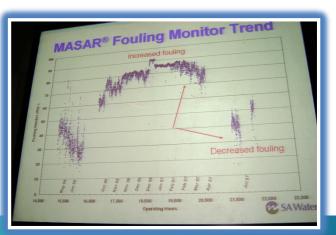


## The **SMART**<sup>™</sup> Solution to Real-Time Performance Optimization & Fouling detection & Management of Membrane Desalination & Filtration Plants



A Presentation by:

#### MOHAMAD AMIN SAAD

President, Principal Consultant & Developer

smart@masar.com



MASAR TECHNOLOGIES, INC.





Modeling of site-specific system design conditions.

### Achieving maximum attainable conversion.

- Reliability of system performance evaluation and monitoring as critical and dedicated part of plant O&M.
- Unpredictability of fouling (cancer of the membrane).



- Modeling of system design conditions
  - Lack of site-specific, representative raw water analysis profiles.
  - Pre-set unrealistic standard test conditions.
  - > Pre-set "Fouling Factors" for commercial reasons.
  - Pre-set annual membrane replacement rates.
  - Pre-set membrane system performance warranty conditions.



- Achieving maximum attainable conversion
  - Used to maximize productivity and/or minimize feed flow.
  - Critical factor in productivity, feed intake and energy costs.
  - Cost of energy is 50-75% of O&M costs and 25-70% of total costs depending on power cost.



- Reliability of system performance evaluation as critical and dedicated part of plant O&M
  - ASTM D 4516 standard normalization method (developed by DuPont's Permasep Products in the 1970s).
  - Ideal (non-fouling) conditions assumed.
  - Based on long-term trending analysis to monitor fouling and optimize performance (*not in real-time*).
  - Performance evaluation and monitoring not viewed as critical and dedicated part of plant O&M.

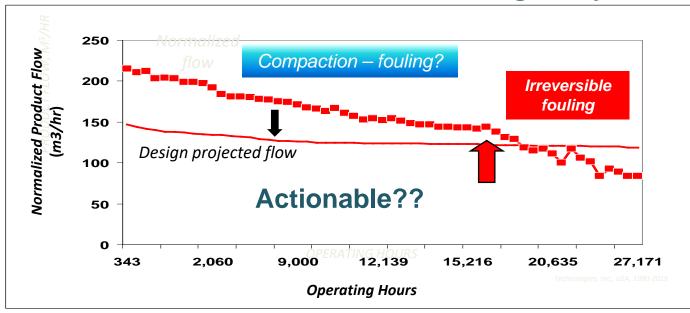


Unpredictability of fouling (cancer of the membrane)

- Fouling cannot be reliably simulated or modeled in system design projections, unlike chemical scaling.
- > Can only rely on monitoring actual system operation to detect fouling.
- Very difficult to define if and when fouling starts to take place before it exhibits significant impact on plant.
- SDI<sub>15</sub> & MFI<sub>0.45</sub> are limited as "fouling indicators" of colloidal and organic loading on the membranes.



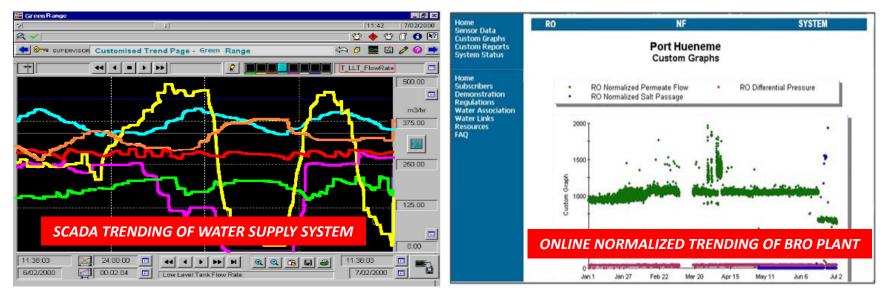
#### **ASTM D4516 Normalization & Trending Analysis**



