



Work package 3.1, Deliverable D 305

Title

MBR-Cluster-Solution in Maghareeb

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1 INTRODUCTION

The aim of the SMART II research project is to investigate and demonstrate several water reuse options at different locations in Jordan such as Maghareeb. A decentralized approach has been chosen for the municipality of Al Salt due to the high degree of scattered housing developments in Maghareeb. The innovative MBR system (Membrane BioReactor), a combination of biological treatment and membrane filtration, is suitable to treat municipal and domestic wastewater in order to produce high-quality service water. The membrane ultrafiltration allows the reuse of treated wastewater for agricultural irrigation purposes. Within this work package a MBR-Cluster-Solution installed in a concrete tank for a housing development with up to 300 PE will be installed in order to demonstrate wastewater reuse.

Within a screening study a suitable location for the MBR-Cluster-Solution was identified. The identified site for the implementation of the MBR system consists of a housing development within Maghareeb (Phase II → Triangle Site; fig. 1 and tab. 1). The goal is to treat the wastewater of the houses to a quality that is suitable to be reused for agricultural irrigation according to Group A of Jordan standards (JS: 893/2006). The realised MBR plant with a separate membrane module and a mechanical pre-treatment is a permanent solution to be operated by a local operator after the end of the project. The plant ensures the treatment of up to 15 m³ to 30 m³ of wastewater per day. A plant-specific concept has been developed for the project which includes remote data transmission and will be implemented in the form of an operator model. Due to the online transmission of important parameters, such as operation pressure or flow rate, etc., telemonitoring of the plant will be possible. This will reduce the required operator attendance to a minimum.

To ensure optimal project implementation and plant operation, two students working for HUBER SE (HSE) spend several months in Jordan to take care of the plant during construction and start-up. The planned “trainee phase” has been shortened to 1-2 weeks due to massive delays of the project schedule. The training of employees of the municipality of Al Salt (MAS) and the engineering office Wakileh Engineering Services (WES) will take place in the end of March 2014. It should guarantee best possible capacity building within the project, which is an important element for future plant operation after project finalisation. After the project run time it is intended to leave the complete plant to MAS for further use. Huber Middle East as main contractor concluded the necessary contracts with WES for the required building measures under WP 3.1. HAE assisted with support and advice as supervisor during the complete project run time.

