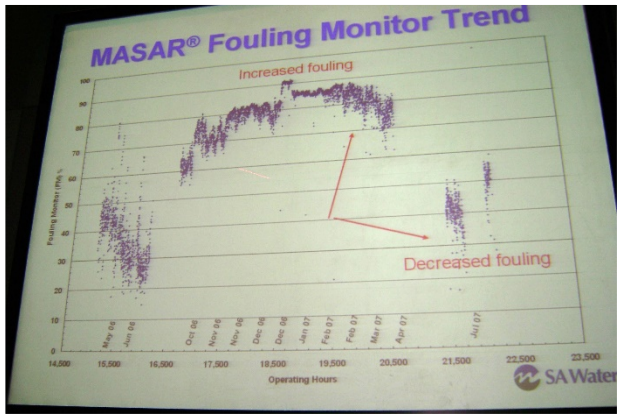
تقنيات
MASAR مسار
Technologies, Inc.

Experience. Innovation. Performance. ➡ LEADERSHIP

The SMART™ Solution to Real-Time Performance Optimization & Fouling detection & Management of Membrane Desalination & Filtration Plants



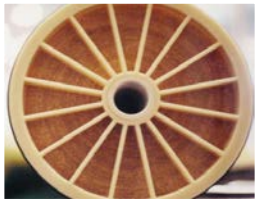
A Presentation by:

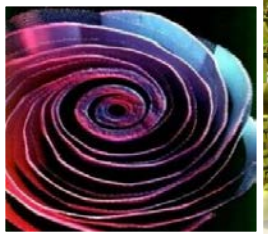
MOHAMAD AMIN SAAD

President, Principal Consultant & Developer

smart@masar.com

MASAR TECHNOLOGIES, INC.