FLUX DECLINE PERFORMANCE TRENDING BY ASTM STANDARD METHOD



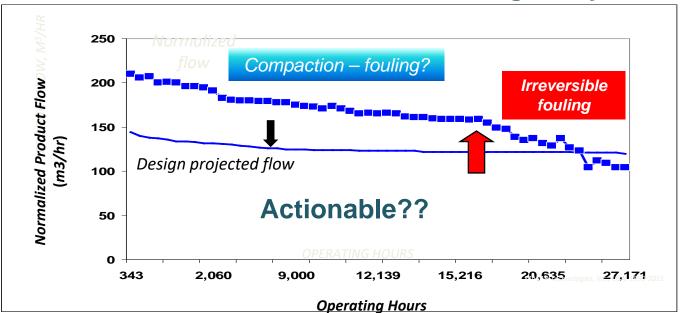
### **The Problem with Trending**



#### **Actionable??**



#### **ASTM D4516 Normalization & Trending Analysis**

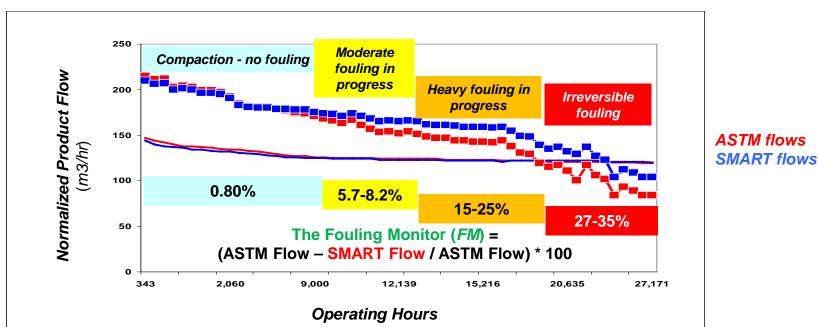


SilentAlarm-CORRECTED FLUX DECLINE TRENDING FOR REAL PLANTS

9



#### The **SMART** Solution



**REAL-TIME MONITORING BY THE SILENT ALARM TM METHOD** 



### Criteria of a SMART System

### As defined by Wikipedia, a standard **SMART** system must be:

- > **Specific:** Significant, Simple, Sustainable.
- > Measurable: Motivational, Manageable, Meaningful.
- > Actionable: Attainable, Achievable, Adjustable, Acceptable.
- > *Relevant*: Realistic, Result-based, Resourceful, Reprodcuable.
- > **Tested**: Timely, Time-sensitive, Testable.



### SilentAlarm<sup>™</sup> FM Guidelines – SWRO Desalination Plants

FM RANGE	FOULING STATUS	RECOMMENDED ACTION
0%-5%	No significant fouling.	Good operation. Continue to monitor.
5%-15%	Low to moderate fouling may be starting to develop.	Monitor more closely. Consider trouble- shooting if FM trend continues to rise.
15%-25%	Moderate to heavy fouling is in progress.	Start trouble-shooting immediately to identify and eliminate source of fouling.
> 25%	Heavy to irreversible fouling is occurring.	Significant membrane replacements and/or additions required due to extensive loss of performance.

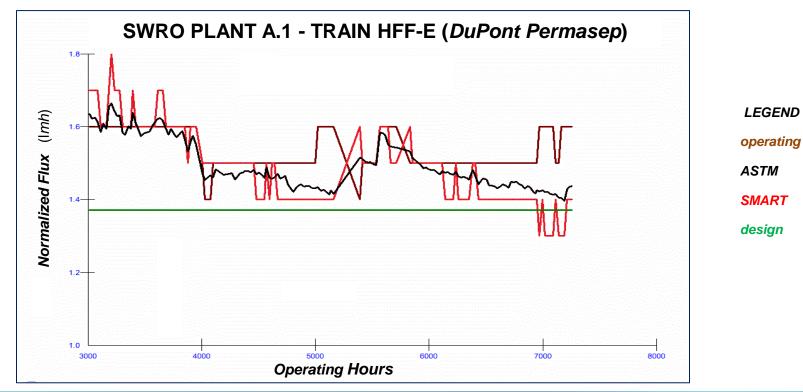


### SilentAlarm<sup>™</sup> Real SWRO Plant Case Studies

Based on 3,412 operating data records selected from 5 representative trains from 3 SWRO Arabian Gulf plants (306,000 m<sup>3</sup>/day) out of 16,765 data records from 30 trains studied