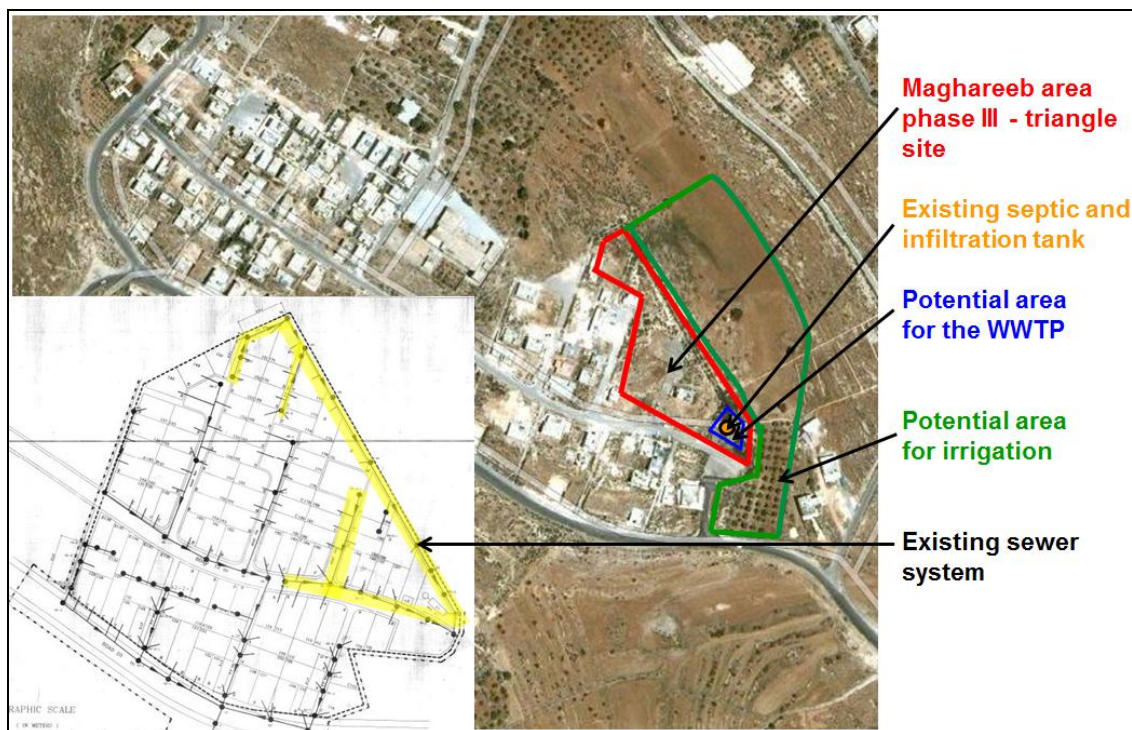


Figure 1: Location of MBR site

Table 1: Key data form the Maghareeb location

Address	Al Salt / Maghareeb	Data of:
Location	32°02'15"N / 35°42'01"E	UFZ
Population	~ 75 (August, 2010)	Eng. Nabil
Estimated population (max. in 5-7 a)	~ 300 (<i>Has to be confirmed</i>)	UFZ
Number of houses ¹	~ 17	HSE
Type of population	Residential area	UFZ
Land area	12,084 m ²	UFZ
Wastewater collection system	Existing sewer system (Phase III of Al Salt)	Eng. Nabil
Wastewater management system	Preliminary septic tank and infiltration tank	Eng. Nabil
Wastewater quality	Analyzed in Dec. 2013 (see 3.2.3)	BAU
Mean wastewater production (Sep.13)	~ 5 m ³ /d	HSE
Wastewater production/ep	~ 90 l/d*ep (assumed consumption for Jordan)	HSE
Reuse option: Irrigation	Below the settlement; gravity line possible (<i>Have to be confirmed by the land owners</i>)	UFZ/HSE

¹ Number of houses identified in December 2013 (some houses were under construction)

1.1 Water Reuse

The aim of the SMART II research project is to reuse treated wastewater for agricultural irrigation in compliance with *Jordanian Standard JS 893/table 1/A*. The high clarification efficiency provided by the MBR process has already been proven in several plant installations and even within WP 3.2 (MBR container for groundwater recharge). Due to this very high clarification efficiency the produced permeate can be used for agricultural irrigation purposes. From today's perspective the optimal solution at the location Maghareeb is to use permeate for irrigation of the area below the plant (olive trees, fields). With the capacity of 25 m³/d about 9,000 m³/year permeate will be available for irrigation. During winter permeate can be infiltrated via the infiltration tank (ground water recharge) or it can be used as service water for other applications under considering the water quality.

1.2 Consideration of the Existing Infrastructure

The implementation of the MBR system took into consideration the existing infrastructure at Maghareeb and was carried out in accordance with MAS. The necessary concrete tanks were constructed above ground. Following aspects were respected:

- The existing sewer network was not affected in its structure by the work carried out under this project.
- The existing wastewater treatment system (septic tank and infiltration tank) was functioning during the building phase.
- The existing wastewater treatment system (septic tank and infiltration tank) is available to MAS in its original functionality (as at the start of the project) both during the project time and after the end of the project.

2 Implemented MBR-Cluster-Solution

2.1 Process Equipment

The MBR-Cluster-Solution consists of:

- Pre-treatment plant
- Membrane filtration module

2.1.1 Pretreatment Plant

The micro strainer Ro9-E® treats wastewater after sedimentation in the septic tank. The mechanical treatment is a precaution for the membrane unit if rejects passed the sedimentation

process. The runtime of the Ro9-E gear and the screenings discharge will be marginal. Figure 2 shows the schematic diagram with a description of the installed HUBER ROTAMAT® Micro Strainer Ro9-E.

