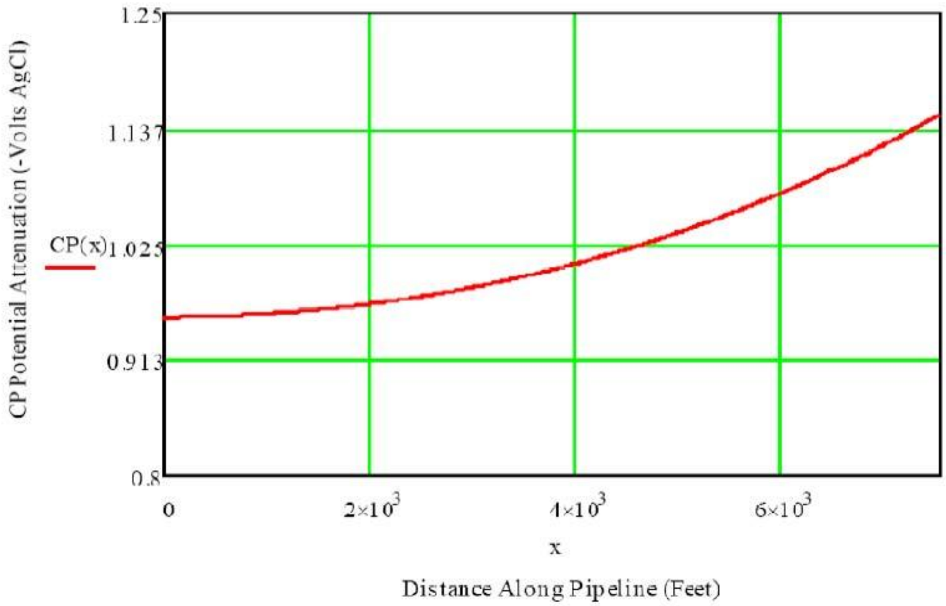


Plate 29: Attenuation Calculations

The pipes resistance, coating conductivity, level of polarization and the line length, affects the attenuation rate. In order to determine the number and location of impressed current groundbeds required for adequate protection, it is necessary to carry out attenuation calculations. Results of the current attenuation calculations are presented in the following plate. The current attenuation calculation was conducted in order to confirm the current distribution from the proposed groundbed location.

<u>Groundbed Calculations</u>

The proposed groundbed will be a Multiple Vertical Anodes in Parallel. This system requires the installation of 20 Nos. Canister Anodes installed with a 3.0 meter separation between the individual anodes installed in a 25 Ω-m resistivity soil. The individual dimensions are 3m length by 0.3m diameter.

Due to the installation of multiple vertical anodes, interference occurs between the individual anodes therefore interference and loss of conductivity has been included.

<u>Anode Material</u>

Impressed current anodes shall be Mixed Metal Oxide (MMO) type. The anode groundbed (multiple vertical type) shall be installed near to the wastewater treatment plant. The location of the groundbed takes into account the availability of AC power, soil resistivity, static water levels and optimum current distribution along the outfalls.

The groundbed configuration will consist of multiple shallow vertical anodes perpendicular to the outfalls.

The Canister anodes consist of a Mixed Metal Oxide (MMO) anode on a titanium substrate. The anodes will be centre connected (compression fitting) and sealed tubular type installed within a metallic canister which is backfilled with petroleum coke breeze installed within a canister backfilled with petroleum coke breeze. Due to the stability of the MMO anode it is anticipated that no consumption will occur of the MMO, however the coke breeze will be consumed at a rate 0.9 kg/Amp/Year (typical).

These Canister Anodes (3 m length x 0.2 m diameter) will house a single 2 m length x 0.02 m diameter MMO Anode, and be backfilled with 82.56 kg of petroleum coke breeze.

The Multiple Vertical Anodes will be installed in a Parallel groundbed, this groundbed will consist of 20 Nos. 3m long canister anodes which are individually connected by two positive junction boxes.

The groundbed will be installed along the northern perimeter of the proposed location for the new water works treatment plant. The total length required will be around 80 m. The anodes will each require a 6 m deep hole drilled at least 0.4 m in diameter and the canister anode would be installed (top of the anode must be at least 3 m below grade), in the hole and backfilled with either sand or soil (not crusted stone).

Groundbed Consumption Rate

The groundbed consumption rate takes into consideration the operation of the ICCP for the next 25 years with increasing coating breakdown between now and the end of the design life of the system.

The groundbed consumption rate will be based on the mean of the maintenance current in 2010 and in 2035:

- Maintenance Current Required in 2010: 16 Amps
- Maintenance Current Required in 2035: 32 Amps
- Average = (16 + 32) / 2 = 24 Amp

The Average Total Groundbed output over the 25 years will be 24 Amps distributed by 20 anodes, the individual anode output being 24/20 = 1.2 amps per anode. With a consumption rate of 0.9 kg/amp/year over the 25 year life of the anodes is it expected that 27 kg of the backfill will be consumed.

The individual canister anodes will have a redundancy of ~70% consumption (the large redundancy is required to increase the size of the groundbed thus lowering the overall resistance of the system).

Circuit Resistances

Due to the length and size of the outfalls and their environment, the resistance to earth can be disregarded as it will be an insignificant amount. Therefore, the only other resistances which need be considered are the cable resistances between the Transformer Rectifier and each of the outfalls and the anodes.

Power Supply

DC Power supplies shall be transformer rectifiers. The sizing of the rectifier will be 50V – 100A unit. A 100 amp Transformer Rectifier is considered required as the additional current will allow for future losses and any anticipated current drains. The cathodic protection system will consist of a single power Transformer Rectifier source which will be connected to the groundbed and the outfalls.

The transformer rectifier (TR) and other associated equipment will be installed in non-hazardous areas. The transformer rectifier should comply with IEC 60076, IEC 60726 and IEC60947. It should be of a special design for cathodic protection service and should accept three phase input of a 400 Volt-AC ±5 %. The transformer rectifier shall be variac controlled, oil cooled type which is supported by its own structure with its own sunshade.

Installation will be outside near to the pipeline isolation flanges. The unit will be supplied with 2 years spares. All terminals, connectors, bolts and contact hardware will be of copper, brass or stainless steel. Locking devices should be used at all bolts and screw connections.

Monitoring Junction Boxes

Monitoring Junction Boxes (MJB) shall be installed at the inlet of each pipeline, the MJB will also function as a drain point (negative return to the Transformer Rectifier) and bonding facilities for the two outfalls. Alternatively a negative junction box will be required.

The anode junction boxes will be cabled back to the Transformer Rectifier (+ terminal). The negative terminal of the TR will be connected to the two outfalls via a negative junction box or monitoring junction box. The TR will be located near to the isolation flanges within the proposed wastewater treatment plant. The negative junction box will be located near to the isolation flanges within the proposed wastewater treatment plant; it will house the negative drain connections from the Outfall Pipe lines and two return cables to the TR. The positive junction boxes (2 Nos.) will be installed along the northern boundary of the proposed wastewater treatment plant. Each positive junction box will terminate 10 anode header cables and a single return cable to the transformer rectifier.

Monitoring junction boxes will be installed near to the existing flanges, one large enclosure will be used which will be installed at the DEMCO Steel boundary wall. The required cable connections will be trenched back to the outfall flanges where they will be terminated. A structure connection will be required and a permanent reference electrode $Cu/CuSO_4$ type will be installed at each outfall, along with a polarization coupon.

At the isolation flange installed at the proposed wastewater treatment plant, two structure connections will be required on each outfall. One is required for the negative drain cable, and the second is a monitoring cable. Within the junction box will be a bond cable which will allow the bonding of the two outfalls via the negative drain cables. All monitoring cables will be 10mm² XLPE/PVC/SWA/PVC.

All monitoring test stations and junctions boxes will be housed in stainless steel enclosures with a minimum ingress protection of IP65. The junction boxes will be fitted with secure locking devices to prevent unauthorized entry.

Reference Electrodes

Permanent reference electrodes will be of the copper / copper sulfate type. The electrode will be suitable for a minimum period of 25 years. The reference electrode shall comprise of a terracotta handmade container housing copper sulfate crystals and copper electrode. Unique semi permeable design ensures excellent electrode/earth interface connection under most conditions.

The reference electrode shall also conform to:

- Weight: Approx. 25 kg gross
- Cable tail: 40m of 10mm² XLPE/PVC/SWA/PVC
- Design Life: 25 years.
- Stability: ± 5 mV
- Temperature Range: 0 °C to 55 °C

DC Polarization Coupons

Polarization coupons should be employed along with all permanent reference electrodes. The coupons will be supplied with a 10cm² defect (typical of a defect on this coating); this coupon can then be disconnected to measure accurate cathodic protection potentials.

Cables

Impressed current anodes cables and all other cables will be tin-coated stranded single core copper. The cable specifications will be as per the following table.

The minimum rating for all cables and wires should be 600/1,000 Volt grade. Negative cables will be black and positive cables red. Monitoring cables, coupon cables and reference electrode cables will be provided in black. The cables must be identified with stainless steel markers to show their identification, origin and function (provided at site).
All outfall connections will be made via a welded plate connection. They will be required at the negative drain points (at the flanges within the proposed water works) and at the monitoring points (near to the old flanges on the original outfall side). The connections will then be coated using Bicaseal (epoxy easy to apply coating).

Table 7: Cable Types

Cable Use	Minimum Conductor Size (mm2)	Cable Insulation Specifications
TR-Junction Box	95	XLPE/PVC/SWA/PVC
Monitoring Cables (used for coupons, test stations and reference electrodes)	10	XLPE/PVC/SWA/PVC
Anode Feed Cables	10	XLPE/PVC/SWA/PVC
Bonding Cable Between pipelines	95	XLPE/PVC/SWA/PVC

Groundbed Installation Procedure

The impressed current groundbed to be installed requires the installation of vertical canister anodes. The groundbed requires the drilling of 20 Nos. 6m deep boreholes, these will need to be drilled at a larger diameter than the anodes (the anode diameter is 300mm). Once the holes are drilled, a temporary casing may need to be installed until the canister anodes are inserted to stop the borehole sides from caving in. If a casing is installed, it should be removed following the successful installation of the canister anodes.

The correct anode should be selected for each of the boreholes with cable leads of sufficient length to reach the Positive Junction Box (the anodes all have different cable lengths which depend on their installation distance from the Positive JB). The anode leads shall be continuous from each anode to the terminal box. All cable leads shall be checked for defects along their entire length before installation. Patching or repairs of the insulation or dragging of the anode lead wires shall be not be permitted.

All cable leads should be numbered and permanently marked. Anode cables to be coiled on individual reels and the reels mounted on an A frame (cable reel support block frame which will allow easy uncoiling of cable from reel) allowing gradual cable unreeling during lowering of the anode assembly in the hole. The lowering of the anode shall be done in a way not to stress the anode cable or anode/cable connection. The anodes must be lowered to the bottom of the 6m borehole. The remaining top 3 m section of the borehole shall be backfilled with sand or soil, crusted stone is not acceptable.

Measurements and records of the resistance of each anode, and the whole groundbed to remote earth shall be taken; the measurement will be performed by a cathodic protection supervisor, using the 3 Pin Method as per the below diagram:

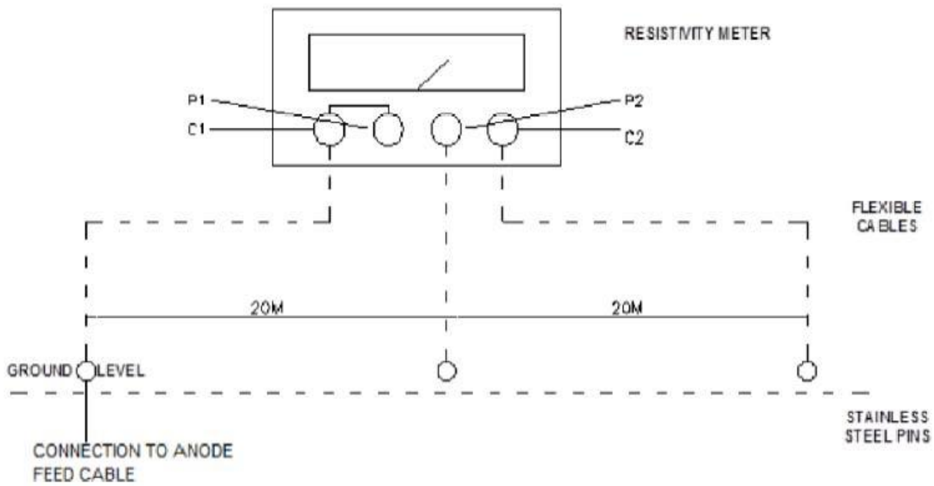


Plate 30: Measurement of Resistance

Cathodic protection cables shall be directly buried within suitable trenches as required. Cable routes shall be devised by the installation contractor and approved by the site authority. All cable trenches shall be provided with cable warning tape as required. All cables must be laid with a 0.5m cove

Quality Control

The Contractor who will install the ICCP shall operate a quality control and assurance system and all project works shall be carried out in accordance with the requirements of the project QA/QC procedures.

A Senior CP Project Engineer (NACE certified or Member of the Institute of Corrosion or other suitable body) with a minimum of 5 years experience shall be assigned to this project.

Health & Safety

The Contractor who will install the ICCP shall carry out all work in accordance with the HSE & Construction (Health, Safety & welfare) Regulations 1996.

Training

Training shall be given by the Contractor who will install the ICCP to the Company operating and maintenance staff to enable them to maintain the CP system in accordance with current Codes of Practice and Standards.

- Training shall include (as a separate scope of works):
- Basic CP Theory
- Installation, commissioning & periodic monitoring
- Use of instruments
- Measurements at CP Stations
- Measurements at CP monitoring points
- Data recording & updating.
- Fault finding methods

Bill of Materials

The following bill of material has been developed for the proposed ICCP system.

Table 8: Bill of Materials

Item	Description	Unit	Item Qty
1	Transformer rectifier unit rated 50V / 100Amp, 400V AC - 3 Phase Input	No.	1
2	Power Generator (additional backup generator required in case of no connection to the power grid)	No.	1
3	ICCP Anode - Canister Type with 2m X 0.05m MMO anode installed within a 3m X 0.3m Canister backfilled with petroleum coke breeze - supplied with varying lengths of $10mm^2$ XLPE/PVC/SWA/PVC cable (to suit installation)	No.	20
4	Spark Gap - to be installed over isolation flange c/w 1m cable and mounting brackets	No.	2
5	95 mm_2 XLPE/PVC/SWA/PVC cable - feed and drain cable	m	700
6	10 mm_2 XLPE/PVC/SWA/PVC cable for monitoring	m	100
7	Negative Junction Box - c/w with internals, IP65, 31 Stainless Steel	No.	1
8	Positive Junction Box - c/w with internals, IP65, 316 Stainless Steel	No.	2
9	Monitoring Junction Box - c/w with internals, IP65, 316 Stainless Steel	No.	1

10	Cu/$CuSO_4$ permanent reference electrode c/w 50 m of 10mm^2 XLPE/PVC/SWA/PVC cable tail	No.	2
11	Polarization coupon c/w 50 m of 10 mm^2 XLPE/PVC/SWA/PVC cable tail	No.	2
12	1 x 95mm^2 XLPE/PVC/SWA/PVC bond cable (10m length)	No.	1
13	Consumables for connections to pipeline (cable lugs and installation equipment)	Lot	1
14	Connection Coating (Bicaseal)	No.	10
15	Electrical accessories to complete (cable warning tape, lugs, PVC tape etc)	Lot	1
16	2 Year Operation Spares	Lot	1
17	Construction Spares	Lot	1

EDTO has already voiced on a number of occasions its concern regarding the implementation at this stage of an impressed current system based on the difficult situation with the Bourj Hammoud Municipality, the absence of electricity and the wastewater treatment plant and therefore a dedicated operator, the need for on-going operation and maintenance with approved yearly budgets and the need to protect the equipment against vandalism.

Furthermore, the presence of asbestos-containing material (ACM) on-site should not be underestimated from a health and safety exposure point of view. The EIB may not allow the funding of projects where full time staff assigned to this operation could be exposed to such substances. A detailed environmental assessment of the site should be conducted prior to considering the impressed current option.

Operating the impressed current system will have its own challenges as a number of environmental and legal issues would need to be such as:

- Land ownership – we understand that the land is not owned by the CDR at this stage,
- Connection to the electric grid or not,
- Quantification of fuel need based on connection to the grid and power shortages,
- Site access and relation with the Bourj Hammoud Municipality,
- Security issues and vandalism,
- Marine damage that could drain supplied current,

- Health and safety,
- Guaranteed operating budgets,
- Force majeure

These are crucial elements that may prevent the implementation of the system in the absence of the wastewater treatment plant.

4.2 INSTALLATION OF MISSING DIFFUSERS

4.2.1 JUSTIFICATION

As stated in the conditional assessment report, 14 diffusers are missing from the Outfall Pipe at this time. Of the 14, three have been completely severed from the pipe crown and 11 have been detached at the horizontal flange level. These diffusers are located in water depths ranging between 40 and 62.5 m. One more diffuser is partially opened. The following table summarizes the current status of the diffusers which are to be replaced and the depths indicated are relative to the horizontal flanges when still in place or to the crown of the pipe where the diffuser has been completely severed at that level.

Table 9: Outfall Pipe Diffusers

Diffuser	Actual Chainage	Status	Alignment	Depth (m)
2	2015	Detached at the Flange	West	62.3
4	1995	Severed at Pipe Crown	West	60.8
5	1985	Severed at Pipe Crown	East	60.1
8	1955	Detached at the Flange	West	57.9
10	1935	Detached at the Flange	West	56.5
12	1915	Detached at the Flange	West	55.1
13	1910	Detached at the Flange	East	54.7
14	1900	Detached at the Flange	West	54.0

16	1880	Detached at the Flange	West	52.6
20	1840	Severed at Pipe Crown	West	50.1
26	1780	Partially open	West	45.8
27	1770	Detached at the Flange	East	45.6
32	1720	Detached at the Flange	West	42.6
34	1700	Detached at the Flange	West	41.5
36	1680	Detached at the Flange	West	40.4

Aside from design intent, reinstatement of the missing diffusers is important as a means to close the openings which currently encourage the intake of extensive marine growth in the form of fauna and flora to the inner pipe surfaces. Such marine growth and oxygen ingress inside the pipe has a detrimental effect on the coal tar epoxy lining and will inevitably accelerate the rusting of the pipe. Should budget constraints prevent the installation of the diffusers until the pipes are commissioned, then temporary sacrificial plates should be installed where diffusers are missing. The actual installation of the replacement diffusers would then be postponed to a later date. The overall cost of this option would be clearly higher than installing the diffusers in full at this stage, however, cash flow and budgeting considerations may dictate the adoption of this option. The specifications for the plate replacement technique are presented in Section 4.3.

Regardless of the method used, it is highly recommended to close the openings of the pipe in some way in order to stop the extensive marine growth currently migrating across the inner surfaces of the pipe.

Although the manufacturing of the diffusers is relatively straightforward, their actual installations will require patience, skill, an acute awareness of the conditions on-site likely to be encountered and a highly experienced dive/salvage team. Below are some of the challenges that will have to be faced by the Contractor:

- Finding a way to reconnect the diffusers severed at the pipe crown. Several methods are available to the Contractor who should propose a system that provides a suitable seal which is structurally effective between the diffuser and the pipe and is fit for purpose.
- The horizontal flange may be bent, twisted or buckled although not obvious to the naked eye. A mould for each flange may have to be made to ensure that the new diffuser is seated properly and sealed effectively.
- Working environment (depth, zero visibility, entanglement in marine debris, current variability, etc.).
- Safety time limitation under water.

- Bulk and weight of the diffuser while positioning by derrick mounted barge from the surface and parachutes underwater in zero visibility working conditions.
- Underwater concrete grouting, drilling, epoxy anchoring and welding as required.
- Experienced technical divers working in tandem at all times for safety reasons.

4.2.2 SPECIFICATIONS

Prior to installations, the diffusers shall be coated externally using a hot bitumatic enamel fiber-glass L.R.8 tissue and bitumatic impregnated thermoglasss of 6 mm thickness. Each diffuser to be reinstated shall be wrapped prior to being lowered in the water in a purpose built protective jute or a similar suitable hard-wearing fabric as available in today's market, capable of protecting the diffuser surface from marine incrustation.