Major Issues in Membrane Desalination

- **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*).**

Major Issues in Membrane Desalination

- **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.**

Major Issues in Membrane Desalination

- **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.**

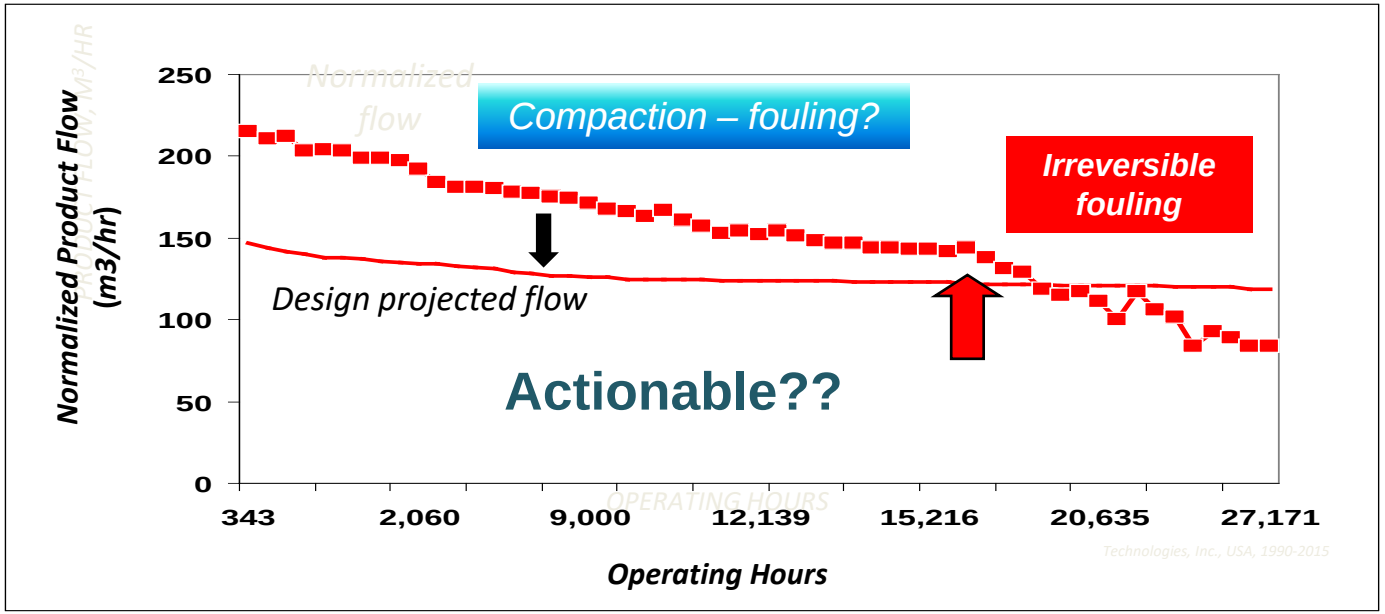
Major Issues in Membrane Desalination

- **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.**

Major Issues in Membrane Desalination

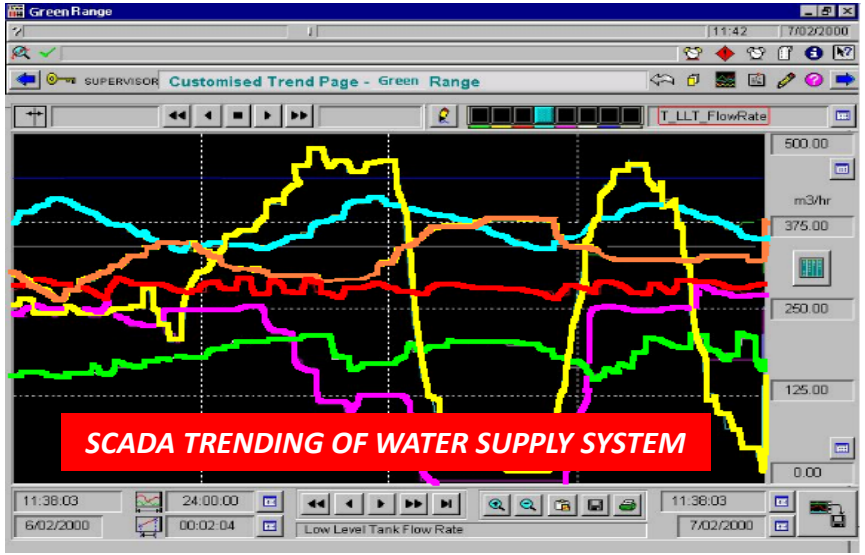
- **Unpredictability of fouling (*cancer of the membrane*)**
  - **Fouling cannot be reliably simulated or modeled in system design projections, unlike chemical scaling.**
  - **Can only rely on monitoring actual system operation to detect fouling.**
  - **Very difficult to define if and when fouling starts to take place before it exhibits significant impact on plant.**
  - **SDI_{15} & $MFI_{0.45}$ are limited as "*fouling indicators*" of colloidal and organic loading on the membranes.**

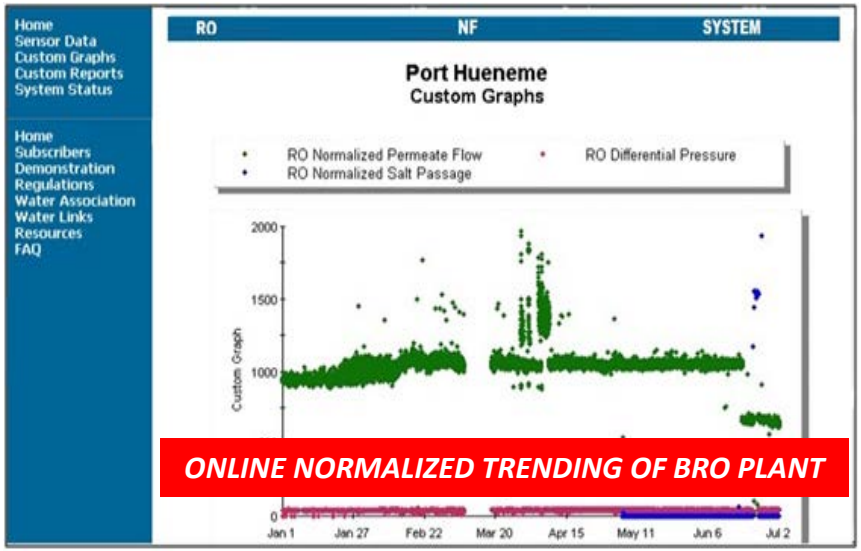
ASTM D4516 Normalization & Trending Analysis