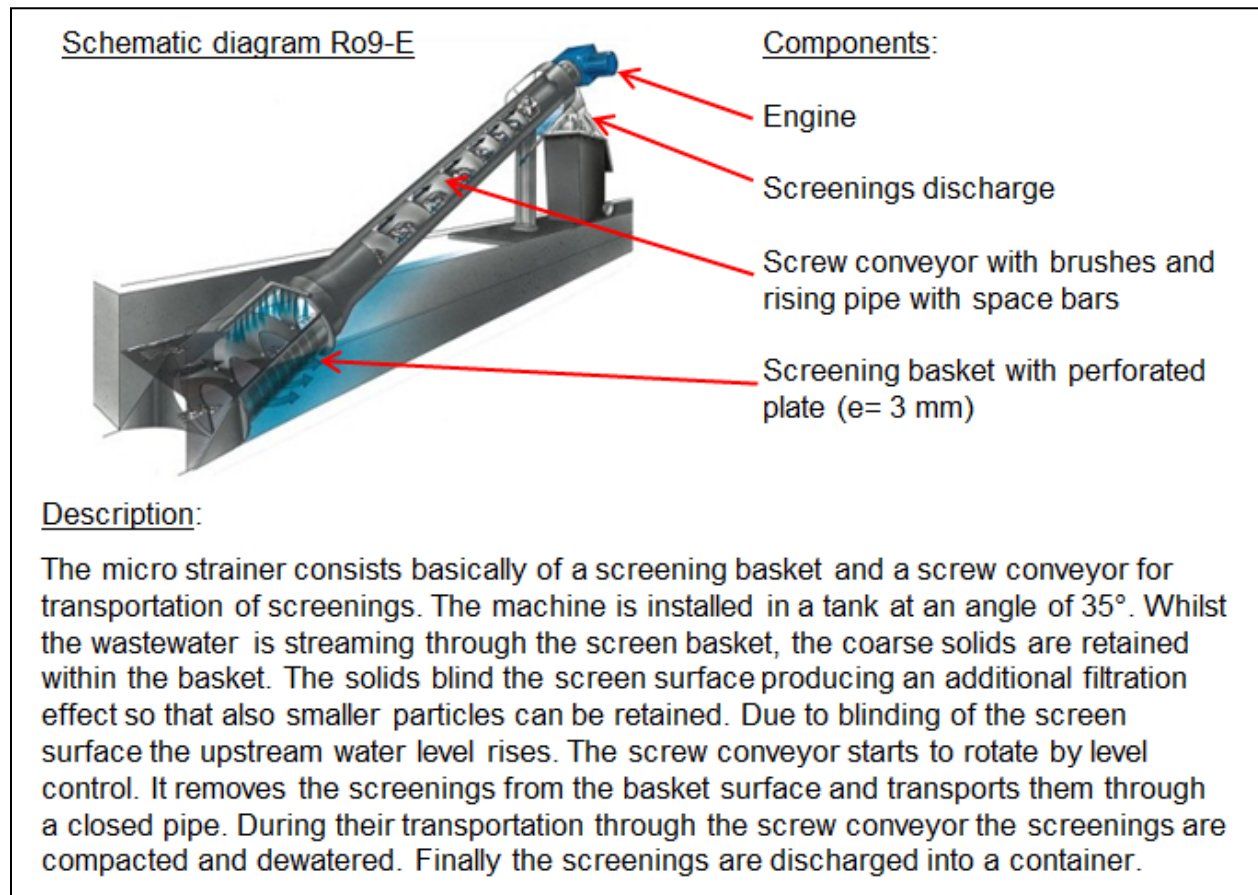


Figure 2: Description of the micro strainer Ro9-E



Figure 3: Ro9E fine screen during installation in separate screen room on Maghareeb site

2.1.2 Membrane Filtration Module

The Huber BioMem® filtration module is intended for separation of activated sludge and clear water. The filtration unit is submerged in a separate filtration chamber. Sludge concentrations should not exceed 14 g/l. The module consists of a stainless steel frame equipped with 5 modules à 25 m². Scouring tubes are installed below the ultrafiltration membrane surface (in total 125 m²). The air introduction below the module ensures that the membranes are cleaned as required.