The inside of the diffusers shall be lined internally with coal tar epoxy of 0.5 mm thickness.

All linings, coatings and wrappings specified herein (or equivalent systems approved by the Engineer) are to be applied by the Contractor to the satisfaction of the Engineer prior to lowering the diffuser in the water. The Engineer shall give his approval on the manufacturing of each diffuser before they are lowered in the water.

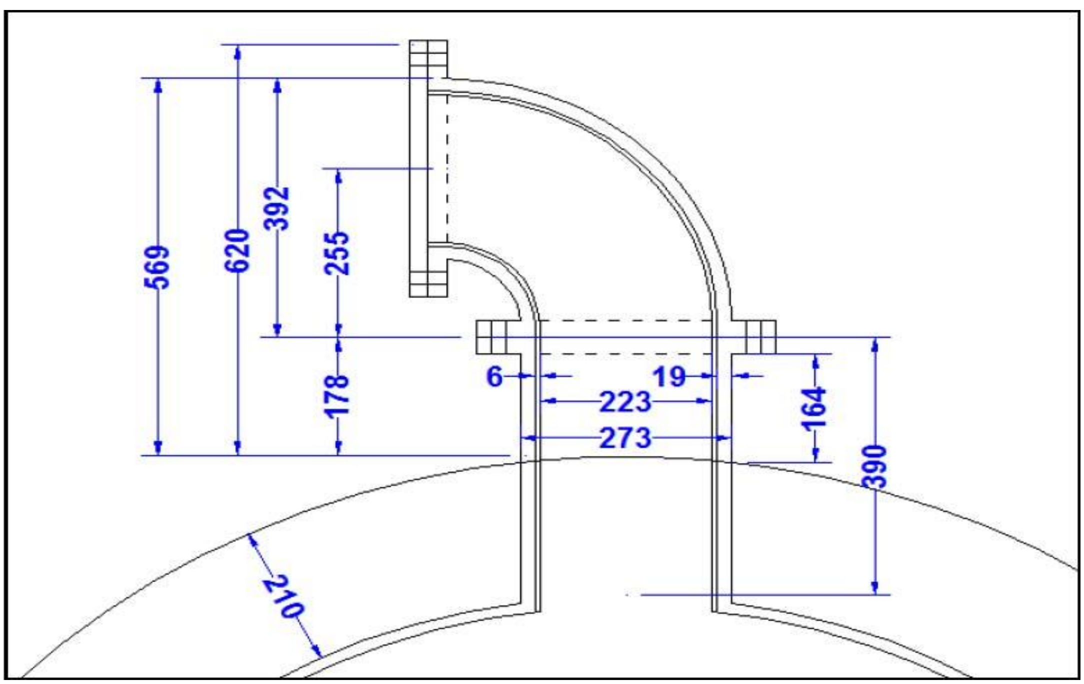


Plate 31: Typical Outfall Pipe diffuser

4.2.3 SUGGESTED METHODOLOGY

The following is a suggested methodology for the installation of the diffusers. The Contractor shall be authorized to propose alternative methods based on his experience and the equipment he plans on mobilizing.

Diffusers Detached at the Horizontal Flange

For diffusers severed at the horizontal flange, the Contractor shall first survey or take an imprint of the remaining horizontal flange in order to assess whether it has been twisted, bent or damaged in any way as a result of the wrenching of the diffuser at the time of detachment. Repair to the horizontal flange in-place shall be kept to a minimum as it will require extensive work at depth. If the deformity of the flange can be compensated by a gasket, then the diffuser could be manufactured with a straight horizontal flange and the deformity will be taken up by the gasket. If the deformity cannot be taken by a gasket, then the flange on the pipe shall be molded in order to manufacture a diffuser with an end plate matching the deformity of the flange. EDTO's assessment of the diffusers as inspected in 2009/2010 indicates that gaskets should be able to take up the deformity.

Incrustation shall be removed from the remaining diffuser 'stump' surviving in place at:

- the horizontal flange upper surface,
- the flange underside,
- the interior of the diffuser below the flange.

There is no need to remove incrustations from the external surface of each diffuser below the flange providing that there will be no effect on the fixing or performance of the diffuser.

Diffusers shall be manufactured in accordance with the original specifications. Replacement units shall be fitted with a temporary cover or end plate at the mouth of the diffuser unless the installation is carried out immediately prior to the time when the pipe will be commissioned.

Installation of the diffusers shall be carried out by lowering the diffuser on location using a barge mounted crane. Once near location, the diffuser will be supported underwater by inflatable buoys in order to assist the divers in the handling of the diffuser at depth. The east/west orientation of the diffusers shall be respected. The diffuser's horizontal flange shall be reattached at the horizontal flange using 12 bolts. Bolts, washers and nuts shall be made of stainless steel. The bolts shall be 10 cm in length with 2.3 cm wide hexagonal heads and 1.5 cm diameter stems.

The Contractor shall be responsible for achieving the required verticality of the diffusers once installed. He shall document the work done with pictures and video and submit a diffuser installation form confirming the as-built conditions of the diffuser on completion of the work.

Diffusers Severed at the Pipe Crown

For diffusers severed at the pipe crown, several methods can be proposed by the Contractor based on his experience and the equipment he has proposed to mobilize. Our recommended approach, as improved by the Engineer, is provided herein as a suggested method only. The dimensions of the diffuser shall be as indicated in Plate 32 in the event that EDTO's proposed approach is adopted. The main constraint is to maintain the same height of the diffuser over the pipe in accordance with the original design.

EDTO recommends manufacturing a diffuser unit with a re-designed horizontal flange bolted over a neoprene circular saddle to assist in mounting the replacement diffuser on the curved crown of the Outfall Pipe. The thickness of the diffusers and the vertical end plate should be as per the original design. The diffuser would be bolted by means of 12 threaded dowels drilled and bedded in the concrete skin of the pipe. The diffuser would have a neck extending within the concrete opening for added stability and in order to minimize the contact of the sewerage with the concrete pipe cover.

A detailed sketch of our proposal is presented below.

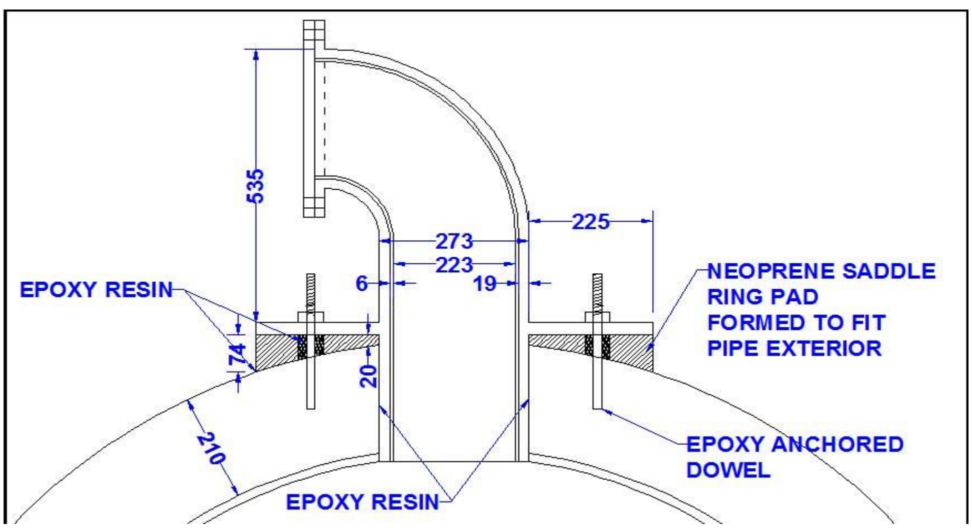


Plate 32: Proposed diffuser installation on the concrete pipe skin

In order for the diffuser to be at the same level as the other ones, the distance from the newly fabricated flange to the top of the diffuser will be 535 mm.

The outer shape of the concrete pipe is circular and irregular. It will not be possible to manufacture a diffuser bottom flange to match the shape of the concrete pipe crown. In order to secure a tight fit between the flange and the concrete pipe, we propose the installation of a special shaped neoprene ring pad that will fill the space and be compressed by the dowels.

Prior to installation of each new-build replacement diffuser, the external surface of the concrete that will be in contact with the neoprene saddle shall be wire brush cleaned and scabbled in order to improve the bonding with the epoxy. The cleaned concrete surface shall be inspected for damage in order to ensure that the dowels are installed in sound concrete. If the concrete is found to be sound, 12 holes would be drilled in the reinforced concrete of minimum diameter 20 mm (depending on exact specification of the epoxy proposed to be used by the Contractor). If the concrete is found to be damaged (as in the case of Diffuser No. 20), patch repairs to re-instate the concrete coating will take place to the approval of the Engineer prior to commencing installation of the saddle and the dowels.

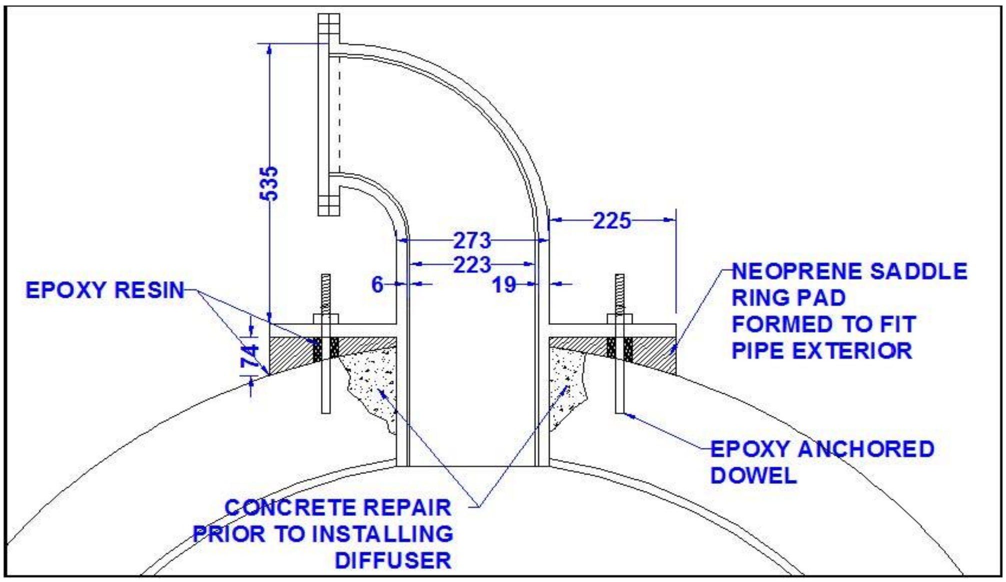


Plate 33: Concrete to be repaired prior to installing dowels and diffusers (Diffuser No. 20)

The dowel holes shall be drilled to a depth of 100 mm in the existing concrete. The alignment and verticality of these holes would be achieved by drilling them through a temporary guide plate. Dowels 15 mm in diameter and threaded in their upper part will be installed with epoxy inside the drilled holes and allowed to set. Recommended underwater epoxy is HIT-RE-500 or equivalent.

Following completion of the concrete surface preparation and the installation of the dowels, the neoprene saddle will be placed over dowels. Resin will be placed between the saddle and the concrete pipe and in the annulus space between the dowels and the neoprene pad. The annulus space shall be at least 45 mm in diameter. The thickness of the epoxy in this annular space shall be 10 mm lower than the level of the saddle in order to ensure proper compression and seal of the neoprene pad (Plate 34).

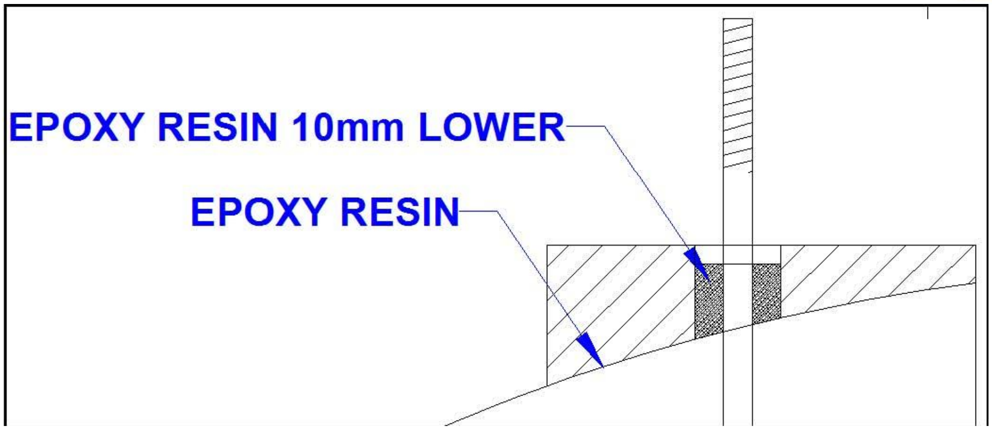


Plate 34: Fixing of the saddle with epoxy resin

Immediately after placing the epoxy, the saddle shall be firmly clamped to the pipe through the central opening of the ring. Once the epoxy has set (depending on the exact specifications of the underwater epoxy used), the clamps shall be removed and the new-build diffuser installed. Recommended underwater epoxy is HIT-RE-500 or equivalent.

The saddle will be 723mm external diameter. The thickness of the neoprene saddle will be variable in order to marry the shape of the pipe crown. It shall be 74mm on the outer edge in the transverse direction and 20 mm at the internal edge and the outer edge on the longitudinal direction.

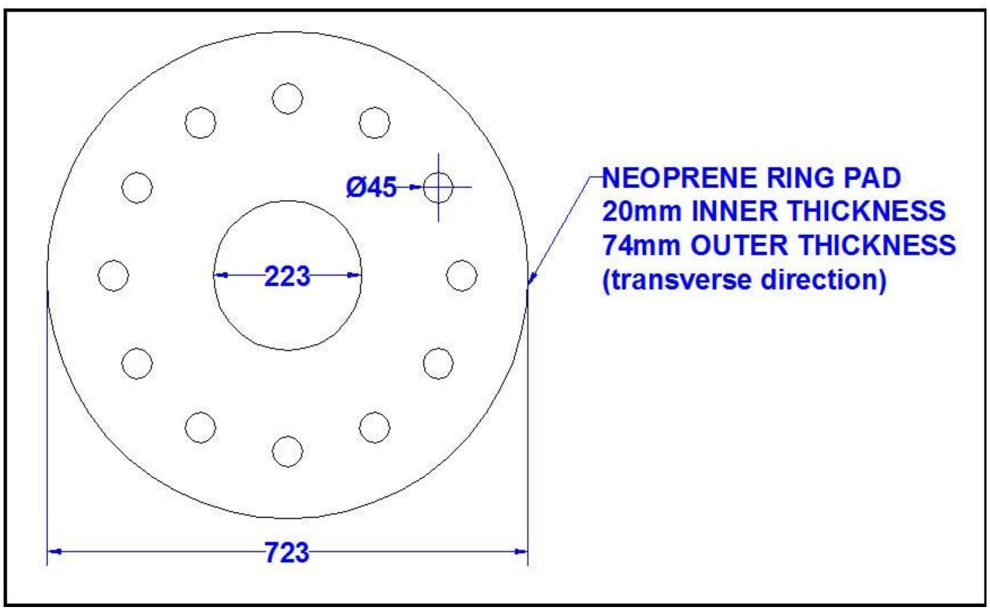


Plate 35: Neoprene Saddle to be installed between the pipe and the diffuser

Installation of the diffusers shall be carried out by lowering the diffuser on location using a barge mounted crane. Once near location, the diffuser will be supported underwater by inflatable buoys in order to assist the divers in the handling of the diffuser at depth. The east/west orientation of the diffusers shall be respected. The neck of the diffuser shall be lowered into the hole after epoxy has been coated, but such epoxy has set on the outside of the diffuser. The diffuser shall be attached at the horizontal flange using 12 bolts. Bolts, washers and nuts shall be made of stainless steel, shall be dimensioned as necessary to suit the methodology detailed in this recommendation and in all cases will provide a structurally secure fixing to the Outfall Pipe concrete coating so as to maintain the design capabilities of the diffuser loading while under operation (all subject to the approval of the Engineer).

The Contractor shall be responsible for achieving the required verticality of the diffusers once installed. He shall document the work done with pictures and video and submit a diffuser installation form confirming the as-built conditions of the diffuser on completion of the work.

Partially Open Diffuser

As stated in the Conditional Assessment Report, Diffuser 26 is partially opened on the horizontal flange. The top part of the diffuser seems to be in good condition. Therefore, at this stage, replacement of the diffuser is not considered. Significant incrustation was noted on the flanges. Therefore, full assessment of the condition of the horizontal flanges was not possible.

Repair to this diffuser shall include the unscrewing or cutting of the bolts holding the diffuser on the horizontal flange and the assessment of the conditions of the two horizontal flanges in accordance with the section above which details the repair requirements for diffusers detached at the horizontal flange. Depending on the extent of damage to the horizontal flanges, repairs can be conducted ashore on the diffuser flange or alternatively through the manufacturing of a dedicated gasket to take up any deformity between both upper and lower horizontal plates.

Once the flanges are ready to be re-assembled, re-installation of the diffusers shall be carried out by lowering the diffuser on location using a barge mounted crane. Once near location, the diffuser will be supported underwater by inflatable buoys in order to assist the divers in the handling of the diffuser at depth. The east/west orientation of the diffusers shall be respected. The diffuser shall be re-attached at the horizontal flange using 12 bolts. Bolts, washers and nuts shall be made of stainless steel. Bolts shall be 10 cm in length with 2.3 cm wide hexagonal heads and 1.5 cm diameter stems.

The Contractor shall be responsible for achieving the required verticality of the diffuser once installed. He shall document the work done with pictures and video and submit a diffuser installation form confirming the as-built conditions of the diffuser on completion of the work.

4.3 TEMPORARY CLOSING OF DIFFUSERS WITH PLATES

Closing of the diffusers one way or another is highly recommended in order to limit the growth of marine life already invading the inside the pipe and in order to limit the ingress of oxygen that will lead to rusting of the internal part of the pipe. Should the necessary budget for replacing the diffusers not be available in the short term, EDTO strongly recommends installing temporary patch-plates over the void in the concrete coating and remaining diffuser ‘stumps’ in order to introduce an effective seal from outside. These plates would have to be removed and actual diffusers would have to be installed prior to commissioning of the pipes.

Under this case scenario, the prime objective will be to limit the extent of work to be carried out underwater as the measures recommended are temporary in nature.

4.3.1 SPECIFICATIONS

Diffusers Detached at the Horizontal Flange

For diffusers detached at the horizontal flange, a circular steel patch-plate of 20 mm in thickness and 387 mm in diameter shall be manufactured with at least four symmetrically located holes to accommodate four 15 mm diameter bolts. The holes shall be aligned with the holes of the horizontal flange.

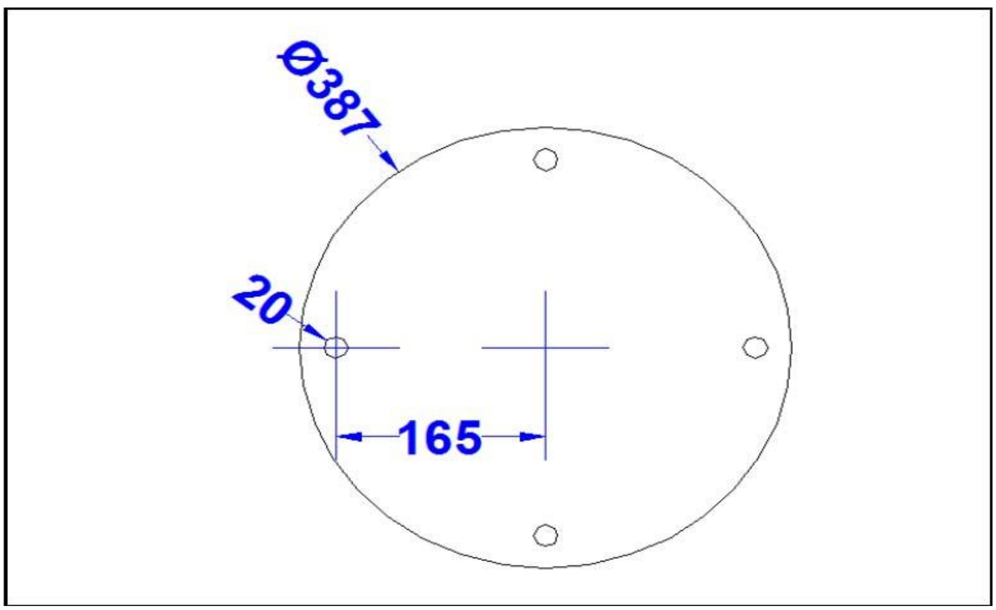


Plate 36: Temporary patch-plate - Horizontal Flange Connection

The horizontal flange upper and lower surfaces shall be cleaned from incrustation and marine life. A gasket shall be used to improve the efficiency of the seal between the temporary patch-plate and the flange. The thickness of the gasket will depend on the extent of damage incurred on the existing flange. A gasket with a minimum thickness of 20 mm shall be used.