FLUX DECLINE PERFORMANCE TRENDING BY ASTM STANDARD METHOD

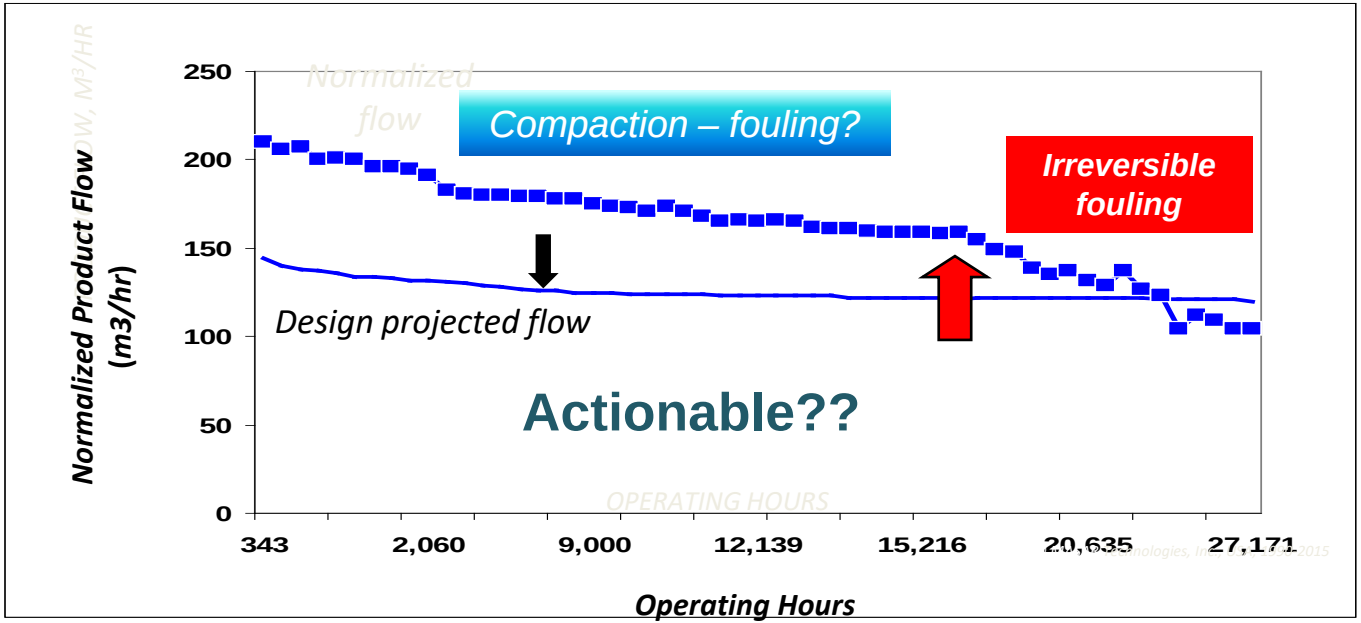
The Problem with Trending





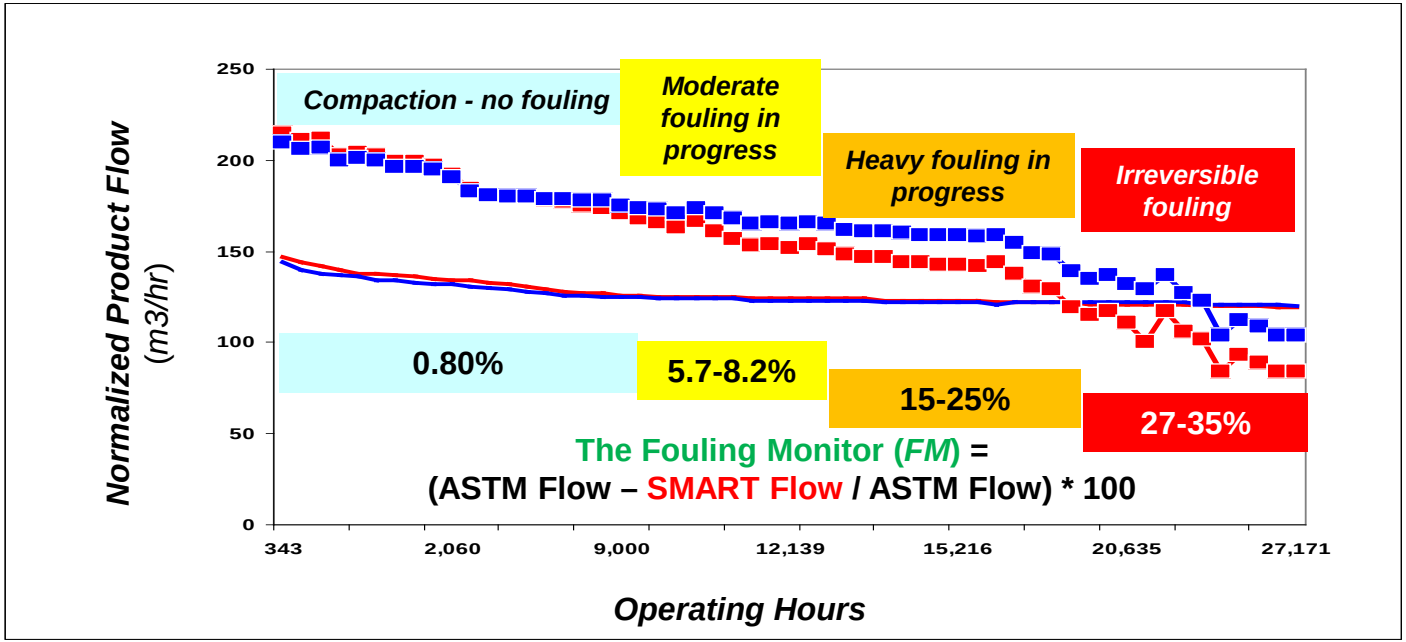
Actionable??

ASTM D4516 Normalization & Trending Analysis



SilentAlarm-CORRECTED FLUX DECLINE TRENDING FOR REAL PLANTS

The SMART Solution



ASTM flows
SMART flows

REAL-TIME MONITORING BY THE SILENT ALARM ™ 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.

