4 Selected Wastewater Treatment Option: Conventional Activated Sludge with Anaerobic Sludge Treatment ("CAS")

4.1 Selection of CAS as the preferred Wastewater Treatment Option

The evaluation to select of the best process alternative was performed in Part IIa of the Feasibility Study (Development of Alternative Processes for the WWTP). The evaluation was performed on six (6) different treatment options, that were chosen based on a number of drivers or criteria (such as proven and robust technology applicable in large scale WWTPs, limited land footprint due to the land restrictions in the design area, assurance of complying with the required ELV, proximity to the Beirut International Airport, etc.) in order to deal with the specific conditions of the Ghadir WWTP in the most effective way.

Based on these drivers, the six alternatives compared in the FS Part IIa were:

- Option 1 – CAS: Conventional activated sludge with primary settling tanks (lamella) and with anaerobic digestion of the produced sludge for energy recovery;
- Option 2 – ASP: Activated Sludge Process without primary settling treatment and with aerobic digestion of the produced sludge;
- Option 3 – SBR: Sequence Batch Reactors with primary settling tanks (lamella) and with anaerobic digestion of the produced sludge for energy recovery;
- Option 4 – MBBR: Moving Bed Biological Reactor with primary settling tanks (lamella) and with anaerobic digestion of the produced sludge for energy recovery;
- Option 5 – MBR: Membrane Biological Reactor with primary settling tanks (lamella) and with anaerobic digestion of the produced sludge for energy recovery;
- Option 6 – UASB: Upflow Anaerobic Sludge Blanket Reactor combined with a smaller capacity CAS treatment option (secondary treatment, clarifiers etc.).

These alternatives were developed in the Part IIa FS report following the phasing presented in Table 24:

Table 24: Synopsis of suggested phasing

Option	Phase I (2015)	Phase II (2030)
CAS	a) Extension of Preliminary Treatment b) Upgrade to Primary Treatment (Settling Tanks) c) Anaerobic Sludge Treatment for Primary Sludge **BOD removal: 25%-30%**	a) Upgrade to Secondary Treatment b) Extension of Anaerobic Sludge Treatment for Secondary Sludge **BOD removal: 96%**
ASP	a) Extension of Preliminary Treatment **BOD removal: 5%-10%**	a) Upgrade to Secondary Treatment b) **Aerobic** Sludge Treatment for Secondary Sludge **BOD removal: 96%**

Option	Phase I (2015)	Phase II (2030)
SBR	a) Extension of Preliminary Treatment b) Upgrade to Primary Treatment (Settling Tanks) c) Anaerobic Sludge Treatment for Primary Sludge **BOD removal: 25%-30%**	a) Upgrade to Secondary Treatment b) Extension of Anaerobic Sludge Treatment for Secondary Sludge **BOD removal: 96%**
MBBR	a) Extension of Preliminary Treatment b) Upgrade to Primary Treatment (Settling Tanks) c) Anaerobic Sludge Treatment for Primary Sludge **BOD removal: 25%-30%**	a) Upgrade to Secondary Treatment b) Extension of Anaerobic Sludge Treatment for Secondary Sludge **BOD removal: 96%**
MBR	a) Extension of Preliminary Treatment b) Upgrade to Primary Treatment (Settling Tanks) c) Anaerobic Sludge Treatment for Primary Sludge **BOD removal: 25%-30%**	a) Upgrade to Secondary Treatment b) Extension of Anaerobic Sludge Treatment for Secondary Sludge **BOD removal: 96%**
UASB	a) Extension of Preliminary Treatment and Pilot UASB reactor (Phase I-a: 2015) b) Upgrade to UASB treatment (Phase I-b: 2016) c) Anaerobic Sludge Treatment for UASB Sludge (Phase I-b: 2016) **BOD removal: 60%-70%**	a) Upgrade to Secondary Treatment b) Extension of Anaerobic Sludge Treatment for Secondary Sludge **BOD removal: 96%**

Of options considered for the design of the Ghadir WWTP, the "CAS" option was selected as the most robust and proven technology for large scale WWTPs associated with the minimum cost (construction and operation/maintenance). Details of this option are presented in the following sections.