The patch-plate shall be bolted on the existing horizontal flange with the gasket properly placed in between. Bolts, washers and nuts shall be made of stainless steel and shall be 10 cm in length with 2.3 cm wide hexagonal heads and 1.5 cm diameter stems. In case the remaining horizontal flange on the stump is bent, the bolts shall be installed in such a way as to allow the temporary patch-plate to bend and follow the shape of the flange

Diffusers Severed at the Pipe Crown

For diffusers severed at the pipe crown, a circular steel plate of 20 mm in thickness and 550 mm in diameter shall be manufactured with at least four symmetrically located holes to accommodate four 15 mm diameter bolts. The holes shall be at least 237 mm from the center of the plate.

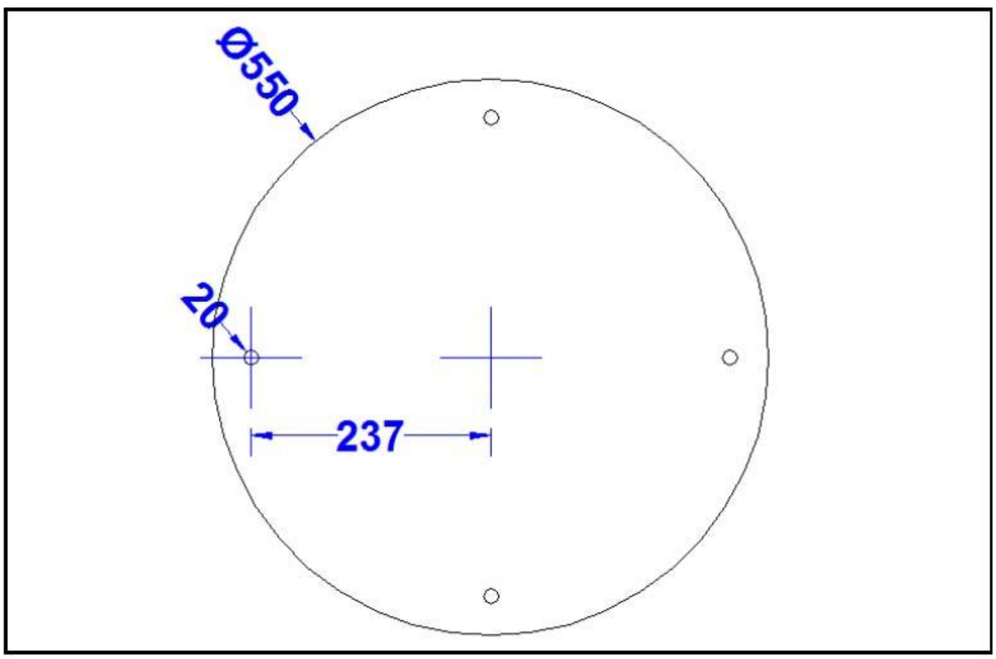


Plate 37: Temporary patch-plate - Pipe Crown Connection

Four dowel holes shall be drilled in the concrete with a diameter of at least 20 mm (depending on exact specification of the epoxy proposed to be used by the Contractor). The dowel holes shall be drilled to a depth of 100 mm in the concrete. The alignment of these holes would be preset based on a guide plate as shown in Plate 37.

Once the holes have been drilled, epoxy shall be injected in the dowels holes. Immediately after placing the epoxy, the steel dowels shall be installed and firmly pressed in position. Once the epoxy has set (depending on the exact specifications of the underwater epoxy used), the plate shall be installed.

The plate shall be installed over a 30 mm ring rubber gasket that will provide a proper seal between the temporary patch-plate and the outer surface of the existing concrete coating as shown in Plate 38.

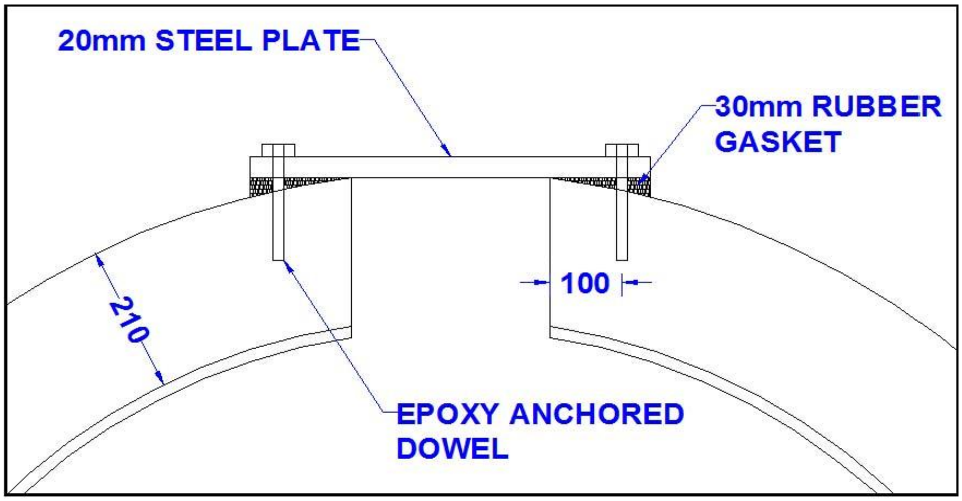


Plate 38: Temporary Pipe Crown Patch-plate

Alternatively, a simpler solution could also be considered where the fixing of the plate could be made through a central screw attached to two or four horizontal arms. The arms would be introduced through the opening of the diffusers inside the pipe. As the central screw is tightened, the arms would press on the underside of the top of the pipe and create the seal. The use of the gasket would still be required in order to ensure a proper seal. This method would not interfere with the future installation of the diffusers in case a different method is adopted by the future Contractor. The following plate depicts the proposed alternative.

Removing the cover will simply require unbolting or cutting the central screw holding the assembly together.

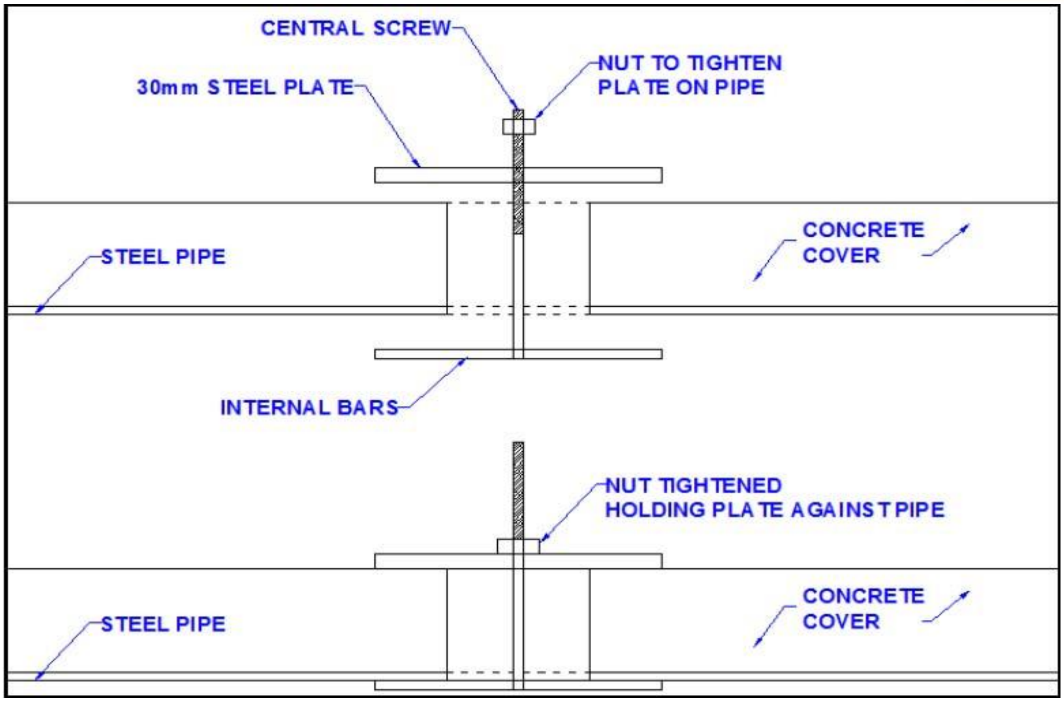


Plate 39: Alternative fixing method for temporary patch plate

Partially Open Diffuser

Temporary sealing the partially open diffuser shall be effected by injecting an underwater filler to be approved by the Engineer within the gap between the partially opened upper and lower horizontal plates. Recommended underwater filler is HIT-RE-500 or equivalent.

4.4 CONCRETE REPAIR

4.4.1 JUSTIFICATION

Concrete damage was noted at several locations between Chainages 900 and 1200. The purpose of the dredging pas defined in Section 3.1 is to assess the full extent of such concrete damage in areas that are currently partially covered by sediments. Damage that has been inspected during the conditional assessment survey has confirmed that the outer cover to the top steel has been breached exposing the outer layers of 10 mm diameter longitudinal and 15 mm diameter hoop bars. The concrete coating breach was seen to extend up to 12 cm in depth from the concrete outer surface. In the inspected zone, the inner (bottom) layer of longitudinal and hoop bar steel reinforcement remains encased within the surviving concrete coating to the Outfall Pipe which in the worst case should have a remaining overall thickness of 9 cm based on the SNE as-built size of 21 cm. The extent of damage to the concrete coating in zones that have yet to be dredged is obviously unknown.

Although the initial damage to the concrete is likely to have been caused by the impact of foreign objects (chain or pipes), the lateral spread of such damage could have resulted from the rusting of the exposed steel reinforcement in the concrete. Delaying the repair of this concrete is likely to result in further rusting of the reinforcing steel that will result in its expansion and the degradation of the concrete cover.

4.4.2 SPECIFICATIONS

Once the extent of each concrete repair area has been identified, the area shall be thoroughly cleaned using compressed air and water jetting. Loose blocks shall be removed and the damaged concrete surface together with any steel exposed surveyed. If the loss of steel section is minimal and the steel reinforcement has not been extensively bent, then the existing steel could be maintained as reinforcement in the concrete repair; otherwise, the steel shall be cut and new reinforcing steel placed. If loose concrete blocks are noted below the reinforcing steel and these blocks cannot be removed because of the steel, then the steel shall be removed in order to ensure a proper cleaning of the area to be concreted. Alternatively, the concrete blocks shall be broken down and removed.

Loss of steel section has been noted in some reinforcing bars as evidenced by the bars recovered by the divers from the dredged areas (Plate 40).

Plate 40: Loss of section in reinforcing steel

Similarly, significant incrustation was also noted on some of the reinforcing rods recovered from the same area.

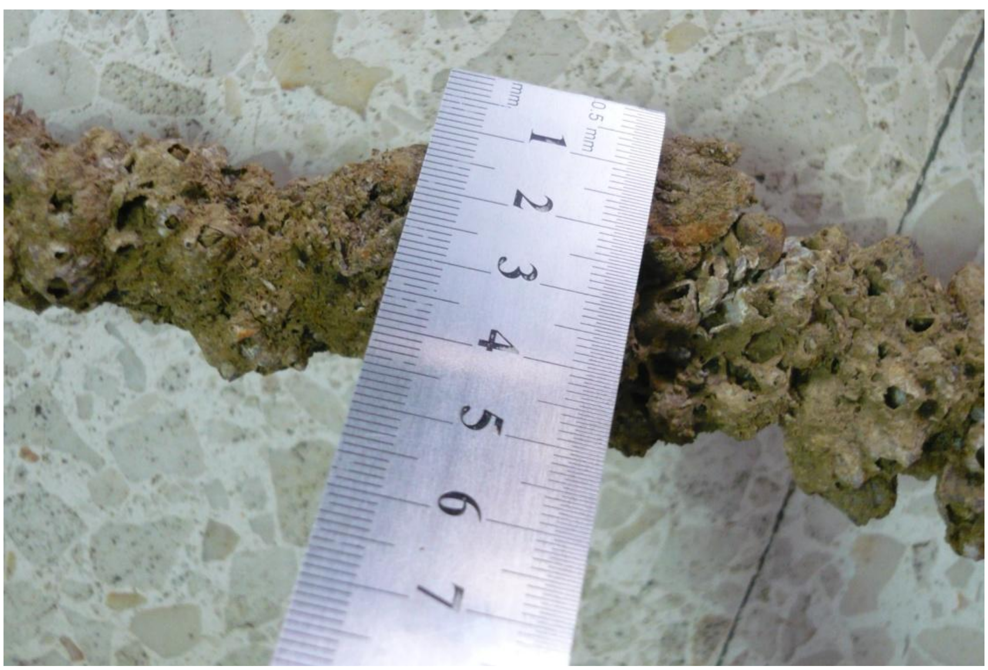


Plate 41: Incrustation on reinforcing steel

In order for underwater concrete placement to be successful, the concrete shall be protected from the water until it is in place so that the cement fines do not wash away from the aggregates. This protection shall be achieved through proper use of placing equipment, such as tremies or pumps.

The quality of the in-place concrete shall be enhanced by the addition of an anti-washout admixture (AWA) that increases the cohesiveness of concrete. EDTO recommends the use of Spec build BA10 which is a water resistant additive and bonding agent for cement systems. Alternatively other admixtures suitable for use in underwater placement of concrete may be proposed by the Contractor subject to the approval of the Engineer. The use of other additives shall be approved by the Engineer prior to being used.

The following procedures shall be implemented for the proper repair of the concrete coating to the Outfall Pipe , unless an alternative is presented by the Contractor and accepted by the Engineer.

a. The location, extent and size of the area to be repaired shall be well defined before the particular job is started.
b. The area shall be thoroughly cleaned of all marine growth, debris and fragmented concrete before new concrete is placed. Water jetting and airlift techniques are effective cleaning methods. Removal of any harder marine incrustation and roughening of unsuitable or weathered surfaces from the damaged concrete area will be undertaken by mechanical 'scabbling' of the affected surfaces. This cleaning is essential for any significant bond to occur between the newly placed and the existing exposed concrete.
c. The steel in place shall be cleaned carefully of all marine growth including harder incrustation by wire brush before checking for corrosion and loss of section. Representative samples of steel which is structurally suspect will be taken by the dive team for further analysis at an approved laboratory onshore. If test results prove that the steel is acceptable, replacement bars will spliced in at the sample locations before any concrete placement occurs. If appropriate, the steel shall be further cleaned and coated. Alternatively if results dictate that the steel in place is now obsolete the existing bars shall be cut and removed where necessary and spliced with new steel reinforcement.
d. Further exposure of steel by cutting back the exposed edges of the concrete may be necessary. Bar spacing by replacement will not exceed 15 cm. Minimum cover of concrete will be 5 cm. All reinforcing bars are to be hot rolled high yield to BS 4449. Mesh is to conform to BS-4483.
e. If steel is to be added, an appropriate number of anchors shall be grouted into the existing concrete to tie the new concrete to the existing concrete. The anchors are necessary to assure good bond because of the difficulty of keeping an existing surface clean until the new concrete is placed.

f. All necessary equipment shall be prepared at the job site in readiness before any concrete placement is begun. There shall be good coordination between all parties involved in the operation, from the concrete batch plant, through marine delivery and ultimately to the diving personnel actually placing the concrete.
g. If the concrete is to be placed in thin lifts, in areas exposed to flowing water, or where it is to flow a considerable distance, the use of an AWA is essential. Under these conditions a relatively small amount of concrete is exposed to a large volume of water. Lifts to the required finished level during each pour working day should be achieved rather than partial lifts over a wider area which will require further surface preparation before the following pour event can commence
h. When AWA's are used, it is not as critical to keep the discharge end of the tremie or the pump line embedded in the concrete as it is when they are not used. However, care should be taken by the dive team to ensure that the concrete shall not be unnecessarily exposed to water during placement. During placement place, concrete containing an AWA can flow up to 10 m without harmful washout or segregation.
i. Based on the relatively small volumes of concrete to be used at each location, concrete will not be pumped from the shore. It will have to be placed from the barge.
j. A qualified diving team experienced in this type of underwater construction work is required when concrete is to be placed to repair the Outfall Pipe concrete coating. Safety cannot be overemphasized and the dive team will pay strict attention to international diving protocols at all times.

The Contractor shall prepare concrete trial mixes in order to ensure the flowability, workability and self compaction of the concrete to be used. The concrete shall be cohesive enough against washout and segregation. It shall have a low heat of hydration. The use of fly ash is highly recommended to reduce such heat of hydration. The set time shall be controlled in a way to ensure sufficient time for transfer from the batching plant to the harbor, marine transportation offshore, concrete preparation, placement, and surface finishing.

The cement shall obviously be sulfate resistant confirming to ASTM C-150 (or equivalent). Typical water cement ratio shall be around 0.40, although this should be confirmed by trial mixes based on the possible admixtures used. Cement content shall be 300 kg/m^3. The compressive strength of the current concrete protection is only 30 N/mm^2 as this concrete is mainly for protection.

The concrete mixture proportion shall be approved by the Engineer. The concrete mixture shall be proportioned to have, at the point of deposit, a maximum slump of 100 mm as determined by ASTM C 143/C 143M. The final checks on slump will take place on the barge on location immediately prior to and during placement of concrete.

Water shall comply with the requirements of ASTM C 94/C 94M and the chloride and sulfate limits in accordance with ASTM D 512 and ASTM D 516. Water shall be free from injurious amounts of oils, acids, alkalies, salts, and organic materials. The steel to be used shall conform with the existing design. If anchor dowels are used to splice rebar, proper development and overlap lengths shall be provided to ensure proper bond. Uniform, high quality concrete cover over the steel reinforcement is critically important for long-term durability. The cover to the principal reinforcing bars shall be at least 50 mm.

Concrete shall not be placed when weather or underwater conditions prevent proper placement. Concrete shall be placed in one continuous operation for the prepared area. ACI 301 methods and equipment used shall prevent the washing of the cement from the mixture, minimize the formation of laitance, prevent the flow of water through the concrete before it has hardened, and minimize disturbance to the previously placed concrete. Tremies, if used, shall be watertight and sufficiently large to permit a free flow of concrete.

The discharge end is to be kept continuously submerged in fresh concrete where possible. In order to ensure that concrete is not lost in unwanted locations, it is considered critical for the marine concrete placement operatives working on the barge to ensure that the shaft is maintained full of concrete to a level visibly well above the water surface. Any visible drop in the concrete level would indicate that concrete is flowing and is being deposited. Care will have to be taken by the Contractor in order to ensure that such deposition is taking place where the concrete is needed. Discharging and spreading of the concrete will be carried out by raising the tremie to maintain a uniform flow, placing the concrete without interruption until the top of the fresh concrete is at the required height.

