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SHAFDAN (Greater Tel Aviv Wastewater Treatment Plant): recent upgrade and expansion

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Abstract

The SHAFDAN is the largest wastewater treatment plant in Israel and currently treats 360,000 m^3/day of municipal wastewater, about 92% of its treatment capacity. Waste sludge from the plant is discharged to the Mediterranean Sea through a marine outfall. The SHAFDAN is committed to ending the disposal of its sludge to the sea by the end of 2016 by providing a land-based biosolids management program that produces a Class A biosolids for agricultural use. In order to implement this strategy, a number of large-scale construction projects were undertaken. These projects include a new sludge thickening and dewatering facility, updated headworks, a new primary treatment facility, and a new 3-stage thermophilic anaerobic digestion facility. The total capital cost of these projects is estimated to be US $300 million. This paper describes the principal components of these projects and their design parameters.

Key words: anaerobic thermophilic digestion, headworks, primary clarifiers, sludge thickening and dewatering

INTRODUCTION

The SHAFDAN (Greater Tel Aviv Wastewater Treatment Plant) is the largest regional wastewater treatment plant in Israel. The plant treats wastewater from 35 municipalities. The population served by the SHAFDAN is approximately 2.3 million people. In 2014, the plant treated an average daily flow of about 360,000 m^3/d. The raw wastewater has a relatively high strength: BOD = 400 mg/l; TSS = 410 mg/l; TKN = 70 mg/l; P = 10 mg/l (Mey Ezor Dan 2014). The SHAFDAN was originally constructed in the 1960s as a large earth-lagoon oxidation pond system followed by lime-treatment and ammonia–stripping lagoons. The lagoon system was replaced by an extended aeration activated sludge facility, consisting of headworks, BNR bioreactors and final clarifiers. Primary clarifiers were not included in the facility. The secondary effluent meets very high quality standards with average values of BOD <6 mg/l; TSS <6 mg/l; TKN <6 mg/l; TP <1 mg/l. The effluent is infiltrated into a sand aquifer with an average retention time of 1 year, pumped and reused for unrestricted agricultural land application in the south of the country, supplying more than 70% of the irrigation needs. All the waste activated sludge (WAS) from the plant was discharged through a marine outfall. The current treatment process flow diagram is presented in Figure 1.

As the plant is approaching its design capacity (the plant is currently at about 92% of its treatment capacity), SHAFDAN had chosen to add a primary treatment stage to reduce the organic loading to the secondary treatment process as part of the plant expansion.

In accordance with a decision taken several years ago, SHAFDAN is also committed to developing a land-based biosolids management program, producing a Class A biosolids product for agricultural use by the end of 2016. In order to implement this strategy, the following facilities were designed and constructed:

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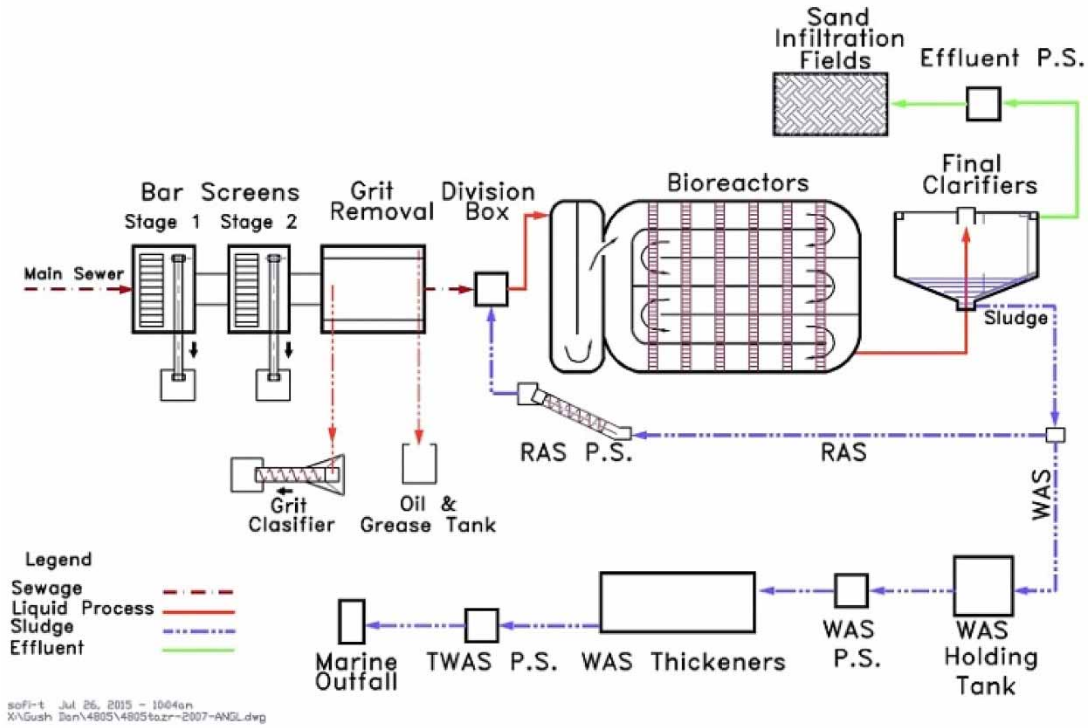

Figure 1 | SHAFDAN current process flow diagram.