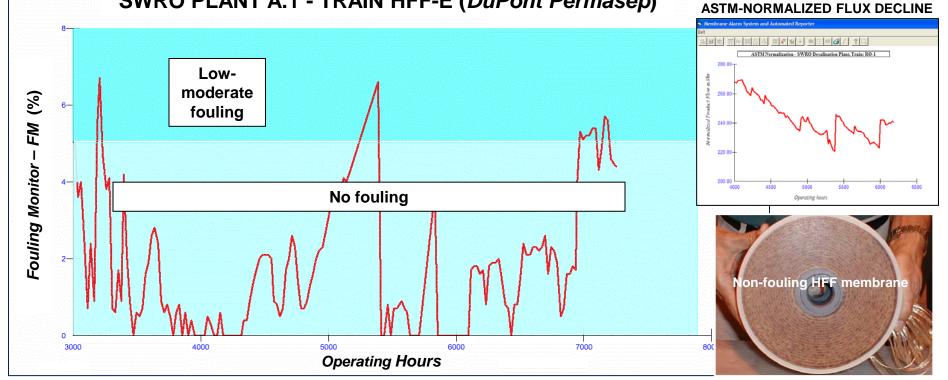
CASE/ Train ID	Membrane Configuration	Membrane Model	Feed TDS mg/l	Train Capacity m³/d	Recovery Ratio %	Operating Hours
A.1/HFF-E	Hollow Fine Fiber (Twin-DuPont Permasep)	High- Pressure	44,450	6,072	35.0	20,964
A.2/SW-D	Spiral Wound (Toray)	High- Pressure	44,450	6,192	35.0	21,041
B.1/SW-11	Spiral Wound (FT)	High- Rejection	38,865	12,000	46.3	7,968
B.2/SW-15	Spiral Wound (HYD)	Low-Fouling	38,813	12,000	46.3	8,712