Plate 42: Conventional concrete placement using a tremie

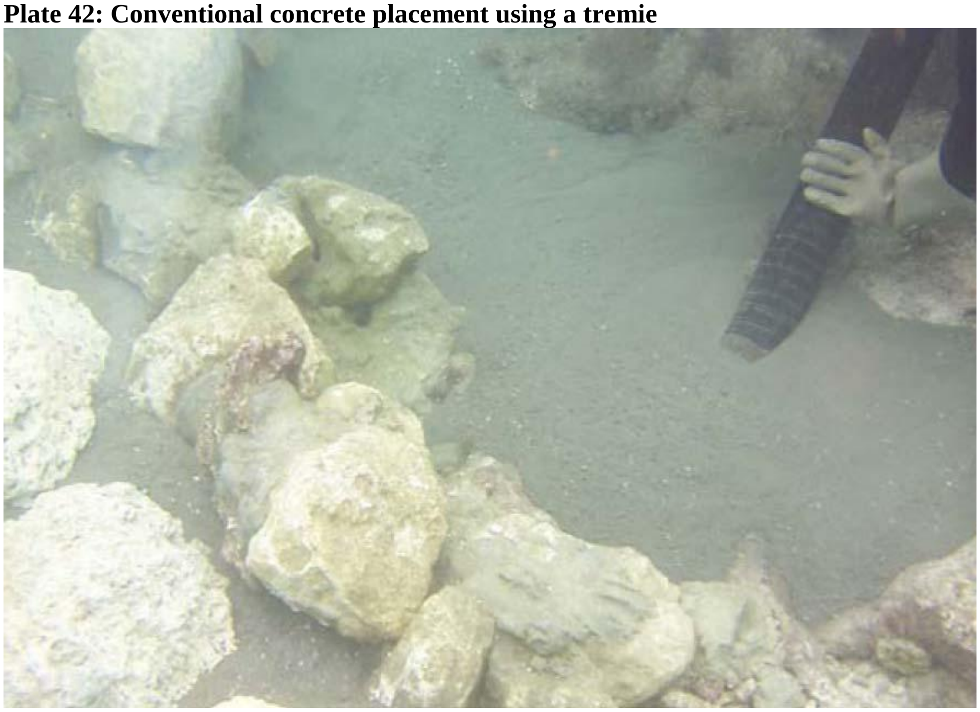


Plate 43: Conventional concrete placement underwater

Plate 44: Concrete finishing underwater

4.6 PROTECTING THE DIFFUSERS ON THE OVERFLOW PIPE

Because of the extensive sedimentation along the shore, the proximity of the Bourj Hammoud dump site and the numerous other reasons outlined in the Geotechnical Report regarding the sedimentation over the pipes, the diffusers of the Overflow Pipe are at risk of being buried. Before commissioning of the pipes, the sediments covering the section of the Overflow Pipe where the diffusers are located should be removed using air lifting technique. Such dredging should extend laterally and southward along a mild slope in order to avoid caving in of seabed sediments with time.

The extent of this dredging is assumed at this stage to extend at least some 40m (from Diffuser 21 to 10m south of Diffuser 26) along the direction of the pipe and some 10m laterally around the pipe. The thickness of sediments at this stage is less than one meter. All these quantities are likely to increase with time. Therefore a re-assessment should be done depending on the date at which such works are done. In order to more permanently protect the diffusers from being covered with sediments, we recommend installing a series of sand bags forming a one meter high retaining wall to be located some 10m south of Diffuser 26. These sand bags would not damage the pipe as they are being lowered in position. A diver would have to assist in the proper positioning of these sand bags.

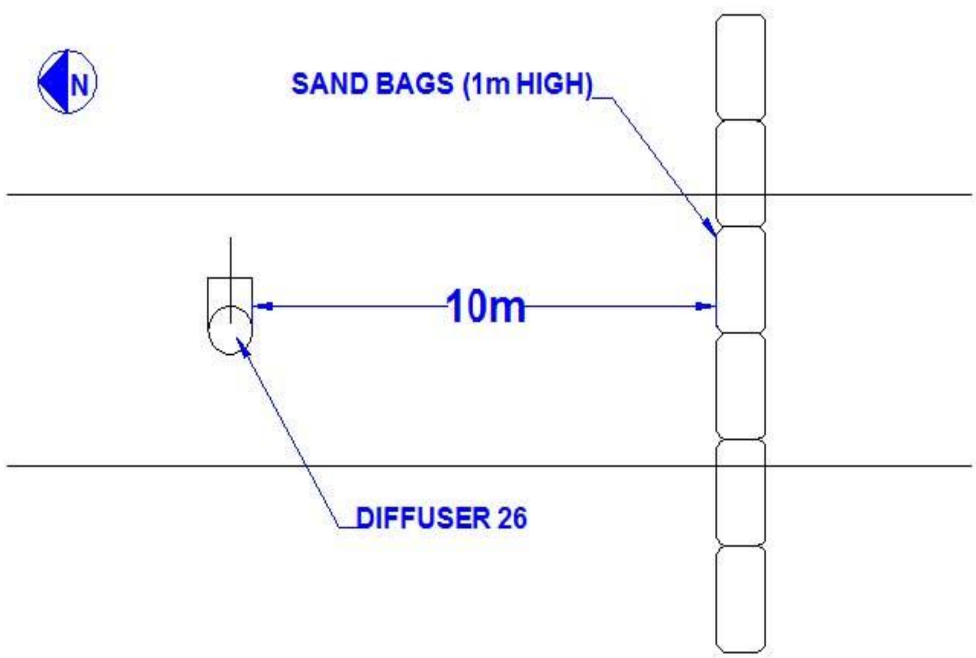


Plate 45: Sand Bag Wall to Protect Overflow Pipe Diffusers

5. GEOTECHNICAL SOIL IMPROVEMENT

A number of geotechnical soil improvement techniques have been presented in the geotechnical report. Although such measures will improve the soil conditions to various degrees, we do not consider their implementation justified at this stage based on the relatively low profile sensitivity of the pipes and the absence of direct life threatening impact to humans.

In case a major earthquake occurs, the pipes could be subject to possible failure that would entail abortion of operational activities as a working sea outfall with the added potential for enforced replacement as a worst case scenario. The impact in the event of having to cease operational activities of the pipes would have to be quantified based on the anticipated flow rate and pollution load required to be discharged. Alternatively, assuming that the Overflow Pipe (which is much shorter in length, laid on a flatter gradient and has greater cross-sectional dimensions) had not failed, then the flow and discharge could be diverted temporarily through the Overflow conduit until the main Outfall Pipe is replaced.

A risk assessment should be conducted by the CDR in order to quantify the impact that a failure of the pipes would have on the environment.

EDTO considered Vibrocompaction, Vibroflotation and Stone Columns as potentially adoptable alternatives for geotechnical soil improvement, however given natural, environmental and man-made constraints specific to the site and its surrounding environment, any one or all of the techniques considered could prove to be subject to rapid cost escalation with no guarantee of success and an added risk of causing further damage to the pipes during the necessary site activities. Additionally, due to the now known soft sediment nature of the seabed and zero visibility underwater working environment, high performance Construction Quality Assurance (CQA) supervision procedures would be impractical to administer. The soil improvement is over costly, impractical and not risk-free to the pipes during execution of the work. Other structures (hospitals, fire fighting centers) or infrastructures (bridges, electricity and water distribution network) are far more critical to safeguard during a major earthquake.

The cost of geotechnical soils improvement has to be added to the repair budgets. Adding both these budgets together would result in a repair/improvement cost far exceeding the actual replacement cost of the pipes using the latest design and technologies. As such, in case such a high budget is available, EDTO would recommend full replacement of the pipes instead of soil improvement and additional pipes inspection and repairs.

6 PIPE REPLACEMENT

Pipe replacement is considered by EDTO to be a drastic option that is not be considered justified at this stage based on the present condition of pipe and the concerns regarding the current location of the pipe with respect to natural and man-mad hazards and constraints.

Another factor with the benefit of experience gained during the inspection survey that should be considered is the apparent reluctance of the Bourj Hammoud Municipality in going forward with the construction of the proposed wastewater treatment plant. An undesirable scenario would be for a new 'state-of-the-art' pipe to be installed and construction of the wastewater treatment plant to be abandoned or continually shelved as has been the case over the last 25 years, due to intense local objection.

Assuming that all parties reach an agreement on the construction of the wastewater treatment plant at the currently planned location within the coming five year period, then EDTO would recommend repairing the existing pipes as described and detailed in earlier sections of this report. This is of course based on the assumption that the pipes sizes and discharging methods are still considered acceptable from a hydraulic and environmental point of view. Indeed, the pipes were installed 25 years ago based on population estimates and projections of the time. These projections should be compared with current and future requirements in order to ensure that the new pipes to be installed are properly dimensioned. Furthermore, environmental regulations have increased drastically in the last 25 years in the Mediterranean in general and in Lebanon in particular. The environmental suitability of this wastewater discharging method should be confirmed with the relevant authorities and the quality of the discharged effluent should be compared with national and international standards and guidelines. Other parameters such as the number of diffusers, the length of the outfall and the ultimate depth may have to be re-evaluated.

Giving due consideration to the condition of the pipes at the time of the Inspection survey, EDTO does not believe that a full replacement is warranted at this stage. However, in the event that repair works outlined herein earlier are delayed, then future accelerated degradation of the pipes is likely to occur that could lead to the ultimate need to replace the pipe in the not-too-distant future. In the event that the wastewater treatment plant will have to be relocated or that the pipes are not repaired in the near future and the inevitable further degradation would necessitate full replacement, then EDTO would recommend using High Density Poly-ethylene (HDPE) Pipes instead of steel pipes coated with concrete to initially replace the Outfall Pipe only.

HDPE pipes do not easily deteriorate under marine environment conditions. While being robust, they are extremely flexible and can withstand bending, torsion and elongation, (attributes that would be critical at the Daoura sewer outfall site) in case of partial loss of base support. HDPE pipes are becoming the standard in terms of marine outfalls and their installation is simpler, less labor intensive and is much less time consuming than the pre-fabrication and deployment process associated with traditional steel and concrete pipes.

Even under harsh environmental conditions, HDPE pipes would provide the best long term solution with an almost un-limited lifespan and in all cases greater than 50 years.

Installing HDPE pipes at the current location with the presence of mooring points for fuel supply vessels will result in a high risk of the pipe being damaged by collision of anchors.

The installation of an HDPE pipe at the exact same location is not recommended by EDTO as there are no safe ways to protect the pipe while maintaining its hydraulic performance. Burying the pipe could be considered. However, this option will increase the cost of installation and will affect the hydraulic performance of the pipe as the diffusers would have to remain well above the seabed.

6.1 METHODOLOGY

It is commonplace for a Contractor such as EDTO to provide a turnkey package on a 'design, build and commission basis'. The completed design would then be forwarded to the manufacturers of the pipes. A number of European and American companies are specialized in the fabrication of such pipes. The design will specify the required pipe diameter, the pipe length, the minimum and maximum depth and the number, design and type of diffusers based on the flow rates and characteristics of the wastewater effluent. In EDTO's estimation the full replacement of the Outfall Pipe could be carried out within a period of in 6 to 8 months.

The thickness of the pipe would be recommended based on the above parameters. The required ballast would also be designed in order to ensure proper resting conditions of the pipe on the seabed. The design would consider underwater current data. Additional current surveys would have to be done to complement the one month data acquired during the inspection survey. The pipes would be manufactured in typically 200 m sections and would be towed from the manufacturing plant to the site. The towing could be arranged by the manufacturer or by the Installation Contractor. All pipe sections required for the sea outfall replacement could be towed by the same tug boat in one operation from the assembly dock (depending on its location) to the site.

In the meantime, ballast blocks would be manufactured locally based on the standard design provided by the pipe manufacturer so that the blocks are pre constructed and available awaiting the pipe sections arrival in Lebanon. Appropriate Construction Quality Assurance (CQA) procedures would be adhered to during every phase of the operation from the factory shop floor, through shipping, delivery, assembly and ultimately installation on site.

Once the pipe sections arrive, the installation contractor would have mobilized in full readiness its welding and installation equipment and plant. Pipe sections would be welded using an automated butt fusion method. Testing of each weld would be carried

The welding of the pipes would take place on a dedicated barge offshore without having to unload any pipe sections on land.
Once sections of the pipe have been welded, the ballast blocks can be added at the designed spacing. This activity can take place on land or on a barge. It is more practical

and cost effective for both the welding and ballasting operation be completed offshore in order to avoid double handling of the pipes by loading them on land and unloading them. Pipe assembly on land, especially in such a congested coastline as Beirut's where land space availability is at a premium, requires heavy cranage, plant, labor and equipment together with expansive working areas for assembly procedures to be conducted properly and on schedule.

Positioning of the pipe will be carried out with a very high degree of accuracy. Differential GPS positioning is used for centimeter accuracy. DGPS transponders are positioned on the pipe. Increasing the number of transponders along the pipe increases the accuracy of the positioning of the pipe over its length.

The installation method used is known as the "flood and sink" method. The pipe is originally floated over the designed position. Several tug boats are required in order to align the pipe as required on the surface of the water over the designed layout. The pipes are usually attached by lines to the tug boats in order to allow for closely coordinated instantaneous lateral and vertical correction of the position of the pipe during placement.

With the benefit of the pipe being made of HDPE, lateral or vertical bending constraints are regarded as insignificant. The DGPS transponders work under water, therefore the position of the pipe can be adjusted until finally resting on the seabed. Lateral shifting of the pipe often occurs during placement due to of strong and irregular currents. This can be compensated for to a certain degree even after the pipe has been positioned.

Below are a series of pictures showing HDPE pipe installation by EDTO on other projects.

Plate 46: Tug boat towing 10 sections of HDPE pipe lengths

Plate 47: Precast ballast manufactured ahead of time and loaded on a barge

Plate 48: Precast ballast manufactured ahead of time and loaded on a barge

Plate 49: EDTO Project Team inspecting delivered HDPE pipes on a project in Limassol (From Left to right Messrs. Craig Kelly, Jacques Chahine and Darios Melas)

Plate 50: Butt fusion welds of pipe sections

Plate 51: Installing precast ballast blocks

Plate 52: Welding and ballasting pipes in the water

Plate 53: Aligning the pipe as required

Plate 54: Flooding the pipe and sinking it

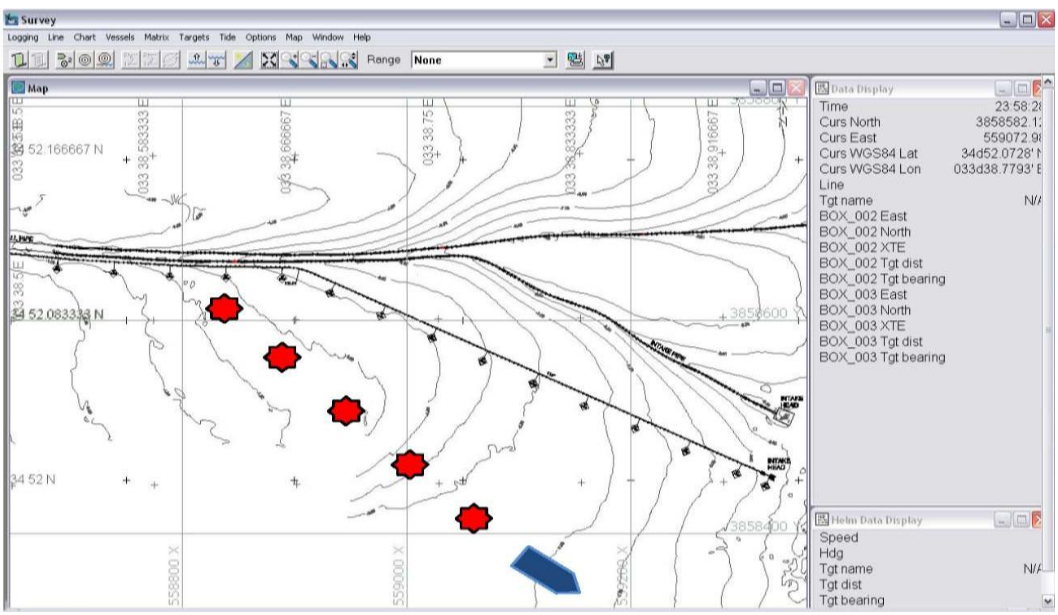


Plate 55: Setting the pipe on position

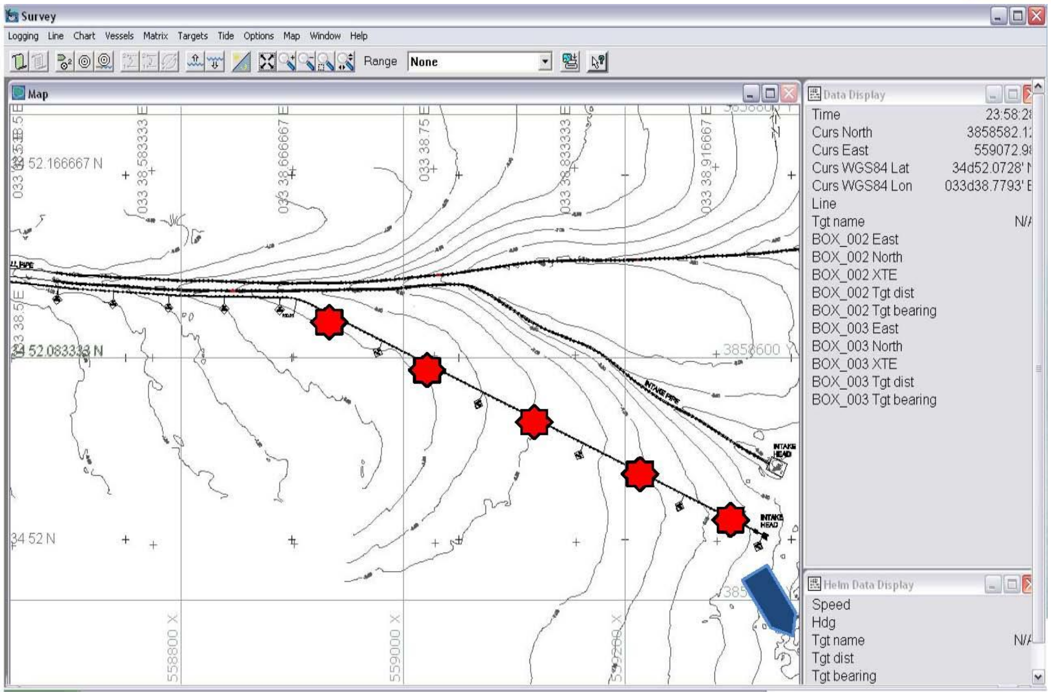


Plate 56: Verifying the final position of the pipe

7 PRE-COMMISSIONING CHECK-LIST

Assuming that all repair works listed in this report have been executed in a timely manner and that no further known degradations of the pipes have occurred between the date of this survey and the date of commissioning of the pipes, a number of pre-commissioning verifications should be done in order to ensure that the pipes are still suitable for commissioning.

7.1 BATHYMETRIC SURVEY

EDTO has already thoroughly documented in the conditional assessment report the significant deposition of sediments over the pipes. With time, such deposition could affect the performance of the diffusers if they become buried under the sediments or too close to the seabed.

We have also indicated that, with the extension of Quay 16 in the Beirut Harbor, the rate of sedimentation over both pipes is likely to increase at a faster rate than has been observed to-date with the coastline being extended northward. Slumps from the Bourj Hammoud Dump Site will also continue to affect the coastline and the extent of debris and sediments deposited over the pipes.

Before commissioning the pipes, it is therefore recommended to conduct a bathymetric survey in order to assess the changes in seabed levels and whether any sedimentation is likely to negatively affect the pipes in general and the performance of the diffusers in particular.

Should extensive sedimentation have occurred, then dredging of the sediments may have to be considered. At worst, if the rate of sedimentation is found to be too significant, then the suitability of the pipe location may have to be reevaluated for the longer term.

7.2 DIVE INSPECTION

A diving inspection should be conducted along the pipes in order to ensure that the pipe has not been damaged by accidental impacts of anchors. In case damage to the concrete is found, then these should be repaired in order to avoid the lateral spread of the damage due to rusting of the reinforcing steel.

If the steel pipe is damaged, then the extent of the damage should be verified internally by ROV and a decision regarding the fate of the pipe should be taken in light of the extent of such damage. Such diving inspections should be done on a yearly basis until the pipes are commissioned in order to ensure that the pipe integrity is still intact and in order to assess if emergency repairs are required.

Delaying the diving inspections to just pre-commissioning will result in significant sedimentation over the pipes that would cover most defects. Dredging of such sediments would be required in order to suitably inspect them. This will result in significant increase in budget. After commissioning, yearly inspection dives are also recommended.

7.3 ROV SURVEY

Regardless of the date at which the additional inspections and repair works are conducted, EDTO highly recommends that the Contractor conducts a full ROV survey of the internal part of the pipes before the final connection of the pipes to the wastewater treatment plant.
Depending on the outcome of the survey at that time, further investigation or remedial works may have to be carried out and further time should be allowed for prior to commissioning in case of this eventuality. If the pipes are fully flushed and properly sealed at the inlet connection piece and this cleansed condition is properly documented by a full video of the internal part of the pipe, then the presence of sediments or debris inside the pipe in the future would be evidence of possible damage to the pipe since the previous survey.