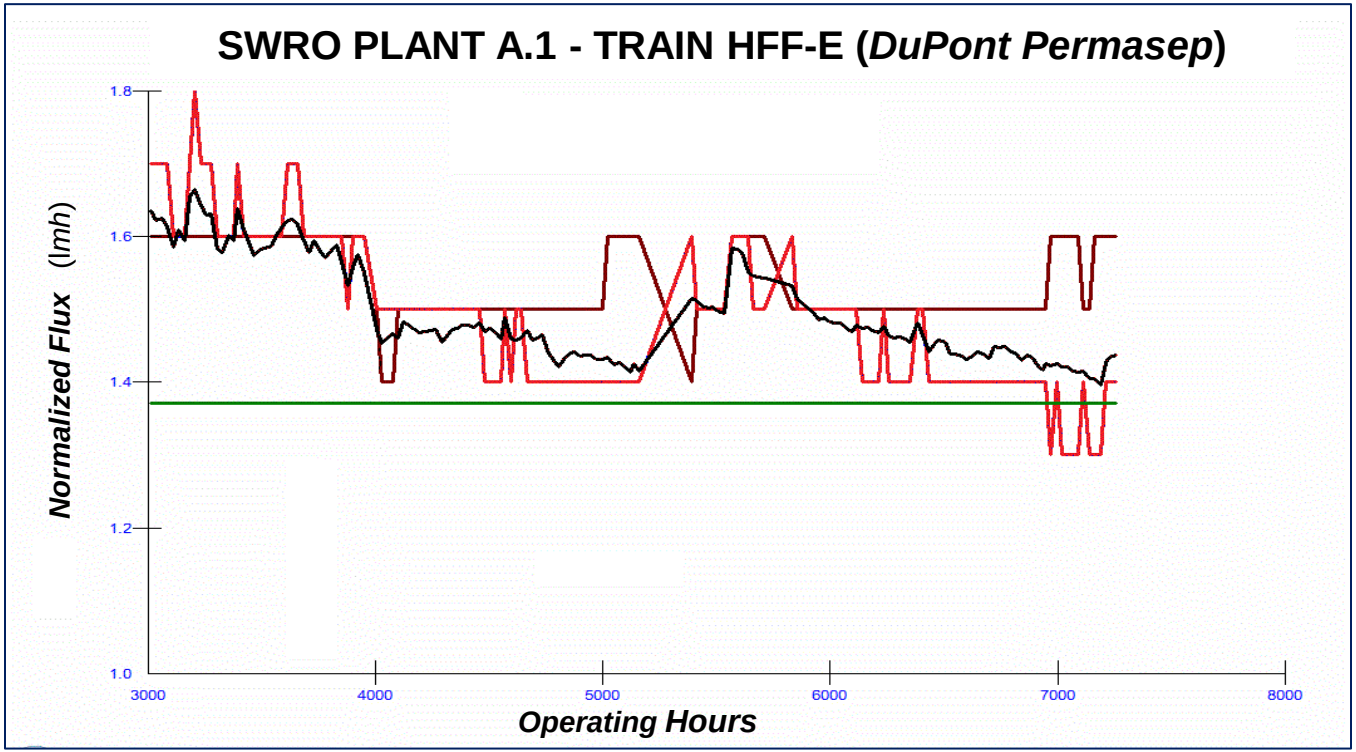
SilentAlarm™ FM Guidelines – SWRO Desalination Plants

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™ 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^3/day) out of 16,765 data records from 30 trains studied

CASE/ Train ID	*Membrane Configuration*	*Membrane Model*	*Feed TDS mg/l*	*Train Capacity m^3/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