4.2 WWTP Design Criteria

The project team suggest that for a number of assumptions made in the previous FS 2000 are still applicable in the current study, including:

- splitting of the area in four zones, for which different methodologies for population growth estimates are followed;
- estimated future population, extrapolated to 2050, can follow the same pattern as the previous FS 2000, with some necessary adaptations to accommodate population movements and saturation estimates for specific areas (based on data derived from most recent studies);
- unit wastewater flow of 144 l/ca/day (80 % of 180 l/ca/day water consumption).

Table 25 presents the estimated population and wastewater flows for the upgrade of the Ghadir WWTP.

Table 25: Projected flows (wet and dry season, 2015 -2050, five years intervals)

	Unit/Year	2015	2020	2025	2030	2035	2040	2045	2050
Population	capita	1,008,296	1,121,129	1,247,217	1,399,556	1,473,904	1,518,491	1,558,705	1,594,734
Population Equivalents	capita	1,209,955	1,345,355	1,496,661	1,679,467	1,768,685	1,822,189	1,870,446	1,913,680
Degree of connection to network		846,969	1,042,039	1,176,239	1,338,994	1,430,223	1,494,195	1,589,879	1,722,312
Population Equivalents connected	capita	1,008,296	1,121,129	1,247,217	1,399,556	1,473,904	1,518,491	1,558,705	1,594,734
Dry season – Unit flows									
Domestic	l/cap/d	112	112	112	112	112	112	112	112
Commerce and industry	l/cap/d	32	32	32	32	32	32	32	32
Infiltration and inflow (long term)	l/cap/d	20	20	20	20	20	20	20	20
Wet season – Unit flows									
Domestic	l/cap/d	112	112	112	112	112	112	112	112
Commerce and industry	l/cap/d	32	32	32	32	32	32	32	32
Infiltration and inflow	l/cap/d	100	90	80	70	60	50	50	50
Peak factor		1.62	1.57	1.54	1.50	1.49	1.48	1.46	1.44
Dry season – flows (in m^3/s)									
Domestic commerce and industry	m^3/s	1.41	1.74	1.96	2.23	2.38	2.49	2.65	2.87
Inflow and infiltration	m^3/s	0.20	0.24	0.27	0.31	0.33	0.35	0.37	0.40
Average flow (total)	m^3/s	**1.61**	**1.98**	**2.23**	**2.54**	**2.71**	**2.84**	**3.02**	**3.27**
Peak flow	m^3/s	**2.49**	**2.96**	**3.28**	**3.66**	**3.87**	**4.02**	**4.24**	**4.53**
Wet season - flows (in m^3/s)									
Domestic commerce and industry	m^3/s	1.41	1.74	1.96	2.23	2.38	2.49	2.65	2.87
Inflow and infiltration	m^3/s	0.98	1.09	1.09	1.08	0.99	0.86	0.92	1.00
Average flow (total)	**m^3/s**	**2.39**	**2.82**	**3.05**	**3.32**	**3.38**	**3.36**	**3.57**	**3.87**
Peak flow	**m^3/s**	**3.27**	**3.81**	**4.10**	**4.44**	**4.54**	**4.54**	**4.79**	**5.13**

In order to decide on the design criteria to apply on the anticipated quality of the incoming flow, suggested pollution loads from SPD 9 were co-assessed with wastewater monitoring results from the existing plant at Ghadir.

The suggested design concentrations are based on SPD 9, incorporating a factor of safety increase of 20% , with the exception of Total P for which the suggested value is based on the average monitoring measurements:

- BOD_5: 360 mg/l;
- TSS: 450 mg/l;

- TKN: 72 mg/l; (Total Kjedhal Nitrogen); and
- Total P: 10 mg/l. (Total Phosphorous TP).