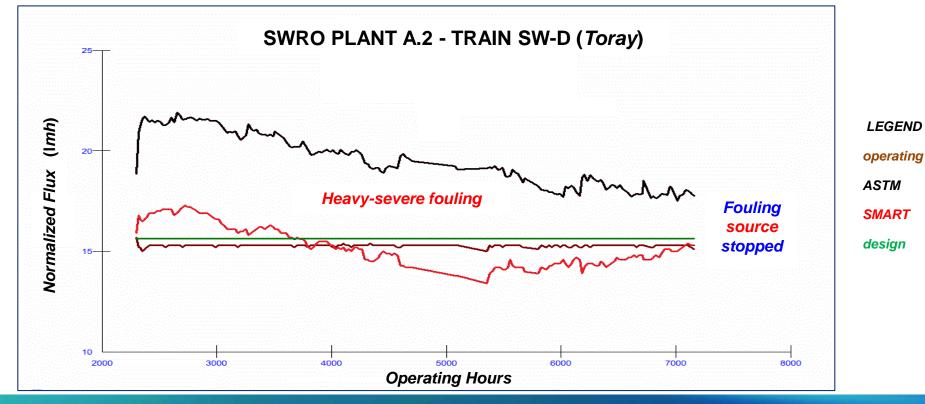




#### SWRO PLANT A.1 - TRAIN HFF-E (DuPont Permasep)

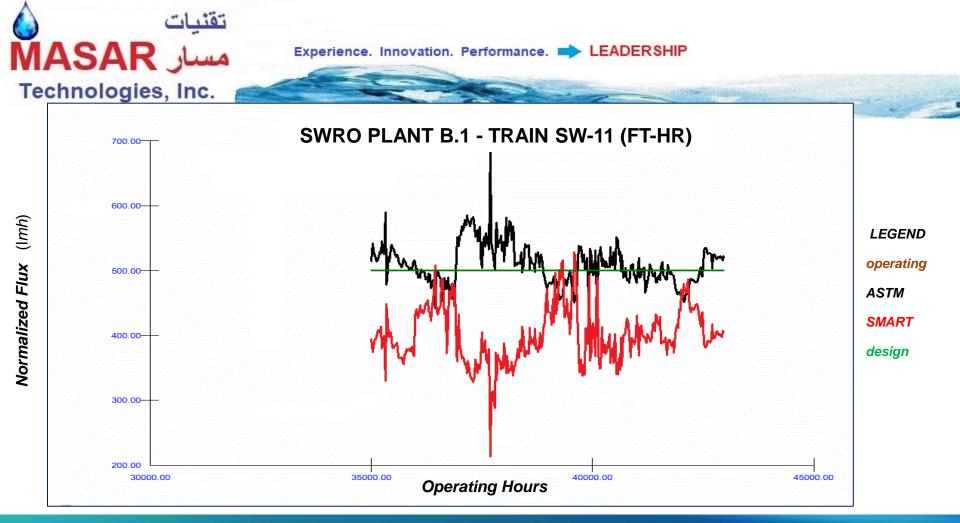






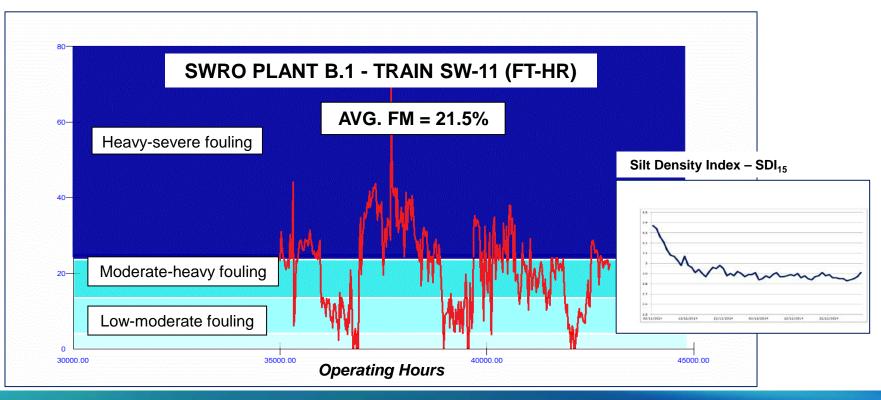


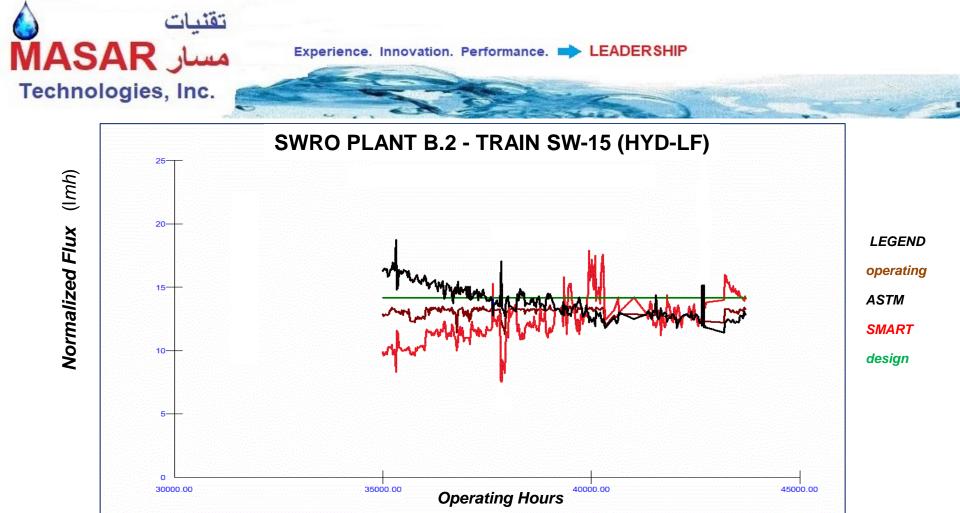
www.masar.com



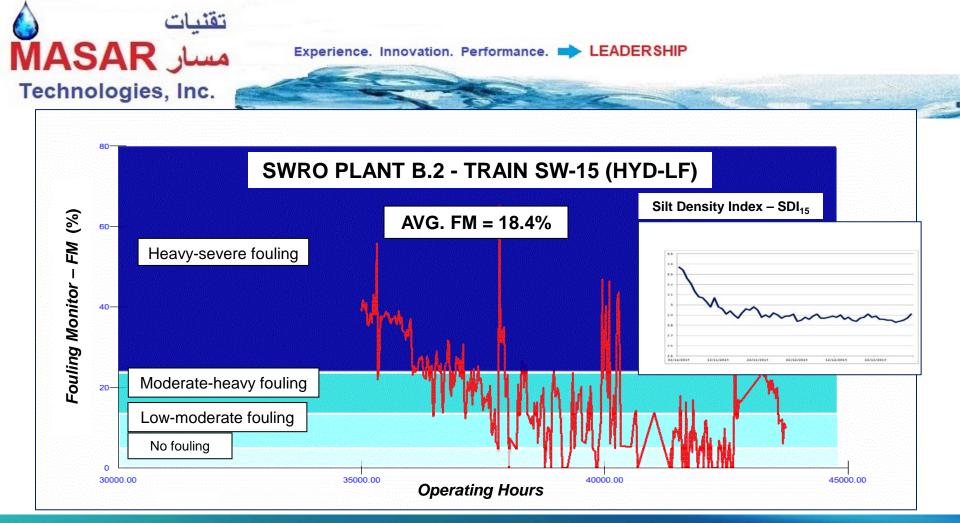


Fouling Monitor – FM (%)