LEGEND

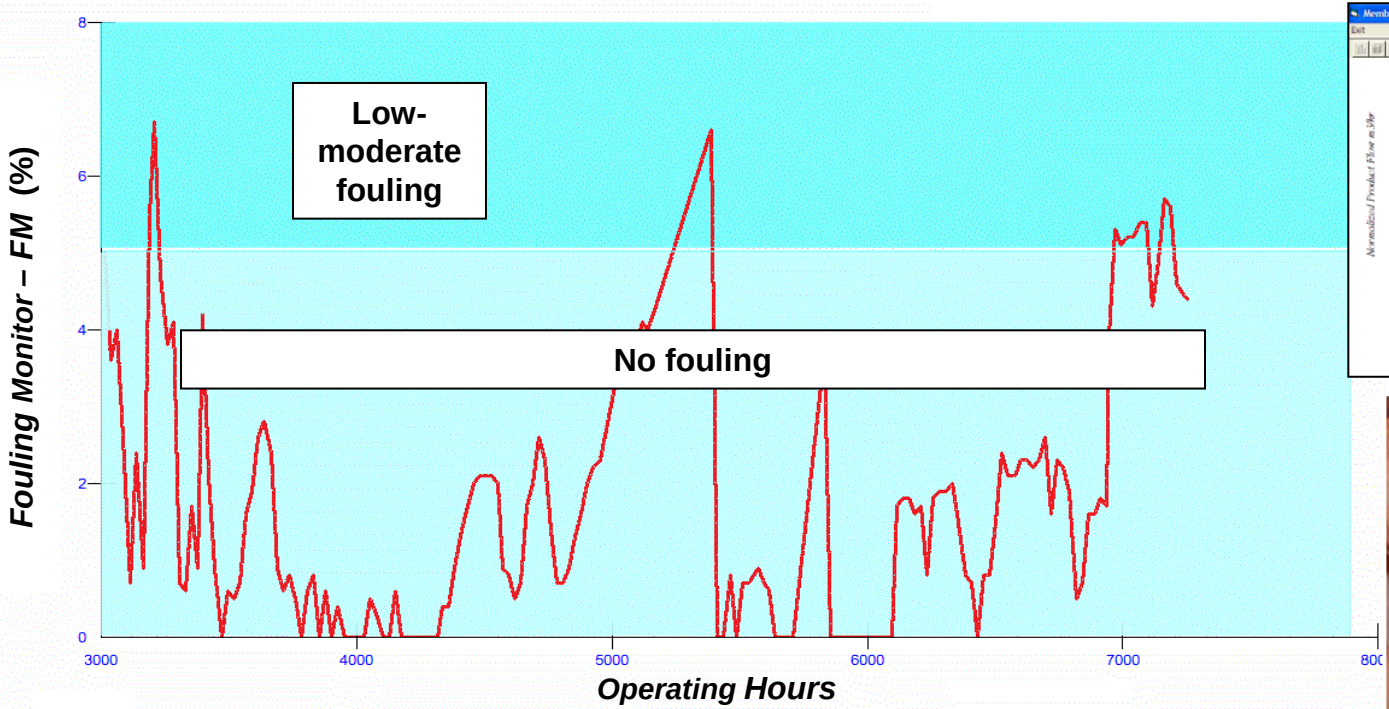
operating

ASTM

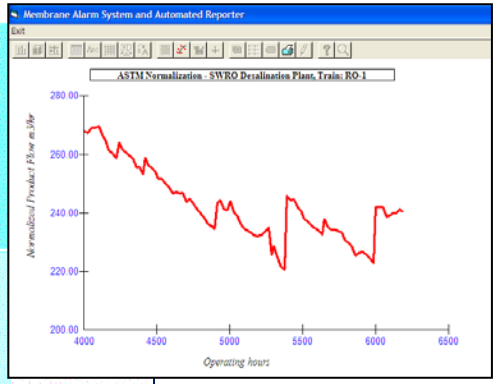
SMART

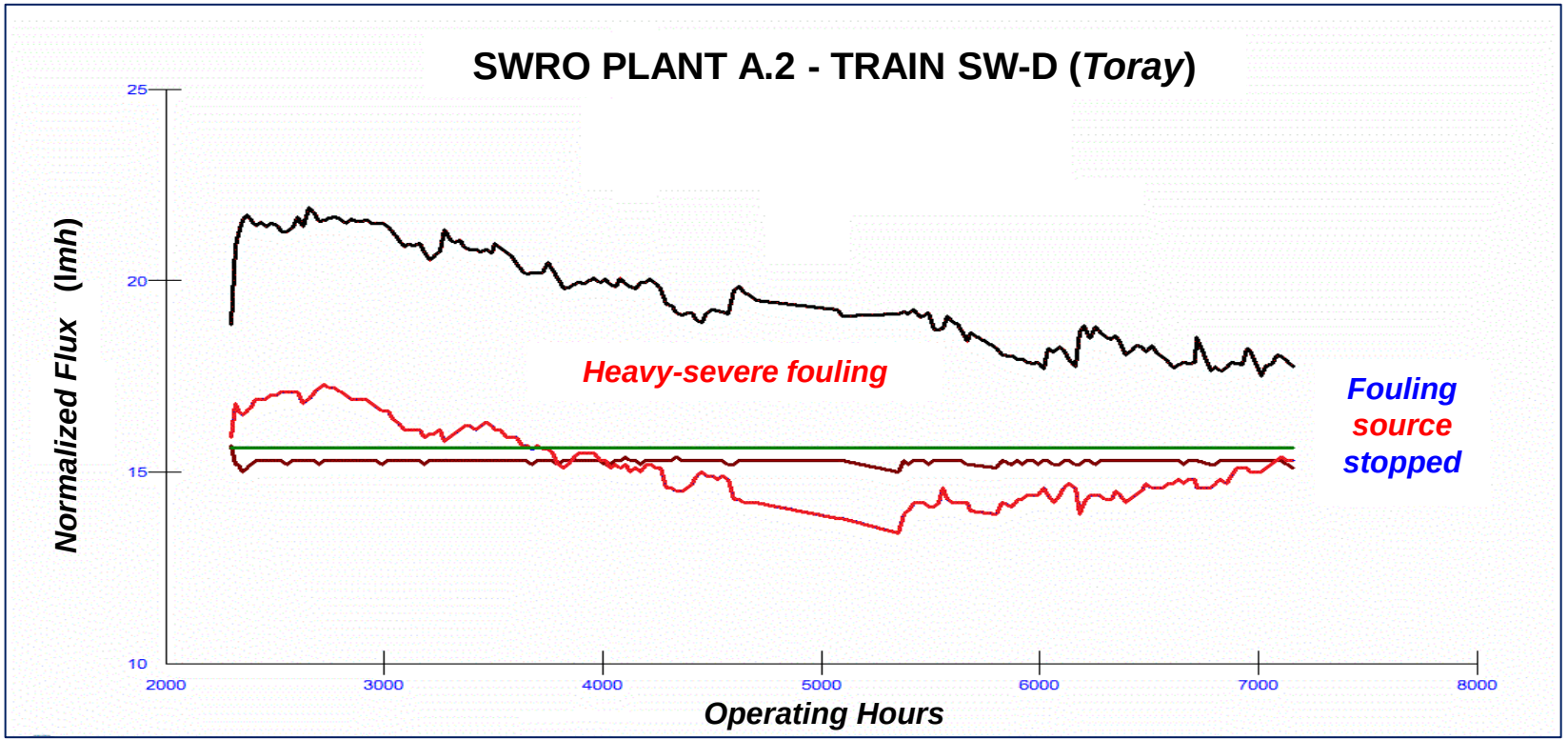
design

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

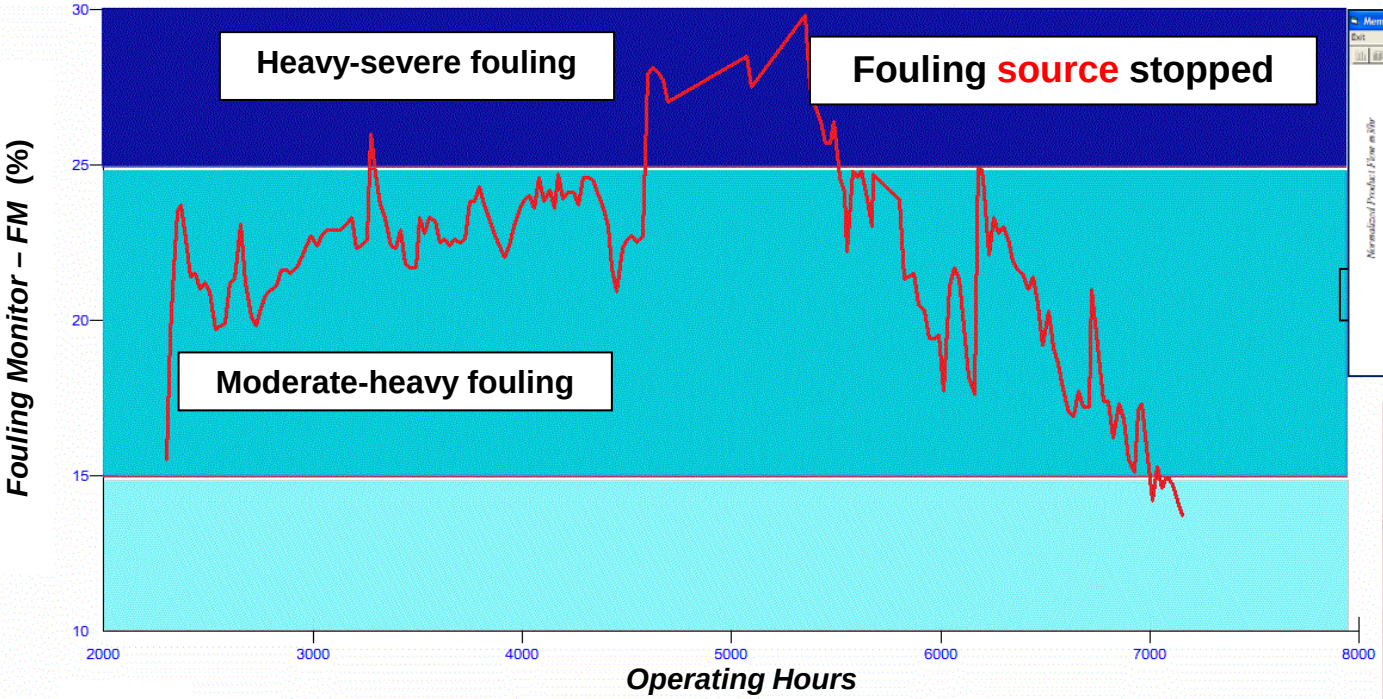


ASTM-NORMALIZED FLUX DECLINE