- Project I: thickening and dewatering facility (US $30,000,000)
- Project II: new headworks facility and new primary treatment facility to replace the old inefficient facilities (US $70,000,000)
- Project III: three-stage thermophilic anaerobic digestion facility (US $200,000,000)

These 3 projects are among the world's largest of their kind. Project I have been completed and have been in operation for 3 years. Project II is now in the commissioning phase. Project III will be commissioned in early 2016.

EXPANSION AND UPGRADE–BASIC DESIGN DATA

Table 1 summarizes the major design parameters for the three projects mentioned above.

Table 1 | SHAFDAN upgrade and expansion: major design parameters

Parameter	Unit	Value
Design Year	year	2030
Average Annual Flow	m^3/d	500,000
Peak Hour Flow	m^3/sec	12
BOD Load	t/d	200
TSS Load	t/d	200
Primary Sludge – max. month	m^3/d	2,500
Primary Sludge – max. month	t/d	110
WAS – max. month	m^3/d	24,300
WAS – max. month	t/d	170

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Project I: thickening and dewatering facility

As the first stage in the implementation to discontinue the discharge of sludge to the sea, a thickening and dewatering facility was constructed and has been in operation for several years.

Three activities take place in the thickening and dewatering facility (Figure 2)

Figure 2 | SHAFDAN thickening and dewatering building.

WAS thickening

The WAS taken from the final clarifier underflow is thickened from about 0.7% solids to about 5% solids on 11 gravity belt thickeners (GBTs) (Figure 3). Each GBT is served by a progressive cavity (PC) feed pump, and a second PC pump that pumps the TWAS to the digesters. The WAS thickening design parameters are presented in Table 2.

Figure 3 | GBTs.

Table 2 | WAS thickening: major design parameters (max. month)

Parameter	Unit	Value
Solids feed rate	t/d	170
WAS solids concentration	%	0.7
WAS feed rate	m^3/d	24,300
Thickened WAS solids concentration	%	5
Thickened WAS flow	m^3/d	3,400
Thickener type and make	GBT	EMO; 3.5-m belt width
Installed machines	No.	11 (including standby)

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Digested sludge dewatering

The combined primary and TWAS digested sludge is pumped to a pre-dewatering holding tank, and from there fed by dedicated PC pumps to 6 decanter centrifuges (Figures 4 and 5).

The sludge dewatering design parameters are presented in Table 3.

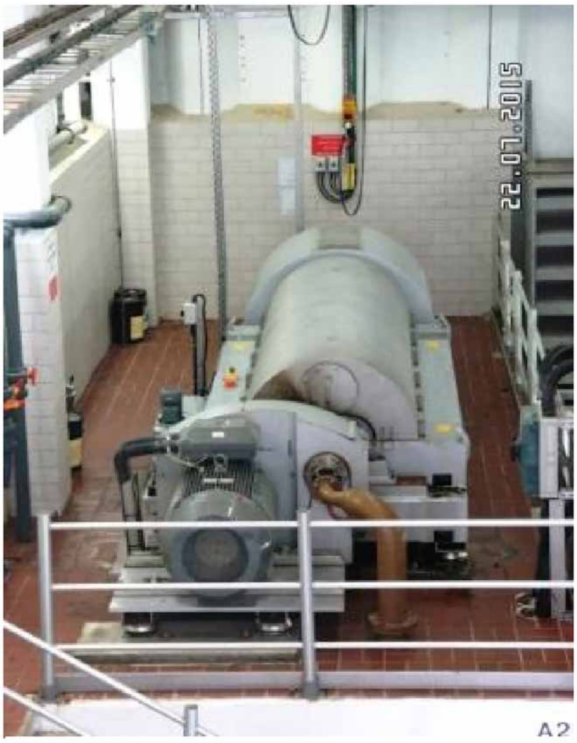

Figure 4 | Centrifuge.

Figure 5 | Dewatered sludge pumps.