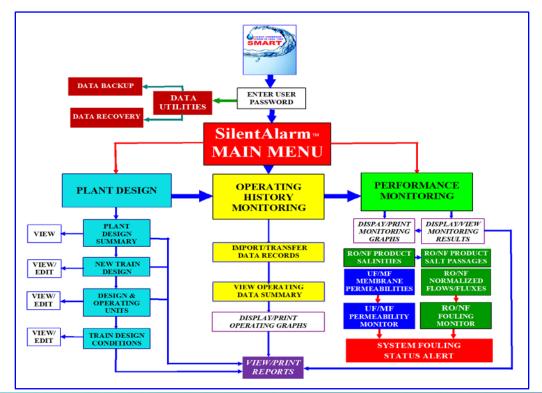


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## SilentAlarm™ Architecture

Serving as a complete membrane plant operational data and performance monitoring, management and reporting system



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2	Silent Membrane Alarm in Real Time

ew/Print Report		Main Menu	Plant Information Menu
	PLANT DESIGN SUMMARY		
	MASAR® SilentAlarm License Number		
	DEMO-SWRO-2019		
Plant:	SWRO Plant		
Owner/Opera	ator: Desalination Company		
Main Applica	ition: Drinking Vear Commissioned: 2018 V		
System Des			
Feed Source	First Pass Second Pass Seawater Seawater Brackish		
Design Capacity	y: 282412.8 V 39340.8 V Total: 281000 V Vsec	~	
Process Type	Reverse Osmosis 🗸		
No. of Trains	: 12 <del>·</del>		
No. of Stages	s 1 -		

Plant design conditions represent your SilentAlarm license terms and cannot be changed.

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Silent Membrane Alarm in Real Time

#### SilentAlarm<sup>™</sup> Screens

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	AIN	Plant:	SWRO Plan	t		~		View/Print Summ View/Print Histo			
	ATING TORY	Train:	Rack D	~	Stage: one		splay Data		/		
nis		Hours From:	1	<u>~</u>	To: 3531	~					
FIRS	T PASS	Dates From:	Wednes	day, April 11, 2018	To: Thurs	day, December 1	3, 2018				
Entered	Parameters									Caclulated Pa	rameters
Record No.	Day & Date	Operating Hours	Feed Temp. C	Feed TDS ms/cm@25	Feed Pressure bar	Product Flow m3/hr	Delta P bar	Product TDS us/cm@25	No. of PVs	Operating     Conversion	Total No. of Membranes
<b>1</b> :	Wednesday, April 11, 201	8 1	33.1	56	57.2	1168	991	1	963	45.9	1736
2	Wednesday, April 11, 201	8 2	33.1	56	57.2	1164.4	997.8	1	961	46.1	1736
3	Wednesday, April 11, 201	8 3	33	56	57.2	1162.8	998.3	1	963	46.2	1736
¢.	Wednesday, April 11, 201	8 4	32.9	56	57.3	1158.4	996	1	959	46.2	1736
5	Wednesday, April 11, 201	8 5	33	56	57.4	1154.7	993.1	1	969	46.2	1736
6	Wednesday, April 11, 201	8 6	33.2	54	57.4	1161.7	1000.6	1	964	46.3	1736
7	Wednesday, April 11, 201	8 7	33.4	56	57.8	1163	998.1	1	973	46.2	1736
в	Wednesday, April 11, 201	8 8	33.5	56	57.6	1170.4	997.9	1	962	46	1736
9	Wednesday, April 11, 201	8 9	33.5	56	57.5	1156.9	996.9	1	954	46.3	1736
10	Thursday, April 12, 2018	10	33.8	56	57.5	1164.6	994.7	4	951	46.1	1736
11	Thursday, April 12, 2018	11	33.8	57	57.4	1154.7	996.3	1	944	46.3	1736
12	Thursday, April 12, 2018	12	33.6	57	57.5	1166.2	998.3	1	942	46.1	1736
13	Thursday, April 12, 2018	13	33.3	57	57.5	1165.1	1010.1	1	934	46.4	1736
14	Thursday, April 12, 2018	14	33.2	57	57.4	1156.5	998.2	1	932	46.3	1736
15	Thursday, April 12, 2018	15	33.3	57	57.5	1163.9	1000.6	1	933	46.2	1736
16	Thursday, April 12, 2018	16	32.9	57	57.7	1159	1000	1	924	46.3	1736