Regarding the effluent quality: based on the national (MoE 8/1 - 2001) limits for discharge to sea and relevant EU limits (Urban Wastewater Treatment Directive 91/271/EEC), the following effluent requirements will apply:

- BOD_5: 25 mg/l;
- TSS: 35 mg/l;
- Total N: 30 mg/l; (Total Nitrogen)
- NH_4^+: 10 mg/l (eq to N- NH_4^+ 7.8 mg/l);
- NO_3^-: 90 mg/l (eq to N- NO_3^-: 20.3 mg/l);
- Total P:10 mg/l (of which P-PO_4^{3-} : 5 mg/l); and
- Total coliforms: 2,000 MPN/100 ml.

Compliance with bathing criteria will also be secured, in accordance with Decision 52/1 of 2001 requirements.

4.3 Description of the Treatment Scheme

In order to comply with the discharge requirements set by Lebanese legislation and EU standards, the treatment scheme of this option will include the following steps:

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

A flow chart of the treatment scheme is presented in Figure 7.

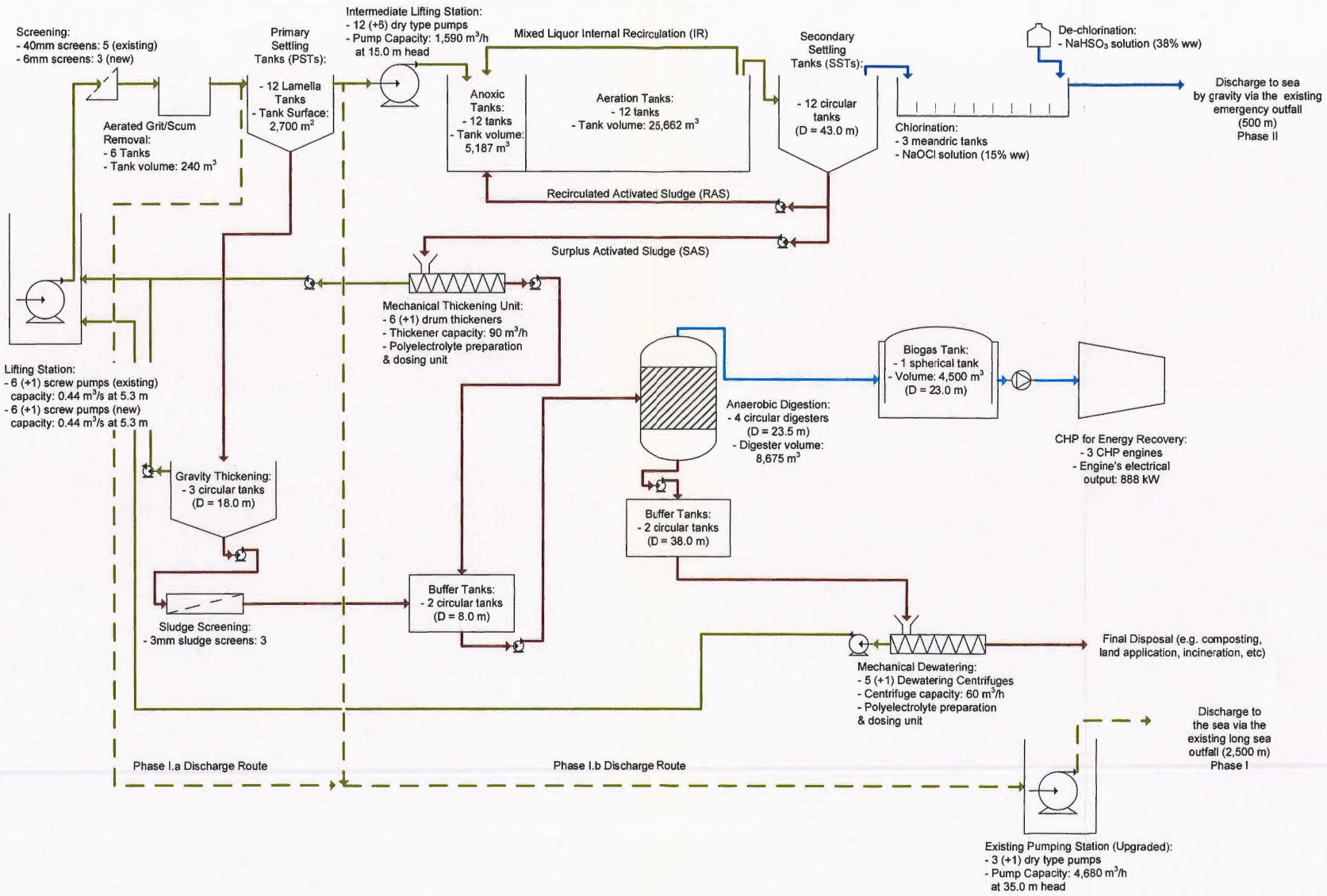

Figure 7: Flow chart of the CAS treatment option

4.4 Phasing of the implementation of the CAS treatment option

It is recommended that the CAS option project is constructed in three phases, based on the assumptions for completion of all necessary networks serving the Ghadir drainage area.

The phasing of the construction of the CAS treatment option is recommended as follows:

a) **Phase Ia (operational in 2018)**: Includes the ***extension*** of the preliminary treatment (to accommodate the increased flow beyond the plant's current capacity).

b) **Phase Ib (operational in 2020)**: Includes ***upgrading*** of the existing facilities to Primary Treatment (settling), including Sludge Treatment and Energy Recovery facilities for the primary sludge. Effluent will be discharged through the existing Long Sea Outfall. There is no need for land reclamation (all facilities are on shore). This process step will remove 25-30% of the BOD and 50-55% of the Suspended Solids.

c) **Phase II (operational in 2030)**: ***Upgrading*** the plant to Secondary Treatment and ***extending*** sludge treatment to accommodate secondary sludge. Land reclamation will be required to extend the plant off-shore.