Even after the commissioning of the pipes, it is recommended by EDTO to conduct annually an ROV internal inspection of the pipes in order to assess the conditions of the pipes and to ensure optimal operation of the pipes for an extended period of time.

7.4 INSPECTION OF DIFFUSERS

Before commissioning the pipes, a detailed inspection of the diffusers should be conducted. Over the last 25 years 14 diffusers have been severed on the Outfall Pipe. Additional damages could occur between the time of writing this report and when the pipes are put into operation. A detailed inspection of the diffusers will confirm and provide reassurance that the units are all present and in good condition. Netting, ropes and other obstructions should also be removed at that time.

If the construction of the wastewater plant is likely to be delayed for whatever reason, then we strongly recommend conducting a detailed inspection of the diffusers by divers once a year in order to document their conditions and attempt to remediate – even partially – damaged diffusers as required. Proper closing of the diffusers is crucial in minimizing marine growth that would damage the inner lining and integrity of the pipes.

If diffusers are found to be missing, they should either be replaced by new units or at the very least by temporary patch-plates that would effectively seal the opening of the diffusers. If temporary patch plates have been installed as part of the emergency works, then new diffusers should be manufactured and installed prior to commissioning of the Outfall Pipe.

Inspection of the diffusers should be done on a yearly basis once the pipes are commissioned. These inspections should be done during periods when the plant is not discharging sewer. Any obstruction (netting, ropes) or irregularity (missing bolt, excessive gap at the flanges, bent or missing diffuser, etc.) found by the divers would be reported in order to allow rapid remediation and prevent further deterioration of the irregularity. Prompt preventing maintenance and remedial measures will ensure the proper performance of the diffusers.

7.5 REMOVAL OF DIFFUSERS PLATES

Once the pipes are ready to be put into operation, the end plate from the diffusers must be removed. Any rope, net, chain or other obstruction found to be entangled on the diffusers should be removed at that time in order to allow free flowing conditions during discharge.

Entangled netting, fishing lines and heavy marine chain on the diffusers as reported on the Condition Assessment Report on various diffusers introduces a possible danger both to the stability and the free flow of the raw sewerage volumes through the diffusers. Anchors can be easily entangled to the aforementioned material and thus introducing the danger of severing the diffuser and in addition, marine growth or incrustation built up on them, in synergy with further material entanglement on such diffusers, could possibly result in the clogging of their outlet thus preventing the free flow of the sewerage. Proper cleaning of the diffusers shall be done prior to commissioning the pipes.

7.6 REMOVAL OF PIPES END PLATES

In case the downstream end plates of the pipes have to be removed for the operation of the pipes, then proper dredging of the area surrounding them should be done prior to commissioning of the pipes. The extent of the area to be dredged is to be confirmed by the designers in order to ensure a proper performance of the pipe. Once the area has been dredged, the end plates could be removed.

7.7 LINING REPAIRS

The inner and outer coating at the flange rim of the inlet structure of both pipes should be repaired prior to installing the head-works connection. The exposed steel should be grinded and proper lining coat applied to the prepared surfaces ensuring a sound connection to the existing lining. Underwater grinding is done with pneumatic or manual systems. Underwater coating could be applied by divers in the form of an epoxy type slurry.

8 CONCLUSIONS

EDT Offshore Limited (EDTO) has been awarded from the Council for Development and Reconstruction (CDR) the inspection and survey of the Daoura Outfalls. Two marine Outfall Pipes were installed in the mid 1980’s along the northern shore of Beirut at a location between the Bourj Hammoud Dump Site and the Beirut River outlet. The pipes were never commissioned and understood to be sealed at both ends at the time of construction. The main Outfall Pipe is 1,777 m in length and has an internal diameter of 1,700 mm. The second pipe is an emergency Overflow Pipe. Its length is 620 m and its internal diameter 2,000 mm. The pipes are made of steel and are covered with an outer concrete skin of 210 and 270 mm respectively. A conditional assessment report and a geotechnical report were submitted by EDTO under separate cover. This report focuses on the recommendations and rehabilitation aspects of the pipes.

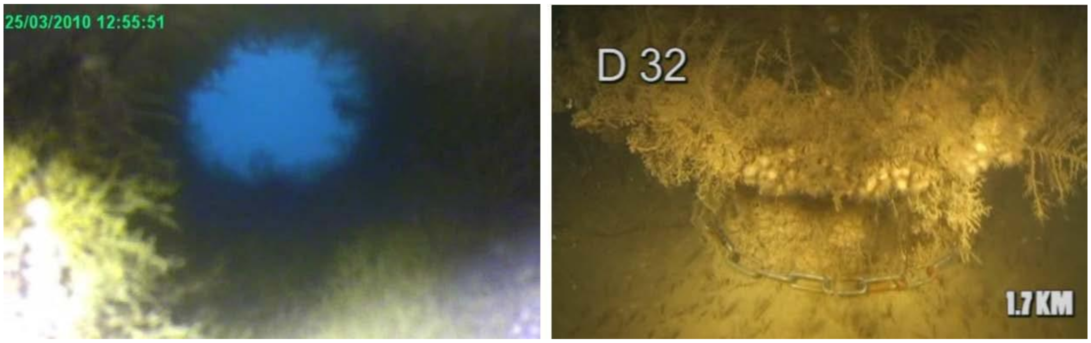
Regardless of the extent of damage identified as part of this survey, the pipes are located in a relatively unsuitable area. Their location is not compatible with the natural setting and on-going activities in the area. Indeed, a number of mooring points for fuel supply vessels are located over and adjacent to the pipes. Marine traffic is extensive and is likely to increase with the expansion of the Beirut Harbor. The area being sheltered, it is used during storm events for emergency sheltering of vessels. In addition, extensive fishing activities take place in the area. Fishing nets were found stuck on almost every diffuser on the Outfall and Overflow Pipe.

In addition to the above, the pipes are located at proximity to the Bourj Hammoud Dump Site. Significant quantities of waste and debris have covered the pipes on the inshore section. The presence of the Beirut River is also contributing to the deposition of sediments over the pipes and the modification of the coastline. The area has been a repository of very fine sediments since geological times. All these factors contribute to having a severe impact on underwater visibility and working conditions, a point that should be emphasized and made known to any contractor either working in the area or planning to submit a proposal for any work related to inspection, repairs or ongoing maintenance of the Outfall Pipes.

The pipes were protected against corrosion with a sacrificial anode system that is now fully consumed. The following plates clearly show the bracket where the zinc was casted. Traces of light grey are the only evidence of the zinc that was installed. The pipes have therefore been suitably protected for the first 20 years by such zinc. However, in the absence of such anode material, the pipes are now exposed to the element and **will rust at an accelerated rate** as the efficiency of the pipes coating after 25 years is now severely degraded. The installation of an impressed current system is not recommended at this stage for a number of practical reasons outlined in this report. In order to salvage the pipes while it is still possible, the installation of a cathodic protection system consisting of sacrificial anodes is of the utmost urgency.


Sacrificial anodes fully consumed on pipes

In addition, a number of damages were also noted on the Outfall Pipe. These typically included diffusers that have been severed by anchors or trawling activities. In total, 14 diffusers have been severed either at the pipe crown or at the level of the horizontal flange. The absence of such diffusers is enhancing marine growth inside the Outfall Pipe that is degrading the internal coating. It is also allowing the ingress of oxygen inside the Outfall Pipe that will accelerate the internal corrosion of the pipe. Closing of the diffusers is a very high priority in order to avoid such accelerated degradation of the Outfall Pipe.



Marine growth inside (left) and outside (right) Missing Diffusers

Furthermore, a number of damages to the concrete pipe surround were noted between Chainages 900 and 1,000 caused by a large chain and fuel pipes crossing the Outfall Pipe as well as possible impacts of anchors or buoy sinker blocks. The damage is spreading along the pipe through the rusting of the exposed steel that is breaking up the concrete cover, exposing more reinforcing steel to seawater. Remediating the concrete is also a priority activity in order to limit the spread of the damage. If not promptly repaired, the entire concrete cover could be destroyed and the steel pipe could be exposed to direct corrosion.

Extensive damage to the concrete cover of the pipe

EDTO has insisted on the need to implement these emergency measures that would protect the pipes from accelerated degradation. These emergency measures were not authorized for budget reasons despite the fact that the accelerated degradation will only result in more repairs and the need to remobilize a Contractor through a new tender procedure where financial mark-ups will be higher than the Variation Order mark-ups.

In addition to the emergency repairs, a number of additional investigations are required. These could not be conducted as part of this contract for budget reasons. These additional investigations include the dredging of the sediments over the pipe in the navigation channel in order to assess the extent of the concrete damage and the cleaning of the internal parts of the pipes from debris and sediments in order to complete the internal inspection of the pipe.

Geotechnical soil improvement and pipes replacement are discussed in this report as required in the Terms of References. However, these activities are not considered justified and required at this stage.

APPENDIX L: CVS OF EIA PREPARERS

PERSONAL DATA:

Family Name:	Khoury
First Name:	Ricardo
Nationality:	Lebanese-Brazilian
Date of birth:	20-02-1973
Place of birth:	Brazil
Civil Status:	Married

KEY QUALIFICATIONS & EXPERTISE:

- Project management
- Environmental policy development
- Institutional strengthening and capacity building
- Oil and gas
- Environmental Impact Assessment (EIA)
- Environmental Risk Assessment (ERA)
- Strategic Environmental Assessment (SEA)
- Environmental baseline studies
- Solid waste management
- Air quality management

EDUCATION

- **Masters in Engineering** (M.E.) Major Environmental and Water Resources Engineering - American University of Beirut (February 1999)
- **Bachelor in Engineering** (B.E.; with distinction) - Major Civil and Environmental Engineering - American University of Beirut (July 1996)

EXPERIENCE RECORD:

1. **ELARD (Full Time, March, 2000- to date)**
   Title: Head of Environmental Division / Manager ELARD Emirates

Coordinating and participating in Environmental Impact Assessment (EIA), Environmental Risk Assessment and Strategic Environmental Assessment (SEA) studies (more than 100 studies successfully completed). Selected references:

- Strategic Environmental Assessment for Offshore Exploration and Production Activities in Lebanon, LPA

- Strategic Environmental Impact Assessment for the Program of Exploration and Production of Hydrocarbons in the Offshore Montenegro, Ministry of Economy
- Environmental, Social and Health Impact Assessment for E&P Activities for Block II, Syria, SNG East
- Implementation of Environmental and Social Action Plan (ESAP) for onshore and offshore oil and gas fields in Egypt, EBRD
- Environmental, Health and Social Impact Assessment for the Iraq Crude Oil Export Pipeline (687 km) – Iraq Oil Projects Company/SNC Lavalin
- Environmental Impact Assessment for OFON II Offshore E&P activities in Nigeria – TOTAL E&P / Subsea7
- Environmental and Social Impact Assessment for the Missan Oil Export Pipeline (270 Km) - PetroChina
- Health, Safety and Environmental Impact Assessment for the Carbon Black and Delayed Coker Project in Ruwais, Abu Dhabi – TAKREER / Samsung Engineering
- Call-off for HSE Services and Risk Assessment for ORYX, Ras Laffan, Qatar – ORYX GTL
- Environmental and Social Impact Assessment for the New Nassiriya Refinery FEED Project (300,000 BSPD) – SCOP/Foster Wheeler UK
- Environmental Monitoring Services and Flare Radiation Monitoring at three Offshore Platforms in Azerbaijan (BP Azarbaijan)
- Environmental, Health and Social Impact Assessment for the Karbala Refinery FEED Project (140,000 BPSD) – Technip Italy
- Strategic Environmental Assessment (SEA)- Offshore drilling program – onshore processing facility – electricity generation from gas flaring - Tullow oil and gas Uganda
- Environmental, Social and Health Impact Assessment (ESHIA)- Exploratory Drilling (Four wells) – SHELL Syria
- Environmental Impact Assessment (EIA) – Arab Gas Pipeline – IPA Consultants
- Environmental and Social Impact Assessment (ESIA) – Onshore drilling, seismic, pipeline and gas processing facility – EBLA Gas Project - PetroCanada
- Environmental Impact Assessment (EIA) – seismic and onshore drilling and EBS Studies – Hayan Petroleum and INA
- Environmental Site Assessment- Tabyeh gas treatment plant – TOTAL Syria
- Environmental Impact Assessment (EIA)- onshore drilling - TATNEFT Syria
- Environmental Impact Assessment for a 2D/3D seismic acquisition project in Ash Shaer Development Area of Central Syria, Syria.
- Environmental Impact Assessment for an exploratory oil and gas wells in Palmyra, Syria.
- Environmental Impact Assessment for an exploratory deep oil well in Syria.
- Ambient Air Quality and Stack Emission Monitoring - Ruwais Industrial Complex, Borouge, UAE
- Environmental Impact Assessment for the Jieh and Zouk Powerships Projects (Karpowership Company Limited), Lebanon.

- Strategic Environmental Assessment (SEA) of Lebanon's Renewable Energy Sector Project
- National Environment Strategy for the Kingdom of Saudi Arabia, Booz Allen Hamilton, contracted by the KSA's Ministry of Environment, Agriculture, and Water (MEWA)
- Updating the National Spatial Strategy for the Kingdom of Saudi Arabia, IBI Group / Ministry of Municipality and Rural Affairs
- Strategic Environmental Assessment (SEA) Of The Capital Surface Transport Master Plan – Abu Dhabi
- Elaboration of a Strategic Sustainable Regional Development Plan (SSRDP) for Akkar (North Lebanon) and the related Strategic Environmental Assessment (SEA)
- Strategic Environmental Assessment for the Liwa Master Plan, Abu Dhabi, UPC.
- Environmental Impact Assessment for Qatar Chlorine Production Company (Messaeed Industrial City).
- Environmental Impact Assessment for a Q-ship Fabrication Yard in Qatar.
- Ecological Risk Assessment (based on biomonitoring study) for Qatalum (Messaeed Industrial City)
- Environmental Impact Assessment for the Iraq Basra Multi Division Project – Iraq (Cameron)
- Environmental Impact Assessment for the Green Line of Damascus Metro.
- Environmental Impact Assessment for Shawka Quarry in Ras El Khaima, UAE.
- Feasibility Study and EIA for groundwater supply and brine discharge of a major steel factory in Hamryah Free Zone, Sharja, UAE.
- Operational Environmental Management Plan for EMAL, Abu Dhabi (2009)
- Strategic Environmental Assessment and Land-Use Planning in Balou Baatara, North Lebanon.
- Strategic Environmental Assessment for the Jounieh Bay Boulevard, Lebanon.
- Air quality and noise impact assessment for the Tripoli Transportation Master Plan.

Climate Change, Clean Development Mechanism and Carbon Financing

- Team Leader of the Vulnerability, Adaptation and Mitigation Strategy for Lebanon as part of the Second National Communication for the UNCCD, Climate Change
- Identification, screening and development of CDM projects in oil and gas sectors, heavy industries (mainly cement), and power sector.

Delivering training and capacity building. Selected references:

- Clean Development Mechanism for the oil and gas sector, Euro-Mashreq Gas Project, Syria (2 days).
- CDM and Carbon Capture and Storage, Workshop, Reducing Emissions in the Oil and Gas Sector, Abu Dhabi, June 2008.
- Environmental Impact Assessment for Gas sector stakeholders, EU project, March 2007 (Beirut and Damascus) and December 2007 (case study training – Homs).

- Team Leader in the preparation and delivery of a Global training program on Development of Integrated Financial Strategies to Combat Desertification, Global Mechanism/CCD (5 days program designed), and delivered in Tunis, Amman, Isfahan, Costa Rica, Cambodia, Sri Lanka, Lisboa.
- Operation and Maintenance of Wastewater Treatment Plants and EMP Implementation , Pontifical Mission/USAID, Chouf, Lebanon, June 2006 (2 days)
- Draft Law on Integrated Solid Waste Management in Lebanon, The World Bank, Beirut, March 2005 (2 days).
- Application of Environmental Legislation, EC LIFE, Beirut, May 2005 (2 days)
- Environmental Litigation, EC LIFE, Beirut, June 2005 (3 days)

2. AUB (2005-2007)
Title: Instructor

- Delivered the following course during spring 2005 and spring 2007: Non-Hazardous and Hazardous Waste Management, Faculty of Health Sciences.

3. AUB (June-1997, March- 2000)
Title: Research Assistant – Freelance Consultant

Experience included:

- Participated and implemented several research and consultancy projects related to the fields of water resources management, solid waste management and coastal zone management. In particular, coordinated the marine part of the Chekka submarine springs project, a major project in the water resources field in Lebanon and assisted in the implementation of a preliminary assessment of coastal waters in Lebanon and evaluation of Coastal Zone Management strategies for the country. Conducted also a feasibility study for artificial groundwater recharge in Ras-Beirut. Participated also to several environmental consultancy jobs.

PUBLICATIONS AND CONFERENCES (FROM RECENT TO OLDEST):

- **R. Khoury** and Alhaj D. –Strengthening Environmental Governance in the Oil and Gas Sector in Lebanon, Lebanese Center for Policy Studies (LCPS), 2016.
- **R. Khoury** – HSE Requirements and Practices of International Oil Companies (IOCs) - Speaker at the Lebanon International Oil and Gas Conference, December 2013
- Hydrocarbons Exploration and Development in the East Mediterranean, Wilton Park, UK – think tank discussions on HSE, export options and geopolitical context – invited to attend as HSE expert (2013) (invitation only event)
- **Khoury R.,** Maasri R., Bou Jawdeh I, and Kayal R., (2002), "Closure of an old dump in Lebanon: risk assessment and project formulation", Proceedings of Appropriate Environmental and Solid Waste Management and Technologies for Developing Countries Congress, organized by the International Solid Management Association (ISWA), Turkey, July 8-12.
- **Khoury R.,** Shazbak S. and Massoud M., (2002), "Air quality impact assessment for the Tripoli transportation master plan", Proceedings of Appropriate Environmental and Solid Waste Management and Technologies for Developing Countries Congress, organized by the International Solid Management Association (ISWA), Turkey, July 8-12.
- Abou-Ibrahim A. and **Khoury R., (2001),** "Case study on the integrated and sustainable management of the coastal zone in Lebanon", Technical Report submitted to the United Nations Environment Program (UNEP).
- El Fadel M. and **Khoury R.,** (2001), "Status of the solid waste sector in Lebanon: Need for an integrated approach", Technical Report submitted to the United States Agency for International Development.
- El-Fadel M., Salhab S., and **Khoury R., (2001),** "VOC emissions from landfills: formation mechanisms, modeling, measurement and control strategies", Technical Report submitted to the United States Agency for International Development.
- El-Fadel M. and **Khoury R., (2001),** "Strategies for vehicle waste oil management: A case study", Resources, Conservation, and Recycling, 33, pp. 75-91.
- Ayoub G., **Khoury R.,** Ghannam J., Acra A., and Hamdar B., (2001), "Exploitation of submarine springs in Lebanon: Assessment of the potentials", Journal of Water Supply, Research and Technology - AQUA (in press).
- El-Fadel M., **Khoury R.,** Abou-Ibrahim A., Zeinati M., Sbayti H., Bou-Zeid E., (2000), "Preliminary characterization of the Lebanese coastal waters", Technical Report submitted to the United States Agency for International Development.
- Ayoub G., Ghannam J., **Khoury R.,** Acra A., and Hamdar B., (2000), "The submarine springs in the Chekka Bay, Lebanon: Delineation of salient features", Technical Report submitted to the International Development Research Center (IDRC), Ottawa, Canada.
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- El-Fadel M., Sadek S., and **Khoury R., (1999),** "Simulation of solid waste settlement in laboratory columns", Proceedings of the 7th International Waste Management and Landfill Symposium, Sardinia, Italy, Vol. III, pp. 521-529.
- El-Fadel M., **Khoury R.,** Sadek S., and Ayoub G., (1999), "Temporal variation of leachate quality in laboratory test cells", Proceedings of 15th International Conference on Solid Waste Management and Technology, Philadelphia.
- El-Fadel M., Sadek S., and **Khoury R., (1999),** "Settlement and stabilization processes in municipal solid wastes", Technical Report submitted to the Lebanese National Council for Scientific Research (LNCSR).
- **Khoury R., (1999),** "Seawater and leachate recirculation effects on physico-chemical processes in municipal solid waste", M.E. Thesis, American University of Beirut, Beirut, Lebanon.