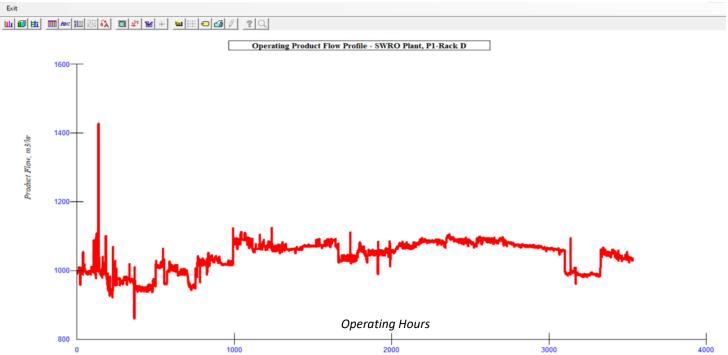


🔀 Silent Membrane Alarm in Rea	al Time								$\times$
View Operating History									
				TOD					
	OPE	RATIN	GHIS	IORI	GRA	PHS			
		F	IRST I	PASS					
Silt Density In	dex	Feed Tur	bidity	Feed	тос	Micro	n Filte	r DP	
	_	-							
Dech	lorinatio	n ORP	Feed	I pH	Chlori	ne Resid	lual		
	Feed	Temperatu	re	E	ed Salin	ity			
	Teeu	remperata			Sed Odini	it y			
	Feed	Pressure		F	eed Flov	v			
	Pro	duct Flow		Pro	duct Sali	nity			
	Reco	overy Ratic	5	Mem	brane De	elta P			



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🖳 Silent Membrane Alarm in Real Time





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#### Select Train, Stage and Hour Range then click on Display Result View/Print Monitoring Graphs TRAIN Plant: SWRO Plant View/Print Summary Report PERFORMANCE Display Train: Rack D Stage: one Results SUMMARY Hours From: To: 3531 To: Thursday, December 13, 2018 Dates From: Wednesday, April 11, 2018 FIRST PASS

#### To select a date range, highlight the hour from or hour to, then point the mouse on the respective date and scroll up or down to the desired date

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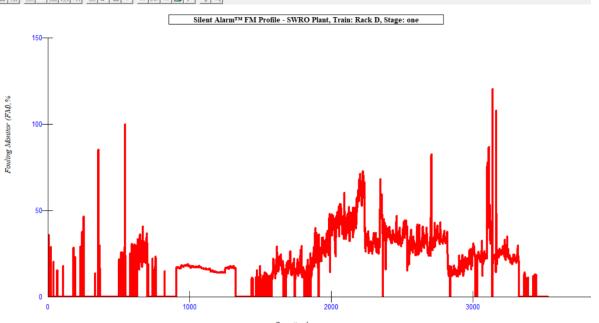
🛃 Silent Membrane Alarm in Real Time

aday, April 11, 2018 aday, April 12, 2018 ay, April 12, 2018	Hour 1 2 3 4 5 6 7 8 9 9 10	m3/hr 966. 97 980. 975. Silent/	7 977 3 980.3 7 975.7 Narm- Performance Moni This value suggests th occuring in your mem	0 0 toring Results is normalized dat at significant me		× 6 7 6 17.87%. 4	1096.3 1095.6	% 32 32 31 32 33 32 33 32 32
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aday, April 11, 2018 aday, April 12, 2018	9 10	975.	7 975.7 Narm- Performance Moni The average FM for th This value suggests th occuring in your mem	toring Results is normalized dat at significant me	14.1 a selection is	13.8 × 6 7 6 17.87%. 4	1085.2 1096.3 1104.7 1119.2	3.1 3.2 3.3 3.2
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aday, April 11, 2018 ay, April 12, 2018	9 10	_ 1	This value suggests th occuring in your mem	at significant me			1110.9	3.2
ay, April 12, 2018	10		<ul> <li>occuring in your mem</li> </ul>		mbrane fouli			
and the second se							1098.1	3.2
y, April 12, 2018			Immediate trouble-sh				1103.3	3.2
	11		of fouling or scaling,				1094.7	3.1
y, April 12, 2018	12		action, is highly recon	mended. Please	continue to r	nonitor 4	1090.3	3.1
y, April 12, 2018	13	c 1	the plant very closely.			3	1082	3.1
y, April 12, 2018	14	_				3	1065	3
sy, April 12, 2018	15					2	1072.5	3
sy, April 12, 2018	16	· · · · · · · · · · · · · · · · · · ·				1	1049.1	3
y, April 12, 2018	17	981.	6 981.6	6.217732E-06	14	13.9	1047.2	3
y, April 12, 2018	18	981.	3 981.3	0	14.2	13.9	1053	3
y, April 12, 2018	19	960.	5 960.5	6.354819E-06	14.1	13.6	1043.9	3
sy, April 12, 2018	20	964.	3 964.3	6.329719E-06	14,1	13.6	1018.3	2.9
1 10 0010		007	a	0.0101535.00		10.7	1000 7	
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📓 Silent Membrane Alarm in R	Real Time	(-)		$\times$
Stage Performance Monit	oring Summary			
TRAIN PERF	ORMANCE MONITORING	GR	APH	S
	FIRST PASS			
Plant: s	WRO Plant			
	Silent Alarm <sup>™</sup> Fouling Monitor <sup>™</sup>			
	Performance Monitoring Flows			
	Performance Monitoring Fluxes			
	ASTM Normalized Flow			
	ASTM Normalized Salt Passage			
	ASTM Normalized TDS			