Details on the implementation programme of the Ghadir integrated project are provided in Chapter 8.

4.5 Description of the facilities

Extension of the preliminary and upgrade of the primary treatment is assumed to take place onshore, after acquiring the surrounding land from the Airport Authority (public land). After completing Phase I works, the occupied land is projected to be 55,860 m^2 or 5.6 ha (of which ~2.5 ha is the land area occupied by the existing facility).

For Phase II and upgrade of the plant to the secondary level of treatment, the total surface area required is estimated at 143.100 m^2 (or 14.3 ha), of which approximately 93,380 m^2 (or 9.3 ha) will need to be developed on reclaimed land (the "offshore" part).

The Layout and Cross sections of the upgraded WWTP are presented in Drawings of Annex 5 (DWG FS5_L & DWG FS5_S, respectively).

4.5.1 Preliminary Treatment Unit

4.5.1.1 Initial Lifting Station

The existing lifting station contains 6 (+1 standby) pumps, each with capacity of 440 l/s at 5.30 m head. These pumps are considered to be in good condition and will be supplemented by additional 6+1 screw pumps of 440 l/s capacity at 5.30 m head. The supplementary pumping station will be identical to the existing one and will cover the needs of the increased capacity expected during the wet season from the first year of the operation of the extended plant (2017 peak flows).

Wastewater from the pumping stations is gravity-fed to the screens.

4.5.1.2 Screening

There are 5 existing rake type screens, of 40 mm bar spacing, in operation at the Ghadir plant. They appear to be in very good condition; and will be maintained in operation until Phase II. It is estimated that their capacity will cover the wastewater flow up to 2050.

Additionally, 3 (+1 standby) fine screens are to be installed after the 40 mm screens, which will serve the flows of the present situation as well as the flows up to 2050. During Phase II, the existing 40 mm screens are to be replaced with new ones, as it is assumed that they will be obsolete by that time.