Table 3 | Digested sludge dewatering: major design parameters (max. month)

Parameter	Unit	Value
Solid feed rate – Conc.	t/d–%	170–2.9
Digested sludge feed rate	m^3/d	5,900
Solid concentration in dewatered sludge cake	%	20–25
Dewatered sludge cake mass	t/d	850–680
Centrifuges type and make	Decanter	Alfa Laval Aldec G2–120
Installed machines	No.	6 (including standby)

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Dewatered sludge cake pumping

The dewatered sludge cake, at 20 to 25% solids concentration, is pumped by special high-pressure PC pumps (one pump per decanter) to a nearby truck loading facility through 300 mm diameter, 120 m long discharge pipes (one pipe per pump). The maximum discharge pressure in the system is 36 bars. In the event that excessive pressure is developed and detected, lubrication pumps automatically reduce the pressure to normal values. The dewatered sludge pumping design parameters are presented in Table 4.

Table 4 | Dewatered sludge pumps: major design parameters (max. month)

Parameter	Unit	Value
Dewatered sludge feed rate (per pump)	m^3/hr.	10 to 15
Dewatered sludge solids concentration	%	20 to 25
Type and make	PC	Seepex THE 70-48
Installed machines	No.	6

Project II: new headworks and primary clarifiers

A new headworks facility (Figure 6) was built to replace the old inefficient facility. A new primary treatment stage was added to reduce the organic loading to the secondary treatment process. The regular operation of the two facilities will start in 2015.

Figure 6 | SHAFDAN new headworks and primary clarifiers.

Diversion chamber and new sewer aqueduct

A diversion chamber and new influent sewer were constructed to convey the incoming wastewater to the new headworks facility (Figure 7).

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Figure 7 | Sewer aqueduct.

The influent sewer consists of 2 pipes, each of 2.7 m internal diameter, pre-fabricated in segments, and based on special pile foundations.

Headworks

The headworks treats the wastewater in 4 stages: very coarse screens, coarse screens, fine screens and grit removal (Figure 8).

The headworks design parameters are presented in Table 5.

Figure 8 | Headworks screening room.

Primary clarifiers

A total of 20 rectangular primary clarifiers equipped with longitudinal chain and flight collectors were constructed Figure 9. The screened wastewater is fed through distribution channels. The sludge withdrawal from the hoppers is controlled by electrically actuated plug valves. The primary sludge is

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Table 5 | Headworks: major design parameters

Parameter	Unit	Value
Design Peak Hour Flow	m^3/sec	12
Very coarse screens		
Installed units	No.	4
Design flow through each	m^3/sec	4
Channel width	M	3.2
Screen opening	mm	100
Screenings conveyance		Belt conveyor
Type and make	rake screen	Huber Rake Max
Coarse screens		
Installed units	No.	4
Design flow through each	m^3/sec	4
Channel width	m	3.2
Screen opening	Mm	20
Screenings conveyance		Screw conveyor
Type and make	rake screen	Huber Rake Max
Fine screens		
Installed units	No.	6
Design flow through each	m^3/sec	2.4
Channel width	M	2.4
Screen opening	mm	6 (perforated plate)
Screenings conveyance		Water trough, chopping, pumping
Type and make	Perforated	Huber EscaMax
Grit traps		
Installed units	No.	8
Design flow through each	m^3/sec	2.7
Chamber diameter	m	7
Grit conveyance		Slurry pumping
Type and make	vortex	Jones & Atwood

Figure 9 | Primary clarifiers – upper and lower (pipe gallery) view.

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pumped by PC pumps along a central pipe gallery, to the anaerobic digesters. The primary clarifiers design parameters are presented in Table 6.

Table 6 | Primary clarifiers: major design parameters

Parameter	Unit	Value
Design peak hour flow	m^3/sec	12
Number of clarifiers	No.	20 (19 + 1 standby)
Clarifier tankage description		
Length	m	45
Width	m	12
SWD	m	3.5 to 4
Floor slope	%	1
Area – per clarifier	m^2	540
Total area	m^2	10,800
Sludge hoppers per tank	No.	4
Collector type and make	Chain and flights	Finnchain
Design parameters		
Average overflow rate	m^3/m^2/day	46
Max. overflow rate	m^3/m^2/hr.	4.0
Performance – max. month		
TSS removal efficiency	%	52 to 55
BOD removal efficiency	%	35
Primary sludge-dry matter	kg/day	110,000
Primary sludge-flow	m^3/day	2,500
Sludge pumping		
No. of units – total	No.	20
Type and capacity		PC, 14 l/sec, VFD
Scum removal		
Scum collection system		Elec. operated slotted pipe. Scum screening-compactor
Scum compaction		

Project III: thermophilic anaerobic digestion facility

The sludge stabilization process selected by the SHAFDAN for a land-based biosolids management program producing Class A biosolids is based on a 3-stage thermophilic anaerobic digestion process. The start-up of the facility will begin in early 2016 Figures 10 and 11.

The digesters facility consists of:

- 8 sludge screens; 6 various sludge tanks
- 8 pumped-mixed thermophilic digesters
- Heat-exchangers and cooling systems
- Gas treatment facilities; 5 waste gas burners
- Membrane holding tank
- 8 co-generation unit

The anaerobic digester design parameters are presented in Table 7.