Data of the membranes:

- PES UF, 38 nm pore size
- Membrane surface per unit: 125 m²
- 3 scouring tubes
- 2 guide rods for optimal positioning inside the tank
- Concrete tank installation

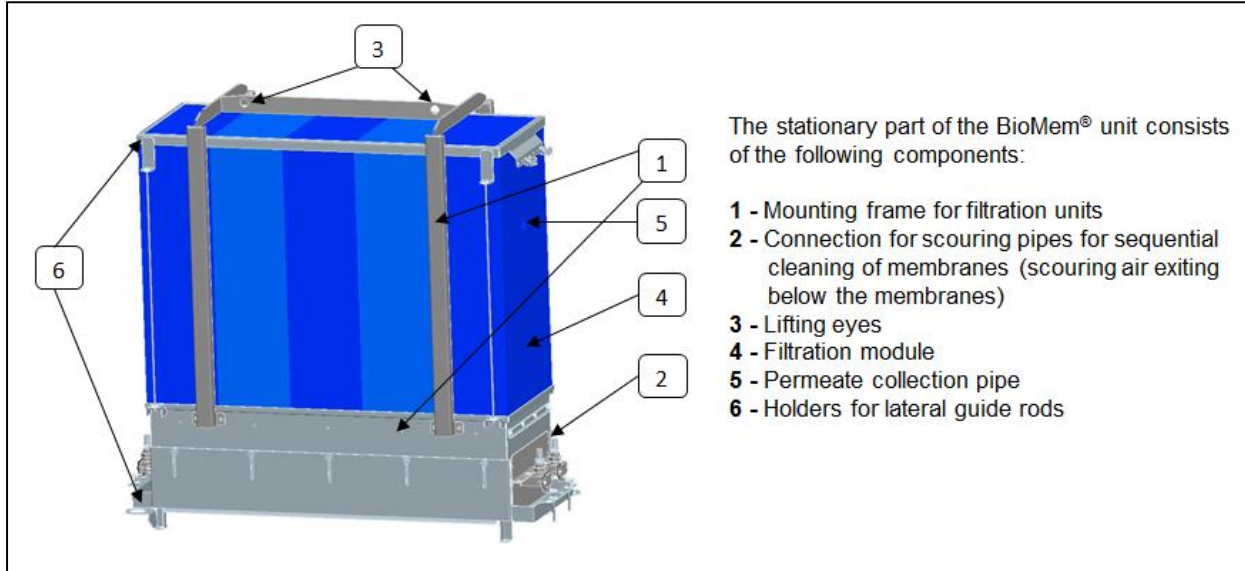


Figure 4: BioMem module with necessary parts

The five membrane cassettes are sealed against each other with an O-seal and connected with each other by a thread rod. The permeate collector is positioned in the upper first third of the filtration unit and leads via a hose to the water surface. The connection with the permeate collection pipeline is achieved by means of a quick coupling.



Figure 5: BioMem membrane module with adapters for scouring air and permeate withdrawal, during storage

2.2 Treatment process

The HUBER BioMem® is operated in a MBR (Membrane-Bioreactor) system. The biological degradation of the wastewater substances takes place in an aeration tank. The BioMem® unit is installed inside a separate filtration tank (1-line design). The wastewater is biologically treated by activated sludge process within the aeration tank and periodically drawn off through the membrane modules by applying an under pressure of 0.1 – 0.7 bar. Filtration with ultrafiltration membranes (separation size of 150 kDA and pore size of 38 nm) retains virtually all germs and bacteria. Permeate is discharged over a maximum of 18 hours (see table 2) with a maximum flux rate of up to 14 l/m²/h (at 20 °C waste water temperature). The flux describes the quantity of permeate in liters which is drawn off through the membrane modules per hour and square meter membrane surface. The treated wastewater (permeate) is collected in a storage tank. The membranes are cleaned by scouring air. The continuous introduction of scouring air below the membrane modules prevents clogging of the membrane surface and also ensures a continuous mixing within the filtration chamber.

A sufficient oxygen supply for the biological processes is ensured by an additional aerator on the tank bottom of the activated sludge tank. Homogenization of the aeration tank during the denitrification process is ensured by stirrers.

During the start up the plant will treat 15-20 m³/d and operate 16 hours per day. Later on, the volume to be treated will gradually be increased to up to 30 m³/d (18h/d). A fill level control system will ensure that the aeration tank volume can be adjusted to rising amounts up to the complete development of the housing area.