LANGUAGES:

Language	Reading	Speaking	Writing
English	5	5	5
French	5	5	5
Arabic	4	4	2
Portuguese	5	5	5
Spanish	4	3	3

Proficiency is marked from 1 to 5, such that 1=basic & 5=fluent

PERSONAL DATA:

Family Name:	Metni
First Name:	Marc
Nationality:	Lebanese
Date of Birth	15/9/1976
Civil Status:	Single

KEY QUALIFICATIONS & EXPERTISE:

Senior Project Manager and Hydrogeologist with about 15 years of experience. He is currently the head of the Geosciences Division at ELARD. He has conducted numerous complex hydrogeological studies especially related to Karstic terrains. In the past two years, he has been directing numerous groundwater resource assessment studies for International organizations and NGO (UNICEF, UNHCR, CISP), and Water establishment to response in the increase in Water Demand caused by the Syrian Refugees. He was also directing a water resources assessment study that entails a General Analysis of the Water Supply Situation in Nahr El Bared Camp and Its Adjacent Areas.

EDUCATION

- **MBA** – American University of Beirut (2008)
- **MS** Environmental Technology - American University of Beirut (2002)
- **BS** Geology - American University of Beirut (1998)

EXPERIENCE RECORD (FROM RECENT TO OLDEST):

- **2015-to date,** Senior Project Manager / Senior Hydrogeologist. ELARD
- **2009-2015,** Project Manager. AECOM, UAE, Lebanon
- **2009,** Project Manager. Cansult Maunsell, UAE
- **2005-2008,** Environmental Consultant/ Geologist / Hydrogeologist. Project Consulting, Lebanon
- **2001-2005,** Head of Earth Studies Department. ELARD (Lebanon)
- **1998-202,** Geologist. Project Consulting, Lebanon

1. **ELARD (2015-Present)**

Senior Project Manager / Senior Hydrogeologist

<u>Selected Projects:</u>

- Hydrogeological study - Well survey in Priority Caza (Akkar, Koura, Jezzine, and Hermel), UNICEF (2015-2016)
- Hydrogeological study - Well survey in Priority Caza (Zahle, Minieh-Dannyeh, Marjehyoun, and Rachaya) UNICEF (2016-ongoing)
- Water Resources Assessment to supply water for 4 Towns (3 in North Governorate and 1 in Bekaa Governorate), UNHCR (2016
- Phase I and Phase II Environmental Site Assessment (ESA) at Beirut International Airport located in Khaldeh, Lebanon
- ESIA for Tripoli-Beirut Railway (2015)
- Initial Environmental Examination of the Tell Square Underground Parking, Tripoli (2015)
- Environmental Social and Traffic Impact Assessment for the Fouad Boutros Avenue (2015)
- Environmental Review Requirements for Water Infrastructure Support and Enhancement for Lebanon (WISE – Lebanon) (2015)
- Environmental due diligence assessment in Turkey, TRC (2015)
- CEMP for Great Beirut Water Supply Project (GBWSP), CMC (2015-ongoing)
- Supporting Industrial Pollution Abatement in Lebanon, Ministry of Environment (2015-ongoing)
- Consulting services related to the activity "Supporting Industrial Pollution Abatement in Lebanon II", Plan Bleu (2015-ongoing)
- IEE for 2 farms in Kfarhazir Koura and Kefraya Zgharta (2015)
- Initial Environmental Examination of the Forest Hill- Haret El Bellaneh Residential Complex in Dbayeh, Forest Hill Dbaye S.A.L. (2015)

2. **AECOM, UAE, Lebanon (2009 – 2015)**

Project Manager

Developing EHS management systems, managing and conducting environmental assessments for permitting requirements, managing and conducting due diligence and compliance audits for different industries, compiling regulatory and legislative frameworks and developing industry applicability tools. Conducting water resource assessments.

- **Environmental and Social Impact Assessment for a Paper Mill – UAE**

  (2015)

  Responsibilities: Project manager of a combined regulatory Preliminary Environmental Review & Equator Principles conformant ESIA submission for a paper mill facility.

- **PPG EHS Compliance Audit – KSA**

  (2014)

  Responsibilities: 8-day EHS compliance audit of 2 solvent and water based paint industries for ensuring compliance with regulatory and client EHS standards.

- **New Port Project As Constructed Conditions Hydrogeological Study – Qatar**

  (2014)

  Responsibilities: PMC role review of Hydrogeological Study conducted by consultant for assessing and modeling groundwater impacts as a result of project activities including flooding of certain areas.

- **Al Wakrah Stadium Precinct Environmental Impact Assessment (EIA) – Qatar**

  (2013-2014)

  Responsibilities: geology, soil, and groundwater discipline lead.

- **Qatar Economic Zone 1 Environmental Impact Assessment (EIA) – Qatar**

  (2013-2014)

  Responsibilities: Structuring the EIA scope and budget and leading the transition into a Ministry of Environment approved SEA scope in accordance with the wishes of the Ministry.

- **North Road Project Environmental Permitting – Qatar**

  (2013-2014)

  Responsibilities: project management support and coordination of environmental permitting requirements for new project components.

- **Lusail Expressway EIA – Qatar**

  (2013)

  Responsibilities: Project management support and coordination of the EIA for formal MoE submission.

- **New Orbital Road and Truck Road EIA – Qatar**

  (2012-2014)

  Responsibilities: project management and compiling and finalizing the EIA report for formal submission to MoE.

- **EHSMS Development for China Harbour Engineering Corporation – Abu Dhabi**

  (2012)

  Responsibilities: Developing an Environment Health and Safety Management System for a construction contractor as a legal requirement in Abu Dhabi. EHSMS was approved in December 2012 following minor comments on first submission.

- **Etihad Rail EIA and CEMP Review – Abu Dhabi**

  (2012)

  Responsibilities: Conducted the official EIA review on behalf of the client as Program Management services for several EIA chapters and the CEMP for the project.

- **Institutional and Legal Policy Framework Chapter Development for an EIS commissioned by Exxon Mobil for West Qurna I Oil and Gas Project – Iraq**

  (2012)

  Responsibilities: Regulatory Framework Task Lead and chapter author.

- **Jeddah Environmental Assessment (JEA) and Jeddah Environmental and Socioeconomic Management Plan (JESMP) – KSA**

  (2011-2013)

  Responsibilities: Discipline lead in PME advisory role for Groundwater and Natural Hazards project tasks. Developed TOR for tendering JEA and JESMP.

- **EHSMS Integration for Tyco Flow Control – UAE**

  (2011)

  Responsibilities: Project manager for on the ground consulting services for the integration of EHS procedures of existing UAE facilities into Tyco's global EHSMS.

- **EHSMS Development for Abu Dhabi Council for Economic Development – Abu Dhabi**

  (2011)

  Responsibilities: Managing the final phases of the EHSMS development for semi-governmental ADCED, and obtaining competent authority EHSMS approval.

- **Phase 1 ESAs and H&S Compliance Audits for Halliburton – Saudi Arabia & Egypt**

  (2011)

  Responsibilities: Conducting and Managing the ESAs and Compliance Audits for an oil and gas equipment manufacturing and maintenance industry.

- **Phase 1 and 2 ESA for GE – Saudi Arabia**

  (2011)

  Responsibilities: Managing and Conducting an Environmental Site Assessment (Phase 1 & 2) for an industrial research site.

- **Phase 1 ESA for Kinan-Savola Group – Saudi Arabia**

  (2010)

  Responsibilities: Managing five Environmental and Infrastructure Site Assessments for different sites in Jeddah and Riyadh in KSA as due diligence for a major real estate developer – Kinan / Savola Group.

- **Environmental Assessment Audit and Compliance Assessment for Oxbow Corporation– Kuwait**

  (2010)

  Responsibilities: Conducting an environmental audit and compliance liability assessment for a petroleum coke calcining industry.

- **ASTM Phase 1 ESA for Kinan-Savola Group – Saudi Arabia**

  (2010)

  Responsibilities: Managing and conducting a compliant ASTM Environmental Site Assessment, and Infrastructure assessment for a 5 km2 area as due diligence for a major real estate developer.

- **Environmental Baseline Assessment for BP – Rumaila field, Iraq**

  (2010)

Responsibilities: Planning for preliminary investigation campaign and reviewing background information, regional hydrogeology assessment, conducting the legislative review, designing and developing the GIS database framework for baseline data and procedure for data compilation.

- **Overall Construction Environmental Management Plan**

  (2010)

  Responsibilities: Preparation of an Environment Agency-Abu Dhabi (EAD) approved standard construction environmental management plan for maintenance works on main roads in Abu Dhabi Emirate for the Department of Transport (DoT).

- **Environmental Assessment Audits for Praxair**

  (2010)

  Responsibilities: Conducting environmental audits in Kuwait, Qatar, and UAE to evaluate gas production industries.

- **Saudi ARAMCO Al Dhahran Master Plan Update; Existing Solid Waste Management Practices**

  (2010)

  Responsibilities: ARAMCO has requested AECOM to provide a preliminary desk-based assessment of the current Solid Waste Management (SWM) situation, and SWM recommendations for the planned expansion of the development.

- **Legislation Review and Applicability Tool Development**

  (2009-2010)

  Responsibilities: Compiling a legislative compliance register and industry specific applicability tool for Egypt.

- **PER and Solid Waste Management Plan for ALMARKAZ Development, Abu Dhabi**

  (2009)

  Responsibilities: Preliminary Environmental Review for submission to EAD and Development of an Integrated Solid Waste Management Plan for the Development

- **Al Dhafra Construction Waste Recycling Facility**

  (2009)

  Responsibilities: Preliminary Environmental Review and Construction Environmental Management Plan for submission for submission to EAD.

- **Al Ruwais Bypass, Abu Dhabi**

  (2009)

  Responsibilities: Preliminary Environmental Review preparation for submission to EAD for a road project.

3. **Cansult Maunsell, UAE (2009)**

Project Manager

Responsibilities: Provided infrastructure project management support; QA/QC services; tender evaluation, bid management, liaison and collaboration with other departments for multidisciplinary projects.

4. Project Consulting, Lebanon (2005 - 2008)

Environmental Consultant, Geologist, Hydrogeologist

- Hazard Assessment for catchment works in Kassarat Antelias Cave. Client: Beirut and Mount Lebanon Water Establishment (October, 2008).
- Renewable energy resource assessment in Lebanon. Desk-based study commissioned by private investors (August, 2008).
- Completion of country assessment for recycling procedures and market characteristics for Lebanon, and compilation of a manual on recycling for municipalities and governmental institutions. Project commissioned by the Italian Embassy / Italian Cooperation / ROSS Emergency Program-Lebanon (June-August, 2008).
- Geologic assessment for a potential stadium construction in Al Ain, UAE. Study commissioned by MZ&Partners (Dec. 2007).
- Baatara pothole site assessment for ecotourism and development potential as part of Lebanon Mountain Trail project mandate; USAID funded project. Extra study component included identification of unique geologic sites of interest along the whole of the Lebanon Mountain Trail. Study commissioned by Ecodit, Inc. (Dec. 2006 - March. 2007).
- Application of DRASTIC groundwater vulnerability assessment using a GIS for an area of 500 Km2 in Mougher el Mir area, eastern Hermon Mountain, Syria (Dec. 2006-Feb. 2007). Study commissioned by ELARD s.a.r.l.

5. ELARD, Lebanon (2001 – 2005)

Head of Earth Studies Department

Conducted and managed hydrogeologic and environmental studies, and natural resource investigations. Work comprised geologic and hydrogeologic assessments including aquifer testing and characterization, groundwater vulnerability assessments using GIS, and environmental assessments related to various sectors (quarrying, solid waste management, wastewater treatment, etc.)

- **Hydrogeological study for the Lebanese Government commissioned by the Council for Development and Reconstruction (CDR) and funded by the French Agency for Development (AFD) to assess the water resources available in the Jezzine Aquifer and the Nabaa Tasseh Spring catchment area – Lebanon**

  (2004 - 2005)

  Responsibilities: Was the project manager during Phase1 of the study ending mid-2005.

- **Solid Waste Management Facility site screening for the Bekaa and Eastern Mountain Range Areas in Lebanon for the Council of Development and Reconstruction taking into account hydrogeology.**

  (2005)

  Responsibilities: Was the project manager of the study

- **Hydrogeological study for the Youssef el Osta Military Base in Kfarchima – Lebanon commissioned by the Engineering Corps, Lebanese Army.**

  (2005)

  Responsibilities: Was the project manager of the project.

- **Well rehabilitation for Société Des Eaux Minérales Libanaise/Perrier Vittel, Nestlé Group in Falougha, Lebanon.**

  (2005)

  Responsibilities: Was the project manager of the project.

- **Deep well assessment for bottling purpose suitability for Société Des Eaux Minérales Libanaise/Perrier Vittel, Nestlé Group in Beit Mere Lebanon.**

  (2005)

  Responsibilities: Was the project manager of the project.

- **Geological and hydrogeological studies as well as environmental impact assessments (EIA) for four quarries in Chekka, North Lebanon. Studies were carried out for Holcim, SLCB, and CMO cement factories as well as for the SCPL lime and plaster factory as part of MoE requirements for quarry permit renewal.**

  (2003-2004)

  Responsibilities: Was the project manager for two of those quarries and was assigned full responsibility of all four studies at a later stage.

- **Groundwater Resources Investigation of The Quetta Province, Phase II, Government of Balochistan, Pakistan. Work consisted of conducting a comprehensive hydrogeological investigation for the development of the groundwater resources of the Quetta Region (>2,000 km2 basin).**

  (2003-2004)

  Responsibilities: Was the expatriate hydrogeologist for this project, main contact with the client and has spent over 8 months in Quetta.

- **Hydrogeological study for the Ghassan Rumman Military Base in Roumie**

  (2004)

  Responsibilities: Was the project manager of the study.

- **Geological and hydrogeological study as well as an environmental impact assessment for a wastewater treatment plant for a slaughterhouse in Chekka area**

  (2004)

- **Geological and hydrogeological studies as well as environmental impact assessments (EIA) for wastewater treatment plants in Hasbaiya and Hrajel**

  (2004)

- **Development of Water Resources for Société Des Eaux Minérales Libanaise/Perrier Vittel, Nestlé Group**

  (2000-2004)

  Responsibilities: Supervision of projects and activities.

- **Evaluation of Groundwater Resources and application of a Groundwater Vulnerability Assessment Model for Jebel el Kneisseh Region; Société Des Eaux Minérales Libanaise/Perrier Vittel, Nestlé Group**

  (2001-2002)

  Responsibilities: Was the project Hydrogeologist and later project manager of the project

- **Landfill Siting for Greater Beirut Area; client Laceco; project commissioned by the Council for development and Reconstruction (CDR). Job involved establishing screening criteria based on environmental, hydrogeological, and geotechnical considerations, etc., and conducting site characterization on the retained sites.**

  (2002)

  Responsibilities: Was the project manager for the project.

6. **Project Consulting, Lebanon (1998 – 2002)**

Geologist

Conducted geologic and hydrogeologic mapping including dam site assessment and underground mapping, gauging, and dye testing.

- Geological and hydrogeological mapping – ELARD s.a.r.l., Lebanon
- Breaker dam site assessment in the UAE– Polytechnical s.a.r.l., Lebanon
- Geological and hydrogeological mapping – BTD s.a.r.l., Lebanon
- Hydrogeological investigation inside karstic networks (caves) including mapping, gauging and dye testing – BTD s.a.r.l., Lebanon.

PUBLICATIONS AND TECHNICAL PAPERS

- **Metni, M.** and Tawk, J. (2009). Baatara Pothole Site: Overview and Development Perspectives. Karst Horizons, 15th International Congress of Speleology, Kerrville-Texas, USA, July 19-26, 2009.
- **Metni, M.,** Bou Jawdeh, I., Karanouh, R., Karkabi, S, and Sarrouf, M. (2009). Al-Kassarat Cave - Antelias: Catchment Works Hazard Assessment. Karst Horizons, 15th International Congress of Speleology, Kerrville-Texas, USA, July 19-26, 2009.
- Editor for the Al-Ouat'Ouate 14 (2008). Magazine on cave exploration and research, published by the Speleo Club du Liban.

- Editor for the Proceedings of the Middle-East Speleology Symposium 2 in 2006 organized by the Speleo Club du Liban at AUB. Member of the Symposium Organizing Committee and Treasurer of the Symposium.
- **Metni, M.,** El-Fadel, M., Sadek, S., Kayal, R., and Lichaa el Khoury, D. (2004). Groundwater Resources in Lebanon: A Vulnerability Assessment. International Journal of Water Resources Development, 20 (4), 475-492.
- El Fadel, M., Kobrossi, R., and **Metni, M.** (2003). Economic Benefits of Reducing Particulate and Sulfate Emissions from the Cement Industry in Lebanon. Journal of Environmental Policy and Management. 5 (1), 99-120. Imperial College Press.
- **Metni, M.,** and Karkabi, S. (2006). Geology and Karst Observations Aiding Archeology: The Faqra Temple Case Study. Middle-East Speleology Symposium 2, AUB, Lebanon, April 2006.
- **Metni, M.,** Bou Jawdeh, I., and Aboulhosn, H. (2006). Speleological Notes on Afqa Cave, Palmyra-Syria. Middle-East Speleology Symposium 2, AUB, Lebanon, April 2006.
- Metni, M., and Nader, F. 2005. Mgharet el Kassarat: History, Morphology and Speleogenesis. Al Ouat'Ouate, 13.
- Nader F. and **Metni M.** (2004). The Jeita Cave Resource Development – Lebanon: Impacts and Assessment. International Transdisciplinary Conference on Development and Conservation of Karst Regions Trans-Karst 2004, 13-18 September 2004, Ha Noi – Vietnam.
- **Metni, M.** (2002). Mghraret Nabaa el Shatawie: Observations on Speleogenesis. Al Ouat'ouate 12, Mgharet Nabaa el Shatawie, Special Publication.
- Bou-Jawdeh, I., **Metni, M.,** and Nader, F. (Speleo-Club du Liban). 2001. Identifying Preferential Karstic Routes within the Qana Plateau, Central Lebanon: A Multidisciplinary Approach. Middle-East Speleology Symposium, Kaslik, Lebanon, April 2001.
- Nader, F., Bou-Jawdeh, I., and **Metni, M.** (2000). Determination of Preferential Karstic Routes By Means of Speleology, Structural Geology, and Hydrogeology (Poster). International Symposium and Field Seminar on: Present and Future Trends of Karst Studies, Marmaris-Turkey, September 2000.