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Figure 10 | SHAFDAN anaerobic digester facility.

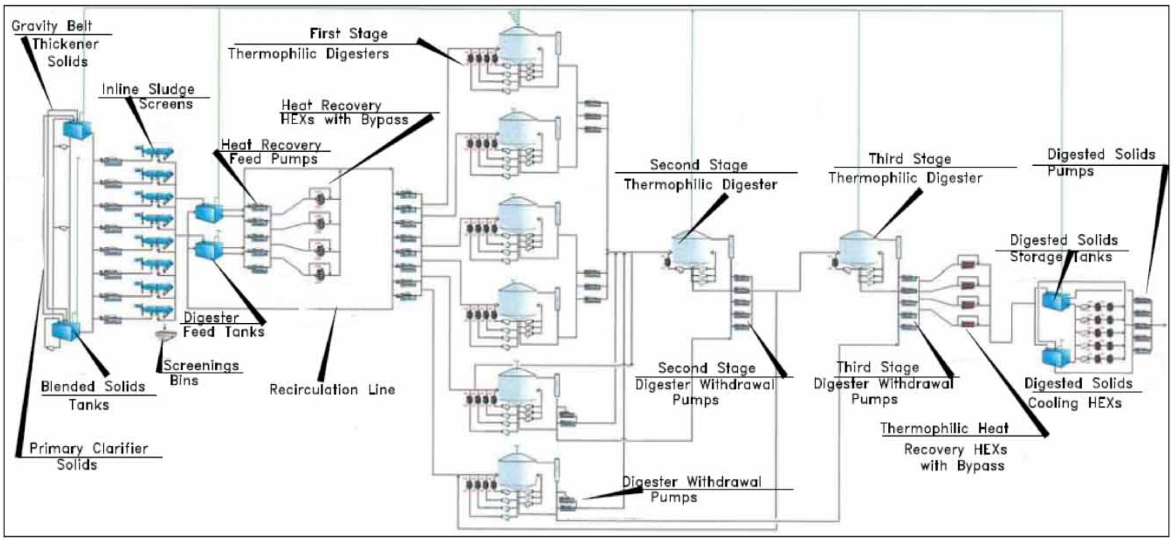

Figure 11 | Anaerobic Digestion Facility Process Flow Diagram.

CONCLUSIONS

The SHAFDAN has been upgraded during the last 8 years to provide a biosolids management program producing Class A biosolids. Three major projects are involved in this plan: Project I – new sludge thickening and dewatering facility; Project II – new headworks facility and new primary clarifiers which provide a necessary treatment stage for a future expansion of the plant treatment capacity; Project III – a 3-stage thermophilic digestion facility. The total construction cost of these projects is approximately 300 million US dollars. These projects will provide the SHAFDAN with a state-of-the-art, long-term, land-based biosolids management system producing Class A biosolids.

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Table 7 | Anaerobic digesters: major design parameters (max. month)

Parameter	Unit	Value
Blended sludge		
Flow	m^3/d	5,900
TSS load	kg/d	280,000
VSS load	kg/d	220,000
Solids concentration	%	4.7
Sludge screening		
Number	No.	8
Max. flow per unit	m^3/hr.	68
Screening opening	mm	5
Thermophilic digesters		
Number (Stage 1/2/3)	No.	6/1/1
Volume (each)	m^3	13,200
Volume (total)	m^3	105,800
Inner diameter	m	34
SWD	m	14.4
Operating temp.	C	57
HRT	days	18
Mixing system		Pumped mixing
Mixing pumps number	No.	24 (16 + 8 standby)
VSS reduction	%	$\geq$ 50%
Biogas production	m^3/day	114,000
Biogas storage and treatment		
Gas storage type		Dual membrane
Storage effective volume	m^3	4,300
Treat. for H2S removal		Biological ($H_2S \leq 50$ ppm)
Burners, number–capacity	No.–m^3/hr.	5–6,300
Burner type		Enclosed stack
Co-generation		
Number of units	No.	8 (7 operating, 1 in service)
Electrical output–each	kW	1,400
Electrical output–total	kW	9,800
Thermal output–each	kW	1,400
Thermal output–total	kW	9,800
Package		Containerized
Type and Make	CHP	Jenbacher JMC420
Siloxane removal		Activated carbon

As the plant is approaching its design capacity, the SHAFDAN is now preparing for the expansion of the liquid stream capacity to 500,000 m^3/day. This expansion, planned for the next 10 years, involves a construction of new BNR bioreactors and final clarifiers as well as side-stream treatment of the dewatering centrate to reduce the nutrient return load to the secondary treatment process.

REFERENCES

Mey Ezor Dan 2014 Dan Region Wastewater Project, Wastewater Treatment Plant Operation.