Table 2: Filtration capacity of the treatment plant

Filtration surface of the BioMem = 125 m ² (5 packs á 25 m ²)					
Treated wastewater	15	20	25	30	m ³ /d
Runtime plant	16	16	18	18	h/d
Ø Flow rate wastewater	0,9	1,3	1,4	1,7	m ³ /h
Flux net ¹	7,5	10,0	11,1	13,3	l/m ² /h
Flux cross ²	8,3	11,1	12,3	14,8	l/m ² /h

¹ effective drawn off of permeate per hour and square meter filtration surface

² drawn off under considering the filtration interval of 270 sec. filtration and 30 sec. pause

The system is controlled by the amount of suspended solids and the oxygen contends. The feed pump (which is equipped with a cutting wheel and float switch) is installed in the second chamber of the septic tank at a height of about 1.5 m in order to reduce the suction of sediments. Due to the high contend of sand inside the septic tank the pump has to be carefully adjusted above 1.5 m where no sediments will be sucked.

The activated sludge is recirculated between the aeration tank and filtration chamber, between 65% and 75% being returned to the aeration tank via a free overfall. The rest is withdrawn through the filtration unit and pumped into the storage tank. The capacity of the permeate

storage tank is 25-30 m³. The tank is equipped with an overflow with a connection to the infiltration tank and with a floor drain and a manhole will be provided for the accessibility of a dewatering pump.

Because of the reduced filling level / volume in the aeration tank, due to recirculation with permeate discharge, the filling level falls down to the minimum level at which feeding from the septic tank is started again.

A fill level meter is provided inside the filtration chamber to reliably prevent that the membrane unit falls dry. If the level reaches minimum filling level (above the membrane module), the plant switches into economy mode and no permeate is discharged any more.

A probe for suspended solids measurement is provided to automate excess sludge removal from the aeration tank. If the probe measures maximum dry substance content, a signal is transmitted to the pump to induce it to remove excess sludge until the dry substance content has reached the programmed content again.

Oxygen is measured permanently for regulation of the aeration blower. Depending on the actual mode (nitrification or denitrification) oxygen level is raised by diffused air or lowered by biological aerob activity. The exact duration of aeration and ablation have to be adjusted according to the local waste water.

2.3 Concrete works / Tanks

The construction of the necessary buildings has been executed by NAW on the site of the existing septic tank. The septic tank structure has not been changed and all new tanks and rooms have been constructed directly connected to the side wall. A brick wall has been constructed to separate the complete area from the surrounding footpath. The main entrance of the plant is from the parking lot from where one can reach the control room, the screen room and the bridge to the tanks. Every compartment is separately closed by a steel door. Between the screen/control room is a small open passage, where big parts like the membranes can be put and be lifted into the tank by a steel rail which connects the screen room and the tank room in 2,2 m height. Coming from the entrance the tanks are as following: filtration chamber, aeration tank, buffer tank (figures 8-10).