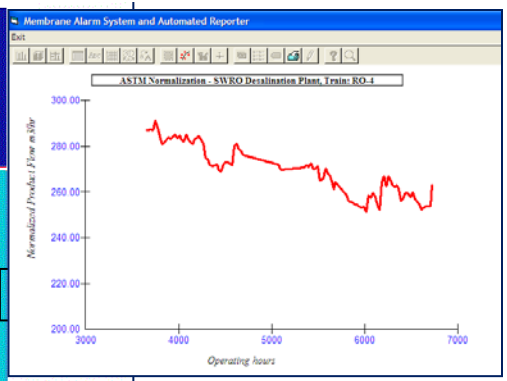


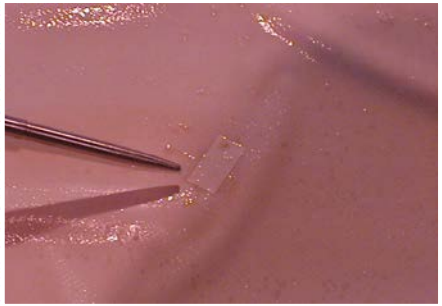

SWRO PLANT A.2 - TRAIN SW-D (Toray)
Normalized Flux (lmh)
25
20
15
10
2000
3000
4000
5000
6000
7000
8000
Operating Hours
Heavy-severe fouling
Fouling source stopped
LEGEND
operating
ASTM
SMART
design