LANGUAGE SKILLS

	Reading	Speaking	Writing
English	5	5	5
French	5	5	5
Arabic	5	5	5

Proficiency is marked from 1 to 5, such that 1=basic & 5=fluent

PERSONAL DATA

Family Name: Gebara
First Names: Fadi
Nationality: Lebanese
Date of birth: 1969
Place of birth Lebanon/ Canadian

EDUCATION:

Masters in Engineering (M.E.) - February 1997
Major Environmental and Water Resources Engineering
American University of Beirut

Bachelor in Engineering (B.E) - July 1993
Major Civil and Environmental Engineering
American University of Beirut

KEY QUALIFICATIONS & EXPERTISE:

- Water Supply and Sewerage
- Water and Waste Water Treatment
- Environmental Impact Assessment (EIA)
- Strategic Environmental Assessment (SEA)
- Environmental baseline studies
- Solid waste management
- Air quality management
- Production methods

EXPERIENCE RECORD (FROM RECENT TO OLDEST):

- (08/2004 – Present) ELARD, Lebanon
- (2000 – 2004) KMK Consultants, Pickering, Ontario, Canada
- Totten Sims Hubicki Associates, Whitby, Ontario, Canada
- Simcoe Engineering Group Limited, Pickering, Ontario, Canada
- (1995 – 2000) Bureau Technique pour le Développement (BTD), Lebanon
- (1993 – 1995) Engico, Beirut, Lebanon

EXPERIENCE INCLUDES:

Waste Water Projects (Selected references):

- Concorde Resort sewerage system preliminary and detailed design, Tartous, Syria

- Odors impact assessment for Dubai Silicon Oasis wastewater treatment plant, Dubai, UAE

- Odors impact assessment for Dubiotech wastewater treatment plant, Dubai, UAE

- Odors impact assessment for Dubai Land 106 Villas wastewater treatment plant, Dubai, UAE

- Odors impact assessment for Dubai Land 103 Villas wastewater treatment plant, Dubai, UAE

- Odors impact assessment for Dubai Land 800 Villas sewage pumping station, Dubai, UAE

- Odors impact assessment for Al Quoz wastewater treatment plant, Dubai, UAE

- Odors impact assessment for Liwan wastewater treatment plant, Dubai, UAE

- Detailed design and tender documents for Qartaba wastewater treatment plant with 1,800 m^3/d average capacity, Lebanon

- Detailed design and specifications for Al Hilal Development sewerage system including gravity sewers (12 km), sewage pumping station (243 L/s) and sewage forcemain (0.6 km), Fujairah, UAE

- Detailed design and specifications for Al Hilal Development storm water drainage system including storm water sewers (15 km), storm water pumping station (486 L/s) and storm water forcemain (1 km), Fujairah, UAE

- Detailed design for Tabuk wastewater treatment plant (67,500 m 3/d) inlet works, filtration and disinfection building, sludge dewatering building and blowers building, Kingdom of Saudi Arabia (KSA)

- Contractor's technical bid documents for Mahelma wastewa ter treatment plant (30,000 m^3/d), includes process design, plant layout, etc., Algeria

- Detailed design for Palm Deira Island Front Promenade sewerage system, Dubai, UAE

- Detailed design and tender documents for Al M urjan Islands wastewater treatment plant (18,500 m^3/d) Ras Al Khaimah Emirate, United Arab Emirates

- Detailed design and tender documents for Al M urjan Islands gravity sewerage system, Ras Al Khaimah Emirate, UAE

- Feasibility study for Aflaj Mohafaza wastewater collection, conveyance, treatment and disposal systems (107,414 population equivalents), Kingdom of Saudi Arabia

- Feasibility study for Haouta Bani Tamim Mohafaza wastewater collection, conveyance, treatment and disposal systems (76,743 population equivalents), Kingdom of Saudi Arabia (KSA)

- Feasibility study for Harik Mohafaza wastewater collection, conveyance, treatment and disposal systems (30,006 population equivalents), Kingdom of Saudi Arabia

- Feasibility study for Kharj Mohafaza wastewater collection, conveyance, treatment and disposal systems (748,846 population equivalents), Kingdom of Saudi Arabia

- Feasibility study for Sulail Mohafaza wastewater collection, conveyance, treatment and disposal systems (80,142 population equivalents), Kingdom of Saudi Arabia

- Feasibility study for Wadi Dawasser Mohafaza wastewater collection, conveyance, treatment and disposal systems (246,251 population equivalents), Kingdom of Saudi Arabia

- Contractor's technical bid documents for M'sila wastewater treatment plant (32,000m^3/d), includes process design, plant layout, etc., Algeria

- Joubb Jannine wastewater treatment plant (10,000m^3/d) detailed design and construction shop drawings, Lebanon

- Saghbine wastewater treatment plant (560 m^3/d) detailed design and construction shop drawings, Lebanon

- Feasibility study for wastewater treatment/re-use (100,000 pe) for Al Rayan and Al Tayssir development projects, Saudi Arabia

- Contractor's technical bid documents for Relizane wastewater treatment plant (21,600 m^3/d), includes process design, plant layout,etc., Alg eria

- Contractor's technical bid documents for Ain Beida wastewater treatment plant (16,840m^3/d), includes process design, plant layout, etc., Algeria

- Tipaza Wastewater Treatment Plant Construction (11,200 m 3/d), Process Design, Technical Assistance and Equipment Selection, Algeria

- Feasibility study for Sarafund Wastewater Project (375,000 population equivalents), Lebanon

- Talbieh Wastewater Treatment Plant Construction (10,000 m3/d) Technical Assistance and Equipment Selection, South Amman, Jordan

- Feasibility study, Pre-Design and Environmental Impact Assessment for Anjar/Majdel Anjar wastewater treatment plant servicing 300,000 population equivalents, Lebanon

- Feasibility study, Pre-Design and Environmental Impact Assessment for Hermel wastewater treatment plant servicing 96,000 population equivalents, Lebanon

- Feasibility study, Pre-Design and Environmental Impact Assessment for Mishmish wastewater treatment plant servicing 69,000 population equivalents, Lebanon

- Feasibility study, Pre-Design and Environmental Impact Assessment for Qaraoun wastewater treatment plant servicing 35,000 population equivalents, Lebanon

- Hawkstone wastewater treatment plant design, Canada

- Muskrat Dam Sewerage system detailed design, Canada

- Feasibility study for Ghadir wastewater treatm ent plant servicing half of Greater Beirut with 1.8M population equivalents

- Environmental Impact Assessment for Hab Valley Wastewater Pollution Abatement

- Environmental Impact Assessment for Mishmish and Machghara wastewater treatment plants

- Feasibility study for El Marj wastewater treatment plant servicing 116,000 population equivalents

- Management of wastewater sampling and analyses program for the establishment of the wastewater characteristics in Bcharre Caza and Akkar Caza

- Wastewater Collection Master Plan and Feasibility Study for Bcharre Caza (28 localities)

- Environmental Impact Assessment for Bcharre Caza wastewater management project

- Mitigation measures for water pollution control in Bcharre Caza

- Preliminary and detailed design of a sewerage system (1 7 km) and a wastewater treatment plant (2000 m^3/day) for the region of Zaarour, Habach and Manboukh

- Preliminary and detailed design of a sewerage system (35 km) and a wastewater treatment plant (4000 m^3/day) for the region of Ouyoun Es Simane

- Detailed design of a sewerage system for an oil base at Kwanda in Angola

- Detailed design of a sewerage system for Al Manar University in Tripoli

Water Projects (Selected References):

- Concorde Resort potable water system preliminary and detailed design, Tartous, Syria

- Preliminary and detailed design for Nabatiye Water Supply Project including water transmission lines (6 km), water storage reservoirs (8) and water distribution systems (37 km), Lebanon

- Preliminary design for Al Hilal Development water supply system including water storage reservoir (15,000 m^3), water pumping station (300 L/s) and water distribution system (13 km), Fujairah, United Arab Emirates

- Preliminary design for Al Hilal Development irrigation water supply system including irrigation water storage reservoirs (1,600 m^3), irrigation water pumping station (36 L/s) and irrigation water distribution system (12.5 km), Fujairah, United Arab Emirates

- Detailed design for Palm Deira Island Front Promenade water supply system, fire fighting system, water storage reservoir, water pumping station, irrigation supply system and storm water drainage system, Dubai, United Arab Emirates

- Detailed design and tender documents for Al M urjan Islands potable water supply system including water storage reservoirs (26,000 m^3), water pumping station (342 L/s) and water distribution system (20.1 km), Ras Al Khaimah Emirate, United Arab Emirates

- Detailed design and tender documents for Al M urjan Islands irrigation/fire water supply system including water storage reservoirs (5,600 m^3), water pumping station (103 L/s) and water supply system (14.5 km), Ras Al Khaimah Emirate, United Arab Emirates

- Feasibility study for Aflaj Mohafaza water production, treatment, storage, transmission and distribution systems (22,888 m^3/d), Kingdom of Saudi Arabia

- Feasibility study for Haouta Bani Tamim Mohafaza water production, treatment, storage,transmission and distribution systems (17,019 m^3/d), Kingdom of Saudi Arabia

- Feasibility study for Harik Mohafaza water production, treatment, storage, transmission and distribution systems (6,271 m^3/d), Kingdom of Saudi Arabia

- Feasibility study for Kharj Mohafaza water production, treatment, storage, transmission and distribution systems (169,589 m^3/d), Kingdom of Saudi Arabia

- Feasibility study for Sulail Mohafaza water production, treatment, storage, transmission and distribution systems (17,038 m^3/d), Kingdom of Saudi Arabia

- Feasibility study for Wadi Dawasser Mohafaza water production, treatment, storage, transmission and distribution systems (55,585 m^3/d), Kingdom of Saudi Arabia

- Feasibility Study for West Bekaa Water Supply, Production, Transmission, Storage and Distribution (62,000 m^3/d), Lebanon

- Rachaine Spring Feasibility Study, Transmission, Storage and Distribution (30,000 m 3/d), Lebanon

- Muskrat Dam Phase II Municipal Infrastructure Servicing Tender Documents, Canada

- Muskrat Dam Phase II Municipal Infrastru cture Servicing Effective Project Approval, Canada

- Gull Bay Water Works Operation & Maintenance, M onitoring and Training TOR, Canada

- Gull Bay Phase II Water & Sewer Servicing Preliminary Project Approval, Canada

- Port Hope new water treatment plant membrane filtration system selection and plant pre -design – Municipality of Port Hope, Canada

- Cobourg water treatment plant compliance upgrades detailed design – Lakefront Utility Services Inc., Canada
- Port Perry water supply system compliance upgrades detailed de sign – Regional Municipality of Durham, Canada
- Blackstock water supply system compliance upgrades detailed design – Regional Municipality of Durham, Canada
- Uxville water supply system compliance upgrades detailed design – Regional Municipality of Durham, Canada
- South Chatham-Kent new membrane filtration water treatment plant – Municipality of Chatham - Kent, Canada
- Class environmental assessment for Springdale Gardens water works – City of Kawartha Lakes, Canada
- Class environmental assessment for Sandwood Est ates water works – City of Kawartha Lakes, Canada
- Preliminary design for Woodfield water works upgrades – City of Kawartha Lakes, Canada
- Preliminary design for Lindsay water treatment plant upgrades – City of Kawartha Lakes, Canada
- Detailed design and specifications and contract tender documents for Sutton Watermain with 400 mm concrete pressure pipe 4.0 km long – York Region, Canada
- Detailed design and preparation of specifications and contract tender documents for Lake Simcoe Intake – York Region, Canada
- Detailed design of a water supply conveyor from Jouaizat spring to Bhannes reservoirs (22.5 km)
- Detailed design of water supply conveyors in the Barouk region: Batloun - Dmit: 19 km; Batloun -
- Semqaniye: 11 km; Raayan - Aaley: 28 km; Maaser - Deir El Qamar: 5 km; Qaa - Beit Dine: 16 km
- Water Supply Master Plan and Feasibility Study for Bcharre Caza: 80 km of transmission pipelines, 180 km of distribution pipelines, 36 reservoirs, 8 catchment works, 6 wells and 6 pumping stations
- Detailed Design of 180 km of water transmission and distribution pipelines in Bcharre Caza
- Detailed design of an irrigation water conveyor from Laboue to Qaa (21 km)
- Preliminary and detailed design of a water distribution system (22 km) for the region of Zaarour, Habach and Manboukh

- Management of the water sampling and analyses program for the Awali - Beirut Water Supply Conveyor Project
- Water supply study and detailed design of a water distribution system (16 km) for Ehden
- Detailed design of a water distribution system for an oil base at Kwanda in Angola
- Detailed design of a water distribution system for Al Manar University in Tripoli

Storm Water Drainage Projects (Selected References):

- Concorde Resort storm water drainage system preliminary and detailed design, Tartous, Syria
- Detailed design and specifications for Al Hilal Development storm water drainage system including storm water sewers (15 km), storm water pumping station (486 L/s) and storm water forcemain (1km), Fujairah, United Arab Emirates
- Detailed design and specifications for Al M urjan Islands storm water drainage system (16km), Ras Al Khaimah Emirate, UAE.

PUBLICATIONS AND CONFERENCES (FROM RECENT TO OLDEST):

Gebara F., (1999), "Activated Sludge Biofilm Wastewater Treatment System", Water Research Journal, Volume 33, No. 1.

LANGUAGES:

Proficiency is marked from 1 to 5, such that 1=basic & 5=fluent.

Language	Reading	Speaking	Writing
English	5	5	5
French	5	5	5
Arabic	5	5	5

PERSONAL DATA:

Family Name:	Antoine
First Name:	Waked
Nationality:	Lebanese
Date of Birth	32 years

KEY QUALIFICATIONS & EXPERTISE:

7 years of experience Atmospheric chemistry: gas and particles; organic compounds; gas chromatography; mass spectrometry; extraction; data treatment; sampling; air pollution sources; receptor-based models; deterministic models (meteorological and air quality); emissions calculations methodologies.

EDUCATION

- **Assistant professor** degree for the section 37 (Meteorology, oceanography, and environment) from the French national council of universities (2016)
- **Assistant professor** degree for the section 31 (theoretical, physical and analytical chemistry) and section 32 (organic, inorganic and industrial chemistry) from the French national council of universities (2014)
- **PhD in Atmospheric Chemistry** Modeling Laboratory : CEREA, Ecole des ponts /Paris-Tech , EDF R&D, Paris, France
  Measurement Laboratory: CAR-FS USJ, Saint-Joseph University, Beirut, Lebanon (2012)
- Master of science (DESS) **in Industrial Technology** Saint-Joseph University, Beirut, Lebanon (2009)
- **Bachelor of science in general chemistry** Saint-Joseph University, Beirut, Lebanon (2007)

EXPERIENCE RECORD (FROM RECENT TO OLDEST):

1. **Consultant at freelance (Nov 2013-Present)**

Air Quality/Climate Change

Green House Gases **(GHG)** Emissions calculations for the transport sector for Lebanon for the third national communication to the United Nation Framework Convention on Climate Change **(UNFCCC)**

2. IMT/Lille-Douai, France, SAGE department (Nov 2014-Sep 2018)

Researcher

Selected Projects:

- **Analysis** of measurements data of Volatile Organic Compounds VOC's and particles in the atmosphere
- **Validation** of measurements data of VOC's for more than 10 years performed by **GC-FID** (detection limit, accuracy, traceability, spatio-temporal variability, co-variation)

- Trend analysis by means of the **non-parametric statistical test of** Mann-Kendall
- Identification of the sources of Formaldehyde in the atmosphere
- Studying the link between **new particles formation (NPF)** and **precursors gases**
- Studying the link between meteorology and air pollution in a context of climate change **(CLIMIBIO; receptor-based models; trends, etc…**

3. French national council for scientific research (CNRS), Glaciology and Geophysics Laboratory, Grenoble, France (Oct 2012- Nov 2014)

Researcher

Selected Projects:

Analysis of Particulate matter (PM) measurements data.

- Responsible of the **validation** of the data base of the **chemical measurements** of **PM** (inspection, audit, quality assurance/quality control) for the AASQA, ADEME and LSCQA
- **Chemical characterization** of PM and identification of **air pollution sources** (Statistical models, tracer-based approach, research and development)
- **Teaching Organic Chemistry** and **Cristal-Chemistry courses** at the University of Joseph-Fourrier in Grenoble, France.

4. Ecole Nationale des Ponts et Chaussées – Paris, France (Sep 2009-Sep 2012)

Researcher

Selected Projects:

Characterization of organic PM in Beirut, Lebanon.

- **Development** of an atmospheric **emission inventory** for **Lebanon** (Air pollutants emissions calculations, spatial resolution, point and mobile sources) 2
- Participation in two **measurements campaigns (Sampling** of PM on **quartz-fiber filters,** solid-liquid **extraction**, analysis of **organic** PM by **GC/MS**)
- **Air quality modeling** by means of the chemistry transport model **Polyphemus/Polair3D** (deterministic model, **WRF** meteorological model, air pollution maps, **prevision**, etc...)

5. Master thesis ALGORITHM Lebanon (Mar 2003- Jun 2009)

Selected Projects:

Implementation of OEE **(Overall Equipment Effectiveness**) in a pharmaceutical industry

- **Key performance indicators** in order to improve **the productivity**
- **Action plan** for productivity improvement (reduction of **bulky flows, stock management, etc…)**

6. Trainee at MASTERPAK, part of INDEVCO group, Lebanon (Jun 2008- Sep 2009)

Selected Projects:

American Standard for Testing and Materials **(ASTM)** procedures

- **Quality assurance** for the quality control laboratory in order to verify that ASTM procedures are followed

PUBLICATIONS AND TECHNICAL PAPERS

- **Waked, A.,** Afif, C. and Seigneur, C.: An atmospheric emission inventory of anthropogenicand biogenic sources for Lebanon, Atmospheric Environment, 50(0), 88–96, doi:10.1016/j.atmosenv.2011.12.058, **2012.**
- **Waked, A.** and Afif, C.: Emissions of air pollutants from road transport in Lebanon and othercountries in the Middle East region, Atmospheric Environment, 61(0), 446–452, doi:10.1016/j.atmosenv.2012.07.064, **2012.**
- **Waked, A.,** Seigneur, C., Couvidat, F., Kim, Y., Sartelet, K., Afif, C., Borbon, A., Formenti,P. and Sauvage, S.: Modeling air pollution in Lebanon: evaluation at a suburban site in Beirut during summer, Atmos. Chem. Phys., 13(12), 5873–5886, doi:10.5194/acp-13-5873-2013, **2013.**
- **Waked, A**., Afif, C., Brioude, J., Formenti, P., Chevaillier, S., Haddad, I. E., Doussin, J.-F.,Borbon, A. and Seigneur, C.: Composition and Source Apportionment of Organic Aerosol in Beirut, Lebanon, During Winter 2012, Aerosol Science and Technology, 47(11), 1258–1266, doi:10.1080/02786826.2013.831975, **2013.**
- **Waked, A.,** Favez, O., Alleman, L. Y., Piot, C., Petit, J.-E., Delaunay, T., Verlinden, E.,Golly, B., Besombes, J.-L., Jaffrezo, J.-L. and Leoz-Garziandia, E.: Source apportionment of PM10 in a North-Western Europe regional urban background site (Lens, France) using Positive Matrix Factorization and including primary biogenic emissions, Atmos. Chem. Phys., 14(7), 3325–3346., **(2014).**
- **Waked, A.,** C. Afif; P. Formenti; S. Chevaillier; I. El-Haddad; A. Borbon; J.-F. Doussin; C.Seigneur. Characterization of organic tracer compounds in PM2.5 at a semi-urban site in Beirut, Lebanon Atmos. Res. 143, 85-94., **(2014).**
- Polo-Rhen, L., **Waked, A.,** Charron, A., Piot, C., Besombes, J.-L., Marchand, N., Guillaud, G., Favez, O., Jaffrezo, J.-L. : Estimation de la contribution des émissions véhiculaires à l'échappement et hors échappement aux teneurs atmosphériques en PM10 par Positive Matrix Factorization (PMF), Pollution Atmosphérique-2014, N 221, Janvier-Mars, **2014.**
- **Waked, A.,** Afif, C., and Seigneur, C.: Assessment of source contributions to air pollution in Beirut, Lebanon: comparaison of source-based and tracer-based modeling approaches. Air Quality Atmosphere and Health, 8, no. 5 (October 1, **2015**): 495–505.doi:10.1007/s11869-014-0298-z.
- Salameh, T., Sauvage, S., Afif, C., Borbon, A., Leonardis, T., Brioude, J, **Waked, A** and Locoge, N. "Exploring the Seasonal NMHC Distribution in an Urban Area of the Middle East during ECOCEM Campaigns: Very High Loadings Dominated by Local Emissions and Dynamics." Environmental Chemistry 12, no. 3 (**2015**): 316–28.
- **Waked, A.,** Sauvage, S., Borbon, A., Gauduin, J., Palleres, C., Vagnot, M-P., Léonardis, T.,and Locoge, N. Multi-years levels and trends of non-methane hydrocarbon concentration observed in ambient air in France. Atmospheric Environment, 141(0), 263-275, **(2016)**

- Dhaini, H. R., Salameh, T., **Waked, A.,** Sauvage, S., Borbon, A., Formenti, P., Doussin, J.-F., Locoge, N., Afif, C. **(2017).** Quantitative cancer risk assessment and local mortality burden for ambient air pollution in an eastern Mediterranean City. Environmental Science and Pollution Research, 24(16), 14151–14162.
- Freney, E., Sellegri, K., Chrit, M., Adachi, K., Brito, J., **Waked, A.,** Borbon, A., Colomb, A., Dupuy, R., Pichon, J.-M., Bouvier, L., Delon, C., Jambert, C., Durand, P., Bourianne, T., Gaimoz, C., Triquet, S., Féron, A., Beekmann, M., Dulac, F., and Sartelet, K.: Aerosol composition and the contribution of SOA formation over Mediterranean forests, Atmos. Chem. Phys., 18, 7041-7056, https://doi.org/10.5194/acp-18-7041-2018, **2018.**
- **Waked, A.,** Bourin, A., Michoud, V., Perdrix, E., Alleman, L., Sauvage, S., Delunay, T., Vermeech, S., Petit, J-E., Riffault, V. Investigation of the geographical origins of PM10 based on long, medium and short-range air mass back-trajectories impacting Northern France during the period 2009–2013 ». Atmospheric Environment 193 (1 november **2018**): 143-52.
- B. Golly, **A. Waked**, S. Weber, A. Samake, V. Jacob, S. Conil, J. Rangognio, E. Chrétien, M.-P. Vagnot, P.-Y. Robic, J.-L. Besombes, J.-L. Jaffrezo. Organic markers and OC source apportionment for seasonal variations of PM2.5 at 5 rural sites in France, Atmospheric Environment, 198, **2019**: 142-157

LANGUAGE SKILLS

	Reading	**Speaking**	**Writing**
English	5	5	5
French	5	5	5
Arabic	5	5	5

Proficiency is marked from 1 to 5, such that 1=basic & 5=fluent

PERSONAL DATA:

Family Name: Shaar
First Name: Karim
Nationality: Lebanese
Date of birth: 15-Nov-1990
Place of birth: Ras Beirut
Civil Status: Single

KEY QUALIFICATIONS & EXPERTISE:

- Developing Environmental Impact Assessment (EIA) studies
- Conducting environmental audits and developing environmental audit reports
- Developing Health, Safety and Environment (HSE) Management Plans for existing projects and tender submittals.
- Conducting Health, Safety and Environment (HSE) inspections and audits.
- Developing HSE risk assessments.