Figure 6: Front side of the new MBR-system building on the site in Maghareeb



Figure 7: Backside of building with pipes

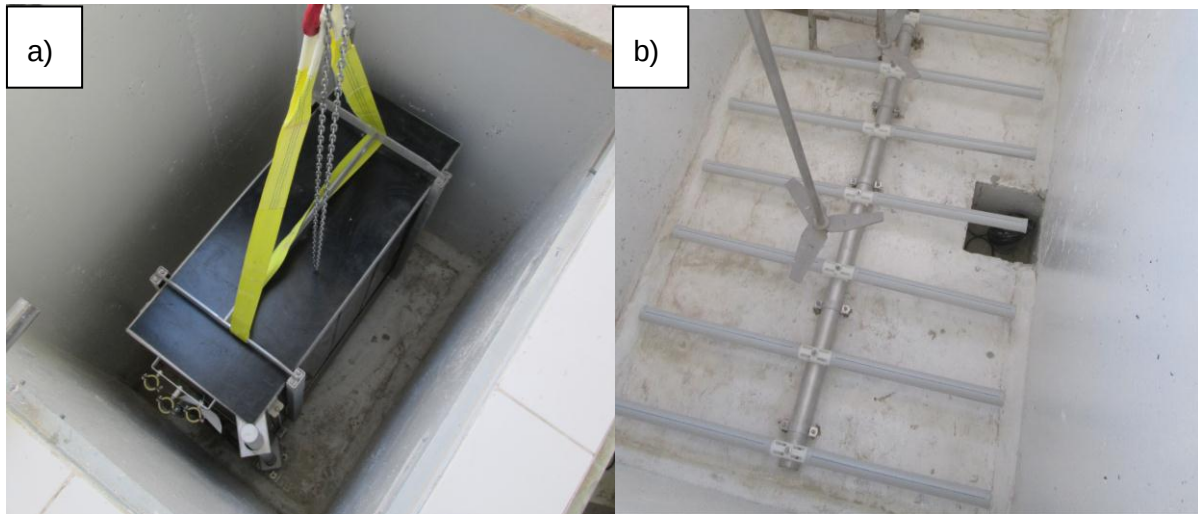


Figure 8a/b: a) Membrane modules being installed in the filtration chamber; b) Aeration