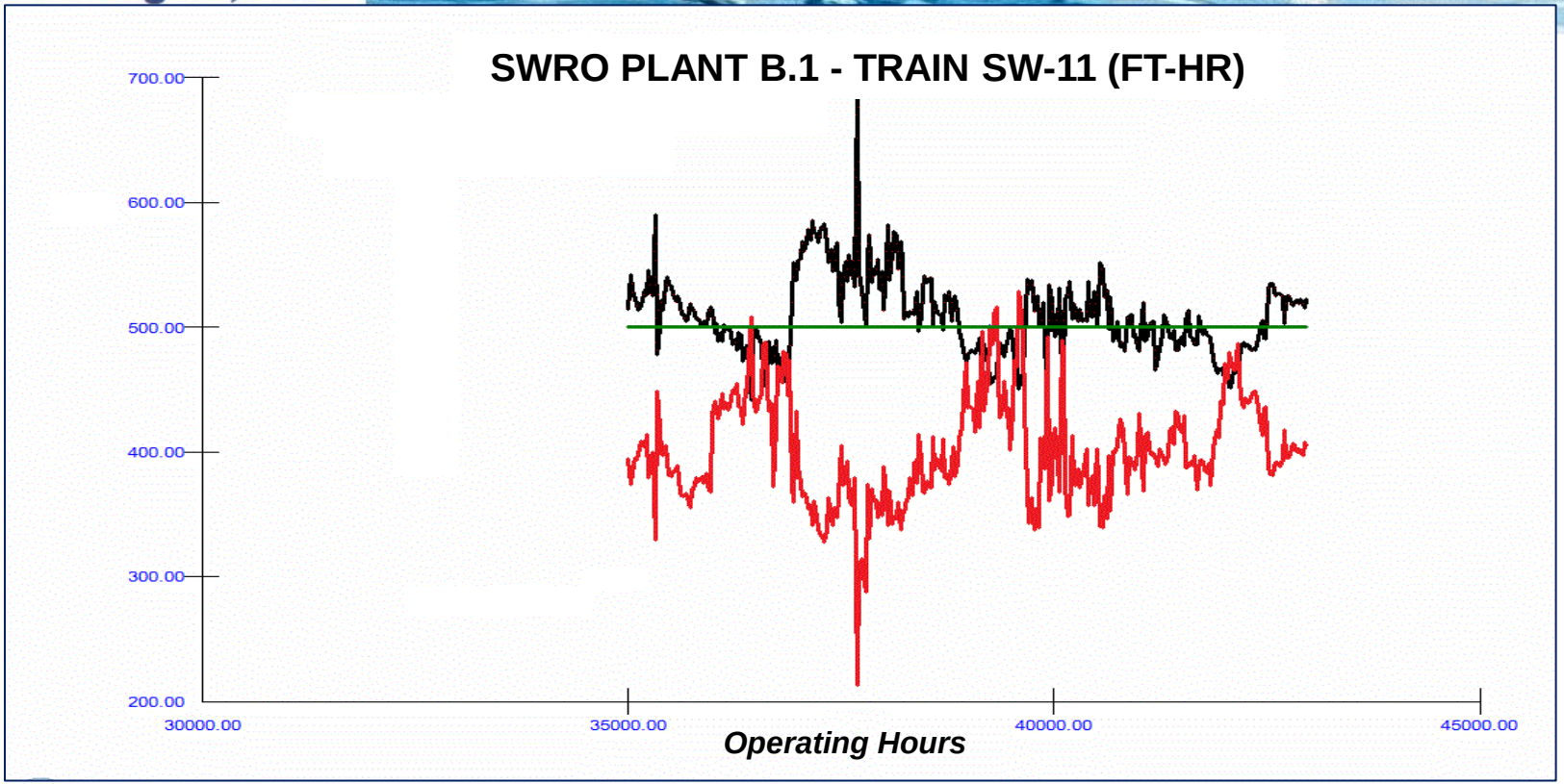
SWRO PLANT A.2 - TRAIN SW-D (*Toray*)