Operating hours



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# **Silent Alarm**... Report

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Train Performance Monitoring Report

Plant Name:	SWRO Plant
Train Name:	Rack D

First Pass

Day & Date	Operating Hour	Normalized ASTM	<b>d Product Flow</b> s SilentAlarm	ASTM	roduct Saliniti MASAR® /cm@25	ieFouling Monitor (FM) %
Wednesday, April 11, 2018	1	966	966	1,093	1,154	0.0
Wednesday, April 11, 2018	2	977	977	1,096	1,164	0.0
Wednesday, April 11, 2018	3	980	980	1,095	1,168	0.0
Wednesday, April 11, 2018	4	975	975	1,085	1,162	0.0
Wednesday, April 11, 2018	5	964	964	1,096	1,149	0.0
Wednesday, April 11, 2018	6	887	1,207	1,104	1,384	36.0
Wednesday, April 11, 2018	7	935	1,105	1,119	1,317	18.2
Wednesday, April 11, 2018	8	940	1,093	1,110	1,305	16.3
				1.000	1.122	
1 of 191 🕨	Cancel 5	] 🚳 🗖		3531 of 3531	Total:3531 1	00%



### The **SMART** Solution Overview

- The technology is capable of monitoring, evaluating and optimizing membrane systems' operational efficiency (i.e., attaining the highest possible recovery ratio and optimum critical operating parameters for without the risk of fouling or scaling, for example).
- It also uniquely detects, measures and monitors any potential membrane fouling or scaling development as soon as it occurs, allowing ample time to address the real causes of the development without interrupting the plant operation or availability.
- These unique capabilities allow the plant operator to continuously monitor the plant performance, fouling status and cost efficiency on a day by day measurable basis instead of relying on non-actionable and oft-ambiguous trending analysis offered by the standard ASTM normalization procedure, (i.e., *no excessive cleaning/replacement cycles, etc.*)



### The **SMART** Solution Overview

- The technology is universally applicable to ALL pressure-driven membrane processes (RO, NF, MF, UF), membrane manufactures, system designs, configurations and feedwater sources. This allows live, dynamic and competitively advantageous product evaluation, optimization and development, and rendering more technical credibility to product marketing efforts with end users.
- Allows for checking the true efficacy of membrane cleaning cycles, chemical dosing regimes, membrane additions/replacements and impact of any process or equipment changes in real time so that appropriate action can be taken immediately.
- Can be fully integrated with any water utility digital transformation tools and systems, including control systems monitoring, performance optimization and alarm-setting.

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### SilentAlarm™ Testimonials

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The beta-site software was extensively \*\* tested, evaluated, and finally *approved* and recommended as an early-warning fouling indicator by the engineers of the world's pioneer in membrane desalination applications, DuPont's *Permasep Products*, the original author of ASTM D 4516 standard method for evaluating RO performance characteristics (i.e., normalization procedures).