tank with air diffusers and mixers during construction



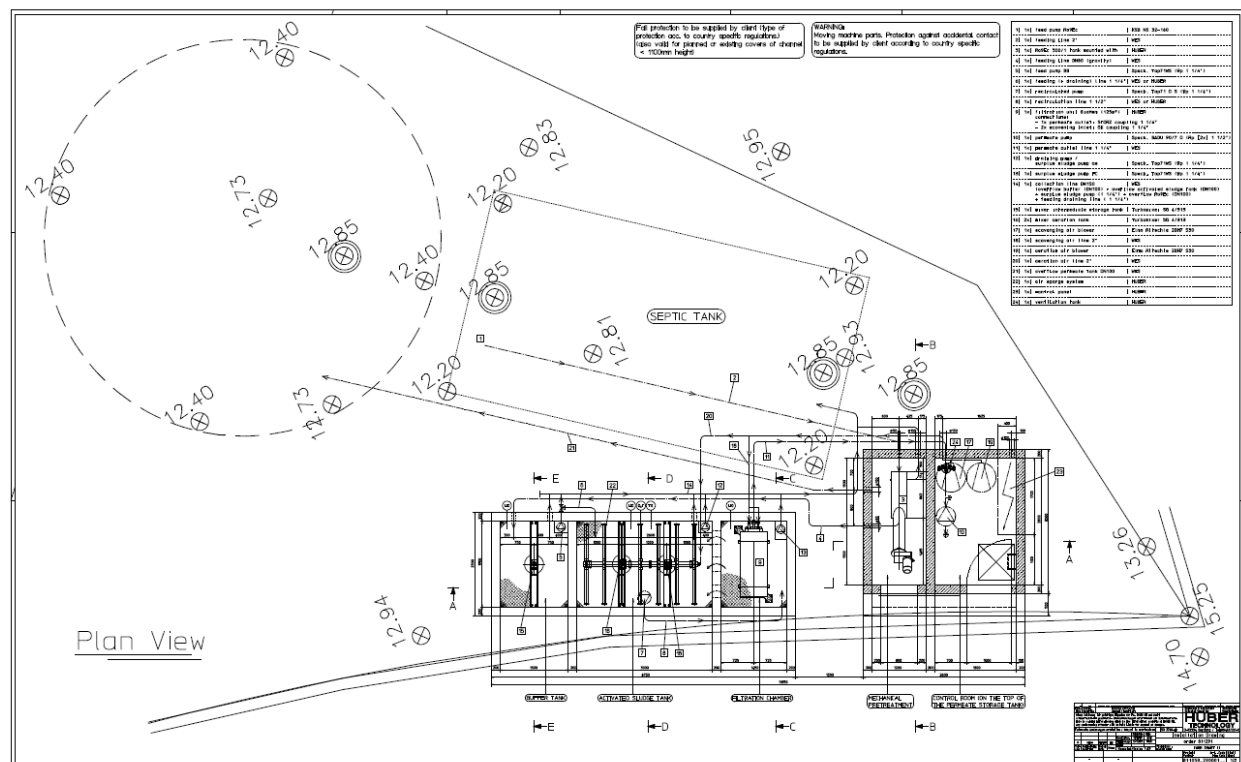
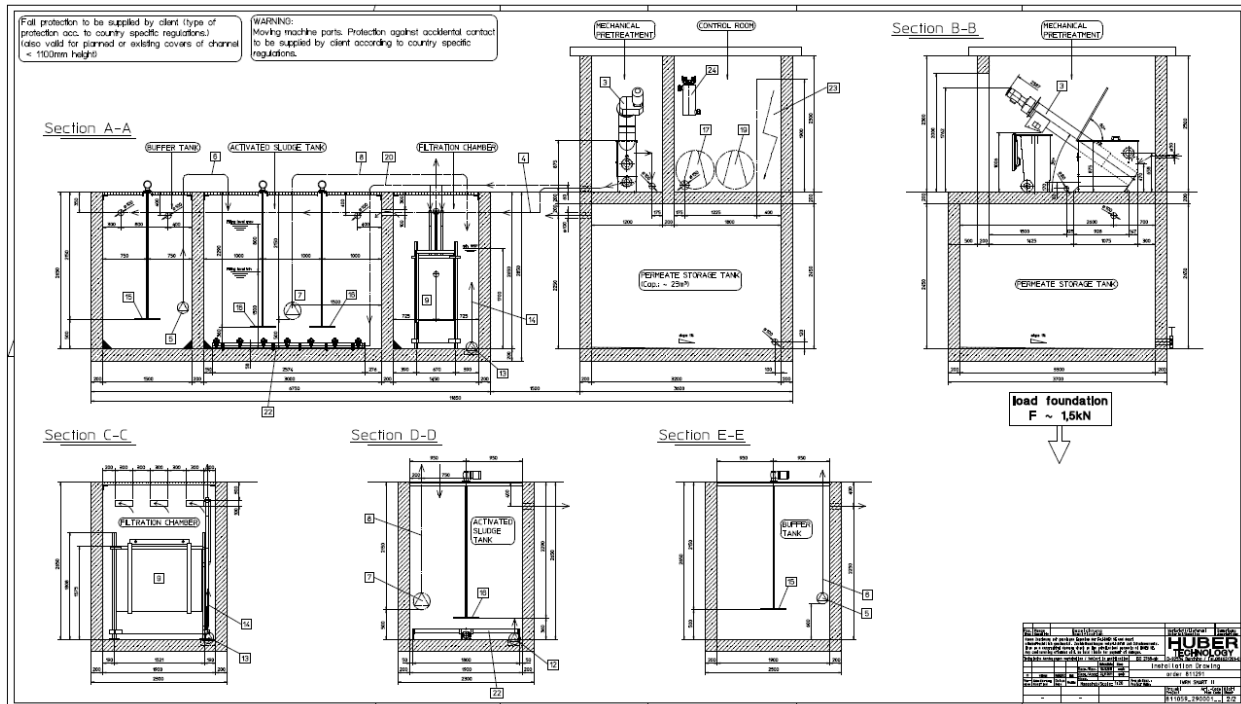
Figure 9: New building implemented around the existing septic tank (see tank covers on the ground)