EDUCATION

- **MSc Environmental Sciences –** Ecosystems Management – American University of Beirut (2016)
- **BSc Environmental Health** - American University of Beirut (2011)

TRAINING

Date	Type of Training	Certificate
October 2017	OSHA 30 Hour Construction Safety	Yes
September 2017	First Aid Training	Yes
May 2017	Excavation Safety	Yes
May 2017	Working in Confined Spaces	Yes
May 2017	Working at Height	Yes
March 2016	ISO 14001:2015 Environmental Management System Transition Course	Yes
August 2014	ISO 14001:2004 Internal Auditor	Yes

EXPERIENCE RECORD (FROM RECENT TO OLDEST):

1. ELARD (January 2018 - Present)

Title: Assistant Project Manager – Environmental Specialist (January 2019 – Present)

Title: Environmental Specialist (January 2018 – December 2018)

Projects:

- Environmental Impact Assessment (EIA) for two constructed wetlands for the treatment of domestic wastewater in Roum, South Lebanon and Aayoun el Ghezlane, North Lebanon.
- Environmental Impact Assessment (EIA) for the Treveria Pharmaceutical and Cytotoxic Waste Storage Facility in Fanar, Mt. Lebanon.
- Environmental Impact Assessment (EIA) for the expansion of the COGICO fuel tanks terminal in Jiyeh, Mt. Lebanon.
- Environmental Impact Assessment (EIA) for the Qalamoun wastewater pumping stations project.
- Developing comprehensive environmental guidelines for the Ministry of Environment, Water, and Agriculture in the Kingdom of Saudi Arabia (KSA) on environmental auditing, mining/quarrying, and land rehabilitation/remediation plans.
- Environmental Management Plans (EMP) for seven designated protected and surrounding areas in Dubai, UAE.
- Data collection and analysis of industrial and touristic establishments as part of the Business Plan for Combating Pollution in the Lower Litani Basin.
- Revising baseline and impact assessment sections in the Strategic Environmental Assessment (SEA) for exploration and production activities offshore oil and gas resources in Lebanon.
- Initial Environmental Examination (IEE) for Ritver Paints Factory in Hosrayel, Mt. Lebanon.
- Capacity building and public awareness raising campaign on solid waste management in five villages in West Bekaa.
- Environmental Training for Municipal Clusters in Lebanon on different environmental topics (air pollution, water pollution, solid waste management, wastewater management, and land use).

2. Consolidated Contractors Company (CCC) (February 2014 – January 2018)

Title: HSE Engineer – Risk Management Lead (April 2017 – January 2018)

- **Future Growth Project – 3rd Generation Plant Project (3GP) – Tengiz, Kazakhstan**
    - Coordinate with workface planning to identify upcoming risks and accordingly develop look ahead risk assessment plans.
    - Review method statements and provide input to risk assessments.

- Ensure proper implementation of the risk assessment, permit to work, and job safety analysis systems.
- Supervise the onsite permit to work coordinators.
- Ensure project operations are in line with Tengizchevroil (client) HSE requirements and procedures.
- Conduct daily HSE inspections to ensure compliance with HSE procedures.
- Conduct weekly HSE audits with client representatives and implement action plans and recommendations based on the findings.
- Conduct HSE investigations and reporting for any incident when needed.
- Attend and participate in client HSE meetings.

***Title: Environmental Coordinator* (February 2014 – March 2017)**

- **CCC HSE Group – Abu Dhabi, UAE**
    - Developed specific environmental procedures for CCC's projects, incoming tenders and prequalification based on client environmental requirements, EIA studies, and CCC procedures.
    - Developed a new comprehensive Environmental Management Procedure, (ISO14001:2015 certified), to be adopted and implemented by all CCC projects worldwide. The plan includes control procedures for all environmental aspects encountered at construction sites.
    - Conducted monthly environmental inspections around the company compound and PMV Yard.
    - Prepared HSE plans and submittals for prequalification and tenders.
    - Coordinated with project management, and prepared their specific environmental and HSE plans in accordance with contract documents and quality standards (ISO
    - 14001 and OHSAS 18001).
    - Participated in corporate HSE audits conducted on projects to check their compliance to CCC HSE standards.
    - Followed up with projects on any HSE incident, audit, and other HSE activities that were/had to be conducted at the project level.
    - Reviewed weekly reports sent by the projects that relate to HSE in general and environmental ones in specific.
    - Prepared HSE presentations for clients.

3. Society for the Protection of Nature in Lebanon (SPNL) (September 2012 – January 2014)

Title: Communications Officer

- Coordinated and worked on local and regional environmental projects related to protecting migratory soaring birds, promoting sustainable hunting in Lebanon, sustainable grazing, and sustainable community development.

- Communicated with local and regional NGOs that relate to the scope of work and the projects handled.
- Participated in local and regional environmental workshops.

4. American University of Beirut (AUB) – Nature Conservation Center (January 2012 – June 2012)

Title: Research Assistant

- Conducted research on community based natural resources management in different rural communities across Lebanon. The project was funded by the International Development Research Center (IDRC) - Canada.

LANGUAGE SKILLS

	Reading	Speaking	Writing
English	5	5	5
French	1	2	1
Arabic	5	5	5

Proficiency is marked from 1 to 5, such that 1=basic & 5=fluent

PERSONAL DATA:

Family Name:	El-Khoury
First Name:	Tina
Nationality:	Lebanese
Date of birth:	15/01/1993
Civil Status:	Single

KEY QUALIFICATIONS & EXPERTISE:

- Developing Environmental and Social Impact Assessment (ESIA) studies
- Conducting environmental audits and developing environmental audit reports
- Projects coordinating, and managing logistical details
- Computer Skills: Microsoft office (Word, Excel, PowerPoint), Google Earth, ArcGIS

EDUCATION

- **MSc Environmental Sustainability** –The University of Edinburgh (2018)
- **BSc Environmental Sciences** –Notre Dame University (2014)

EMPLOYMENT RECORD:

09/2014 – 03/2017	Project Coordinator	AUB-Nature Conservation Center
05/2019 – Present	Junior Environmental Specialist	ELARD

TRAINING

Date	Type of Training	Certificate
August 2019	ISO 14001: 2015 Environmental Management System	Yes
August 2019	ISO 45001: 2018 Health and Safety System	Yes

EXPERIENCE RECORD (FROM RECENT TO OLDEST):

1. ELARD (June 2019 - Present)

Title: Junior Environmental Specialist

Projects:

- Scoping Report for the Overhead Transmission Line between Deir Aamar and Deir Nbouh, North Lebanon (Client: CDR)
- ESMP for Brasserie Almaza (Client: UNDP, LEPAP)
- Environmental Audit for Grate and Crumble Dairy Facility in Hosh el Oumara, Zahle
- EIA for the Burj Hammoud Wastewater Preliminary Treatment Plant (Phase I) (Client: CDR)
- Environmental Audit for Gandour Factory in Beirut
- Environmental Audit for Chateau Marsyas Winery, Bekaa

2. AUB- Nature Conservation Center (September 2014 – March 2017)

Title: Projects Coordinator

Tasks:

- Coordinating two Eco-Entrepreneurship Awards
- Coordinating public relations with local and international startup organizations
- Coordinating and organizing environmental workshops and events
- Researching different environmental subjects

LANGUAGE SKILLS

	Reading	Speaking	Writing
English	5	5	5
Arabic	5	5	5
French	4	3	2

Proficiency is marked from 1 to 5, such that 1=basic & 5=fluent

PERSONAL DATA:

Family Name: Mashtoub
First Name: Tarek
Nationality: Lebanese
Date of birth: 11/9/1989
Civil Status: Single

KEY QUALIFICATIONS & EXPERTISE:

- Data Analysis
- Generation of 3D surface and subsurface Geologic model of Lebanon
- Geologic Mapping
- Generating Cross sections
- Water Well monitoring
- Conducting Pumping Tests
- Computer Skills: Microsoft office (Word, Excel, PowerPoint, Project), Map info, Corel Draw, ArcGIS, GMS

EDUCATION

- **Bachelor** of Science in Petroleum Studies –American University of Beirut (2011)

EMPLOYMENT RECORD:

02/2012 - Present Hydrogeologist ELARD

EXPERIENCE RECORD (FROM RECENT TO OLDEST):

1. ELARD (February 2012 - Present)

Title: Hydrogeologist

- **Study to Define New Site for a Water Bottling Plant in Lebanon**
  - Developing a methodology for the location of a water bottling plant to selected specific zones from the general proposed areas
  - Completing field visits and reports
- **Hydrogeological study in Four (4) Cazas – UNICEF**
  - Completing geological and hydrogeological assessments in four (4) Cazas (Zahle, Rachaya, Marjaayoun and Minnieh Donnieh) and proposing recommendation for future exploration zones

- Completing field visits and reports.

- **Hydrogeological Study in Four (4) Locations - UNHCR**
  - Completing a geological and hydrogeological report with the assessment of the proposed locations for drilling new wells in North Lebanon and Riyak areas.
  - Preparing well design.
- **Hydrogeological Study in Wata Haoub (Nabaa el Korsi)**
  - Completing a geological and hydrogeological report for the area (1/10000)
  - Measuring flow of the spring
- **Provision of environmental services to the UNIFIL – Lebanon**

  Responsibilities:

  - Reports preparation
  - Technical support for UNIFIL's environmental management unit
  - Assessment of wastewater treatment plants operation
  - Assessing soil and water pollution
  - Water and Soil sampling
- **Environmental Impact Assessment for the Jiyyeh Resort – Lebanon**

  Responsibilities:

  - Report preparation
  - Assessing air, noise and water baseline
- **Environmental services to the Water Infrastructure Support and Enhancement for Lebanon (WISE-Lebanon)**

  Responsibilities:

  - Report preparation
  - Conducting groundwater sampling
  - Data assessment
- **Initial Environmental Examination for one water bottling plant in Saghbine – Lebanon**

  Responsibilities:

  - Report preparation
  - Impact assessment of the project activities
- **Initial Environmental Review for Haouch El Omara Water Supply Network, Lebanon**

  Responsibilities:

  Development of the various sections of the IEE:

  - Surface water impact assessment
  - Water channels crossing impact assessment
- **Initial Environmental Review for Deddeh Water Supply Network, Lebanon**

  Responsibilities:

  Development of the various sections of the IEE:

- Environmental baseline
- Impact assessment of the project activities
- Environmental mitigation and monitoring plan and report

- **Provision of Assessing the National Groundwater Resources through Data Collection and Field Assessment Campaign of Groundwater resources across Lebanon**

  Responsibilities: Field Geologist doing mapping and well assessment and analyzing the information.

- **Implantation of Hydrogeological Study for the Construction of Three (3) Boreholes in Zouk Power Plant Property**

  Responsibilities: Field Geologist and analyzing the information

- **Technical Hydrogeological Study for the Proposed Water Bottling Plant in Ainata**

  Responsibilities: Field Geologist doing mapping, generation of cross sections, report writing and analyzing the information.

- **Vulnerability Study of the Nabaa el Aasal Spring to CIL's proposed road and development Project in Kfardebian**
  - Completing geologic field mapping (1/20:000) for Kfardebian area and preparing hydrogeological report and Vulnerability maps based on different methods
  - Measuring the Nabaa Al Aasal Flow

- **Environmental Impact Assessment (EIA) for Mall Of The World-DUBAI**
  - Preparing full geology and soil base line section along with sampling analysis and GIS maps
  - Preparing Impact assessment sections for geology and soil
  - Preparing EMMP sections

- **Hydrogeological Study in 4 Cazas (Hermel, Koura, Akkar and Jezzine)**

  Responsibilities:

  - Field Geologist doing well assessment and analyzing the information.
  - Geological and hydrogeological reporting and assessment for the different aquifers and formations in Akkar, Koura, Hermel and Jezzine.

- **Survey & Reporting of Monitoring Wells Status**

  Responsibilities:

  Field survey in Bekaa, South, North and Mount Lebanon for full checkup of the monitoring equipment in the wells that were installed from the UNDP project.

- **Leak Investigation**

  Responsibilities:

  - Drilling Supervision for five boreholes and setup and completion of monitoring well
  - Continuous soil (SPT) sampling

- Ground water sampling

- **MoE-Support Industrial Pollution Abatement in Lebanon.**
  - Preparation of full geology sections along GIS maps on areas of industry with an analysis on the effect of pollutants on surface water and ground water.
- **CCTV and Logging services in Lebanon**
  - Performing of a field CCTV and logging services
- **Environmental and Traffic Impact Assessment for Fouad Boutros Boulevard**
  - Preparing full geology and soil base line section along with sampling analysis and GIS maps
  - Preparing Impact assessment sections for geology and soil
  - Preparing EMMP sections

LANGUAGE SKILLS

	Reading	Speaking	Writing
English	5	5	5
Arabic	5	5	5

Proficiency is marked from 1 to 5, such that 1=basic & 5=fluent

PERSONAL DATA:

Family Name: Hassan Kassem
First Name: Assaad
Nationality: Lebanese
Date of birth: 12 November, 1993
Place of birth: Shmustar
Civil Status: Single

KEY QUALIFICATIONS & EXPERTISE:

- Groundwater modeling, pumping test analysis, geological reporting, partial differential equations, water quality testing and analysis, water treatment, water treatment using nano-adsorbents, waste management.
- Computer Skills: R-Software, VBA, ArcGIS, Mike She for Groundwater Modelling, AQTESOLV for pumping tests analysis, ISOQX for pumping tests analysis, Hydrus, CorelDraw, Microsoft office.

EDUCATION

- **Masters of Sciences in Environmental Technology**

  American University of Beirut – Faculty of Engineering – Department of Civil and Environmental Engineering (Expected: September 2019).

- **Bachelor of Science in Geology/Minor in Mathematics**

  American University of Beirut – Faculty of Arts and Sciences – Department of Geology (December 2015)

TRAININGS

Date	Type of Training	Certificate
January, 2018	Two weeks training in entrepreneurship (Arab Innovation Academy, Qatar).	Yes
September, 2016	Lab chemical and biological safety (American University of Beirut).	Yes

EXPERIENCE RECORD (FROM RECENT TO OLDEST):

1. ELARD (September 2017 - Present)

Title: Geologist-Hydrogeologist/ Junior

- **Rehabilitation of Existing Pumping Stations in Wadi Jeelo and Batoulay in Tyre, Lebanon (Care, ACF, and South Lebanon Water Establishment)**
    - Conducting Pumping tests on existing wells
    - Analysis of pumping tests to evaluate local aquifer's hydraulic properties
    - Projection of sustainable pumping rates to fit the pumping schemes and water demand
    - Wells installation supervision
    - Assessing wells water quality
- **Comprehensive Environmental Regulations for Kingdom of Saudi Arabia (Booz Allen Hamilton)**
    - Compilation of recognized international soil quality standards.
    - Reviewing environmental settings in the Kingdom of Saudi Arabia (KSA) and their effects on soil quality.
    - Concluding a best fit soil standard that can be applied in KSA taking into account the climatic and land-use variation.
- **Well Siting, Construction Supervision and Well completion Reporting in Rihaniye Akkar- (RMF)**
    - Construction supervision, CCTV, Geophysical Logging, Pumping test and well completion report.
- **Hydrogeological study of Tripoli Caza and Technical Assessment of Public Wells Siting (North Lebanon Water Establishment)**
    - Population and water demand calculations and projections.
    - Proposing recommendations for future exploration zones within the Cazas.
    - Well siting (deep and shallow wells)
- **Monitored Artificial Recharge in Lebanon- Acacia (Netherlands) and AUB (American University of Beirut)**
    - Mud drilling supervision.
    - Pumping test supervision and analysis.
- **General Analysis of The Water Supply Situation in twelve (12) Palestinian Camps- UNRWA**
    - Assessing water quality of groundwater resources within the study areas.
- **Well Siting, Construction Supervision and Well completion Reporting in Nasriyyah Bekaa- UNHCR**
    - Construction supervision, CCTV, Geophysical Logging, Pumping test and well completion report.

- **CCTV and Logging services in Lebanon**
  - Performing various fields of CCTV and geophysical well logging services.
  - Analysis of results and Reporting.
- **Environmental Impact Assessment (EIA) in Lebanon**
  - Preparing full geology and soil base line sections and GIS maps.
  - Preparing Impact assessment sections for hydrogeology and soil.

2. American University of Beirut – Environmental Engineering Research Center (Sept. 2016 – Sept. 2017)

Title: Graduate Assistant

- Analysis and testing of water samples for domestic and industrial purposes.
- Teaching assistant for water treatment engineering course.

3. American University of Beirut – Department of Geology (Feb. 2016 – Sept. 2018)

Title: Research Assistant

- Groundwater modeling within Asal Spring catchment area using MikeShe.
- Surface water mapping using ArcGis.
- Time series data analysis and management by VBA coding.
- Groundwater vulnerability assessment using numerical modeling approach.

4. Lebanese Petroleum Administration – Department of Geology and Geophysics (March 2016 – July. 2016)

Title: Research Intern

- Interpretation of 2-D seismic lines offshore Lebanon.
- Faults mapping offshore Lebanon using ArcGis.
- Identification of geological structures offshore Tripoli
- Interpretation of seismic images of salt layers offshore Tripoli

REFEREED JOURNAL PUBLICATIONS AND CONFERENCE PAPERS

- MSc. Thesis: Assessment of key parameters in groundwater vulnerability methods using numerical modeling approach. (Ongoing)
- Kassem, A., Ayoub, G. and Malaeb, L. (2019). Antibacterial activity of chitosan nano-composites and carbon nanotubes: A review. *Science of The Total Environment*, 668, pp.566-576.
- Doummar, J., Kassem, A. H., & Gurdak, J. J. (2018). Impact of historic and future climate on spring recharge and discharge based on an integrated numerical modelling approach: Application on a snow-governed semi-arid karst catchment area. *Journal of Hydrology*, *565*, 636-649.

- Doummar, J., Kassem, A., & Gurdak, J. J. (2017, December). Prediction of daily spring hydrographs for future climatic scenarios based on an integrated numerical modelling approach: Application on a snow-governed semi-arid karst catchment area. In *AGU Fall Meeting Abstracts*. (Conference Paper)
- Doummar, J., & Kassem, A. (2017, April). Quantitative assessment of key parameters in qualitative vulnerability methods applied in karst systems based on an integrated numerical modelling approach. In EGU General Assembly Conference Abstracts (Vol. 19, p. 15874). (Conference Paper)

Language Skills

	Reading	**Speaking**	**Writing**
English	5	5	5
Arabic	5	5	5

Proficiency is marked from 1 to 5, such that 1=basic & 5=fluent