DuPont Fabrics & Separations

Mr. Mohamad Amin Saad MASAR Technologies, Inc. 1688 Lost Moon Court Tucson, AZ 85737

Subject: MASAR "Software

Dear Mr. Saad,

Our Permasep<sup>®</sup> Products technical personnel have completed their evaluation of your MASAR<sup>™</sup> Membrane Analysis System and Automated Reporter<sup>™</sup> software, which is used to normalize RO data and monitor plant performance. They agree with your findings, that MASAR<sup>™</sup>, when properly applied, is an excellent tool to monitor plant performance and capable of providing an early warning if membrane fouling is occurring. This technology could be very useful to RO plant owners and operators.

Permasep<sup>®</sup> Products approves and recommends the use of your MASAR<sup>™</sup> software technology applied to RO plants using our membrane products.

Sincerely,

Hem Whito

K.G.White Product Manager Permasep<sup>®</sup> Products

October 27, 1998

**DuPont Fabrics & Separations** 

Permasep<sup>6</sup> Products Glasgow – Building 200 P. 0. Box 6101

Newark, DE 19714

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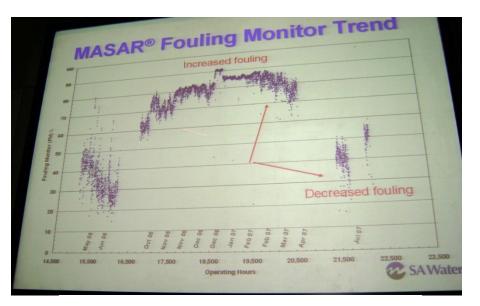
### SilentAlarm™ Testimonials

Analysis of process performance data was performed using a proprietary software package, MASAR®, procured from MASAR Technologies, USA (www.masar.com). The software was custom-designed for South Australia Water Corp.'s Penneshaw SWRO plant, based upon its configuration. MASAR® is able to predict the onset of long-term fouling more quickly than standard datanormalization methods. The MASAR® fouling monitor trend throughout the acid dosing trial is shown in Fig. 7.

"1110"

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Pelekani, et al, Design, Operating and Research Experience at the Penneshaw Seawater Desalination Plant, South Australia, presented at and published by the 2007 IDA World Congress on Desalination & Water Reuse, Spain Experience. Innovation. Performance. 

LEADERSHIP

### SilentAlarm™ Testimonials

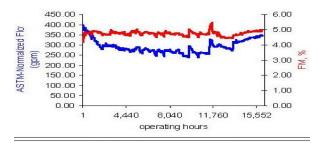
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MASAR J

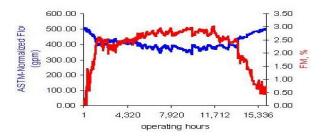
Technologies, Inc.

Design and operating data from RO Train A and NF Train \* A were recently provided by **Port Hueneme Water** Authority for evaluation using a new, early-warning membrane performance and fouling monitoring technology and software system known as MASAR®. The difference in actual performance between the RO and NF trains as shown by the MASAR® evaluation results is truly *remarkable*. Both trains had suffered from biofouling, The plant had earlier discovered that the NF membrane elements also suffered from a manufacturing defect that resulted in the continuing deterioration of their performance as truly indicated by **MASAR**<sup>®</sup> software.

#### NF-A PERFORMANCE







J. Richardson, Saad, M.A., "Real-time Membrane Fouling Monitoring – A Case History", proceedings of the World of Water Conference, Las Vegas, Nevada, USA, December 10-12, 2001.



### SilentAlarm<sup>™</sup> Testimonials

**Posts on Researchgate.com Questions** Asked August 5, 2016

Nishtha Dhunnoo - University of Greenwich

Are there any software which is used in desalination plant to monitor fouling and scaling? and can it be used to monitor or prevent fouling and scaling?

Answer 1

Rafik Karaman added an answer

August 5, 2016

Dear Nishtha.

The innovative "Silent Alarm<sup>™</sup>" technology discussed in the attached article makes a giant and an unconventional **leap** in that direction by allowing for real-time detection, measurement and monitoring of membrane fouling and scaling.

Answer 2

Ashish Thakur added an answer

March 23, 2020

#### Dear Nistah,

MASAR® is useful in testing and optimizing the effectiveness of new treatment chemicals such as coagulants, anti-scalants and biocides, either on pilot systems or on actual plant. It also helps test new processes or equipment (such as microfiltration) and their impact on RO performance and cost.

Ref.: https://www.researchgate.net/post/Are there any software which is used in desalination plant to monitor fouling and scaling





https://masar.com/technology

# SILENT MEMBRANE ALARM in REAL TIME TECHNOLOGY