REFERENCES

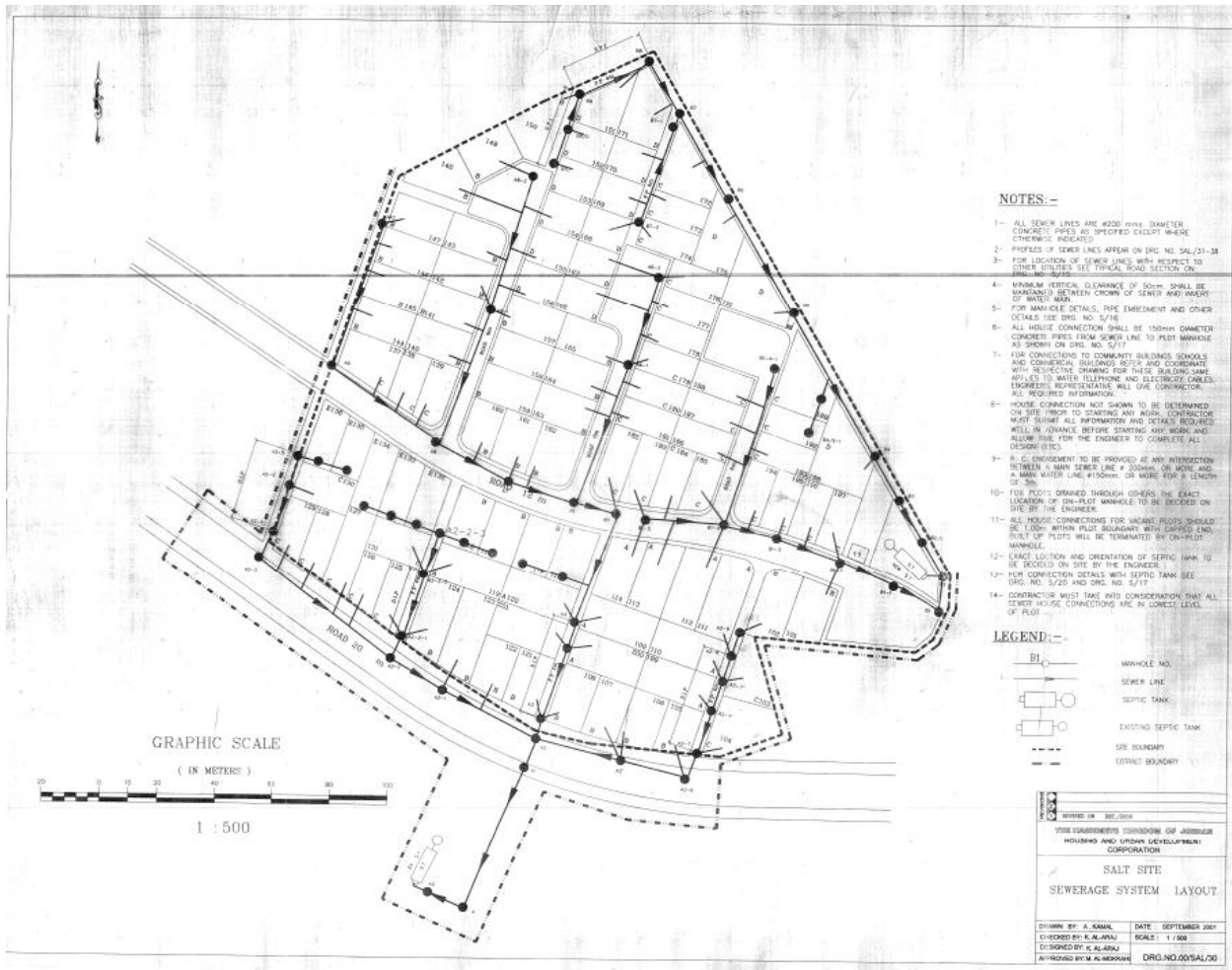
MWI, Jordanian Standard JS 893/table 1/A.

Huber SE, Internal Data, <http://www.huber.de>

APPENDIX 1: MBR site detail drawings



APPENDIX 2: Plan of sewage lines in Maghareeb



APPENDIX 3: Time schedule

March 2014																																																						
IWRM SMART II - Timetable		01.03.2010 - 31.03.2014				2011				2012												2013												2014																				
Pos.	Workpackage	Activities	Responsible		9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12										
	WP 3.1: MBR-Cluster Solution - MBR Treatment Plant; Location: Maghareeb/AI Salt	Site Selection	UFZ / HAE / HSE		BT																																																	
		Draft and signature of the contracts	HSE/HAE/WAJ/WES							BT																																												
		Dimensioning of the plant	HSE																																																			
		Manufacturing of the plant parts	HSE																																																			
		Implementation of water + electric power supply, access device + protection, cleaning septic tank	WAJ																																																			
		Construction civil works, piping, etc.	WES																																																			
		Transportation, Installation and Start-up	HSE / HAE																																																			
		Trainee Phase and Normal Operation	HAE / HSE																																																			
		Operating by WES and Supervision by HAE	HAE / WES																																																			
HSE		HUBER SE Berching/Germany			SU Start-up				TP Trainee Phase for WP 3.1: WES/MAS																																													
HAE	HUBER Middle East			ST Student HSE				S Supervision by HAE																																														
WES	Wakleh Engineering Services			X Operating by WES				BT Business Trip																																														
WAJ	The Water Authority - Jordan																																																					
UFZ	Center for Environmental Research																																																					