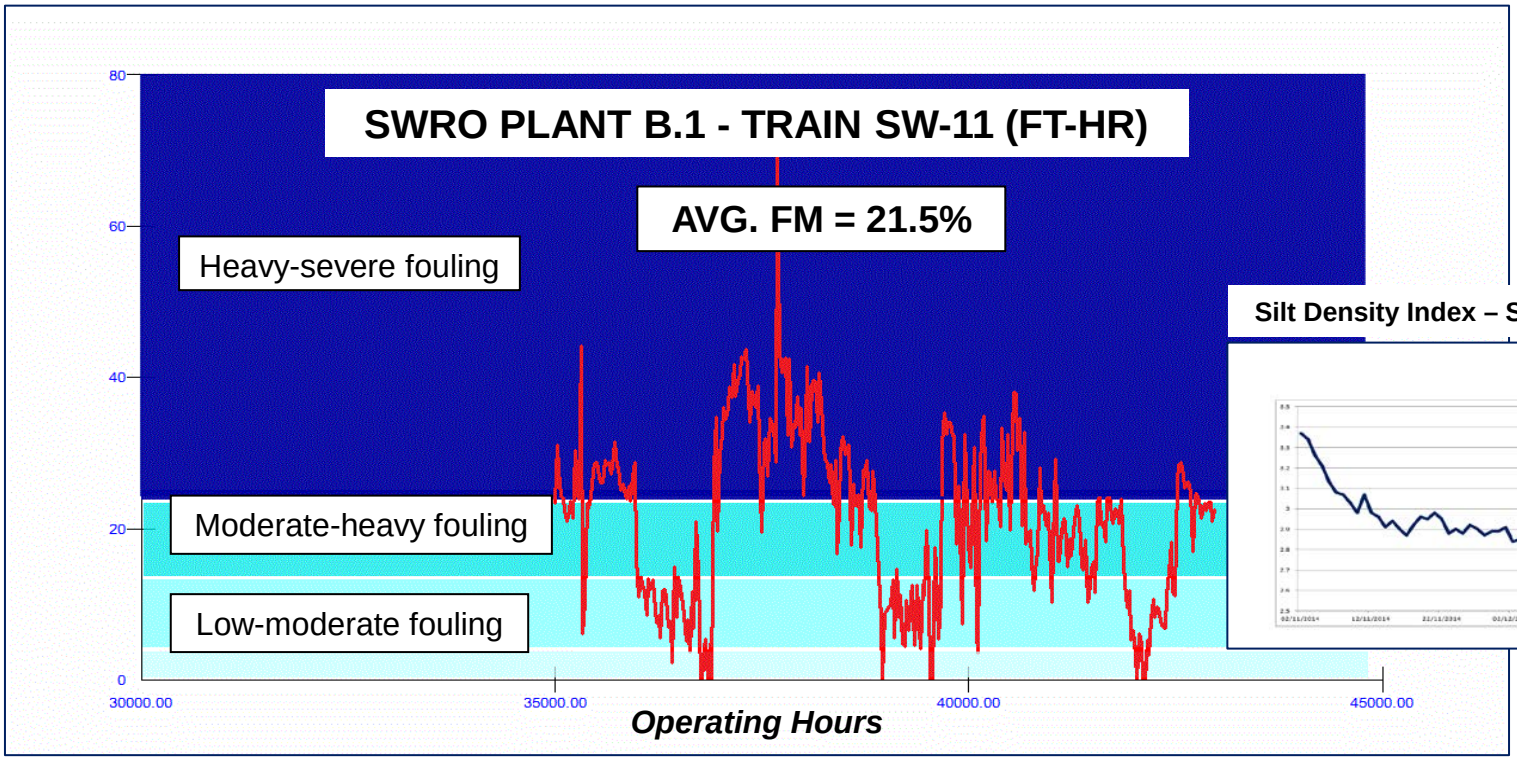


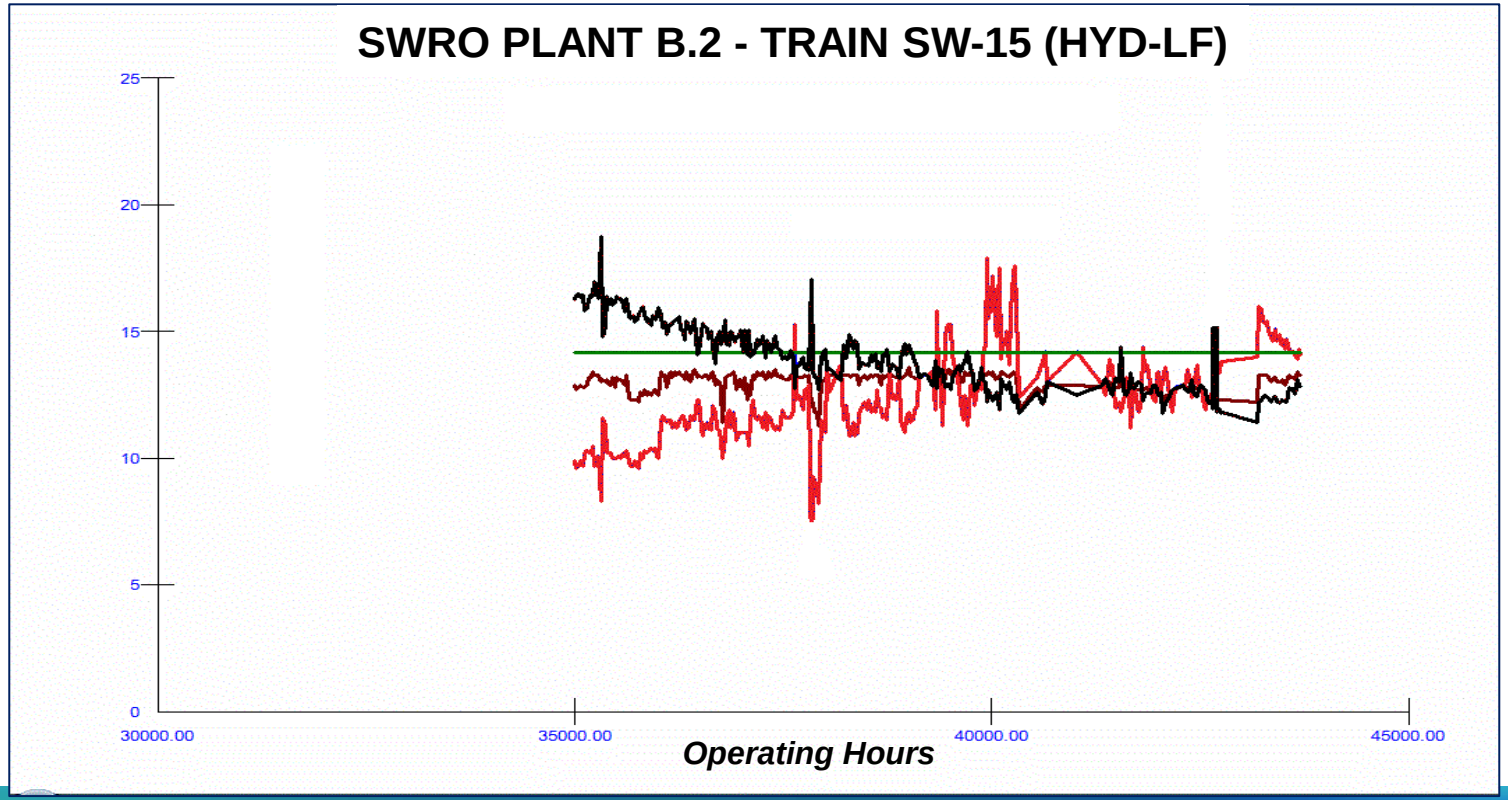
ASTM-NORMALIZED FLUX DECLINE

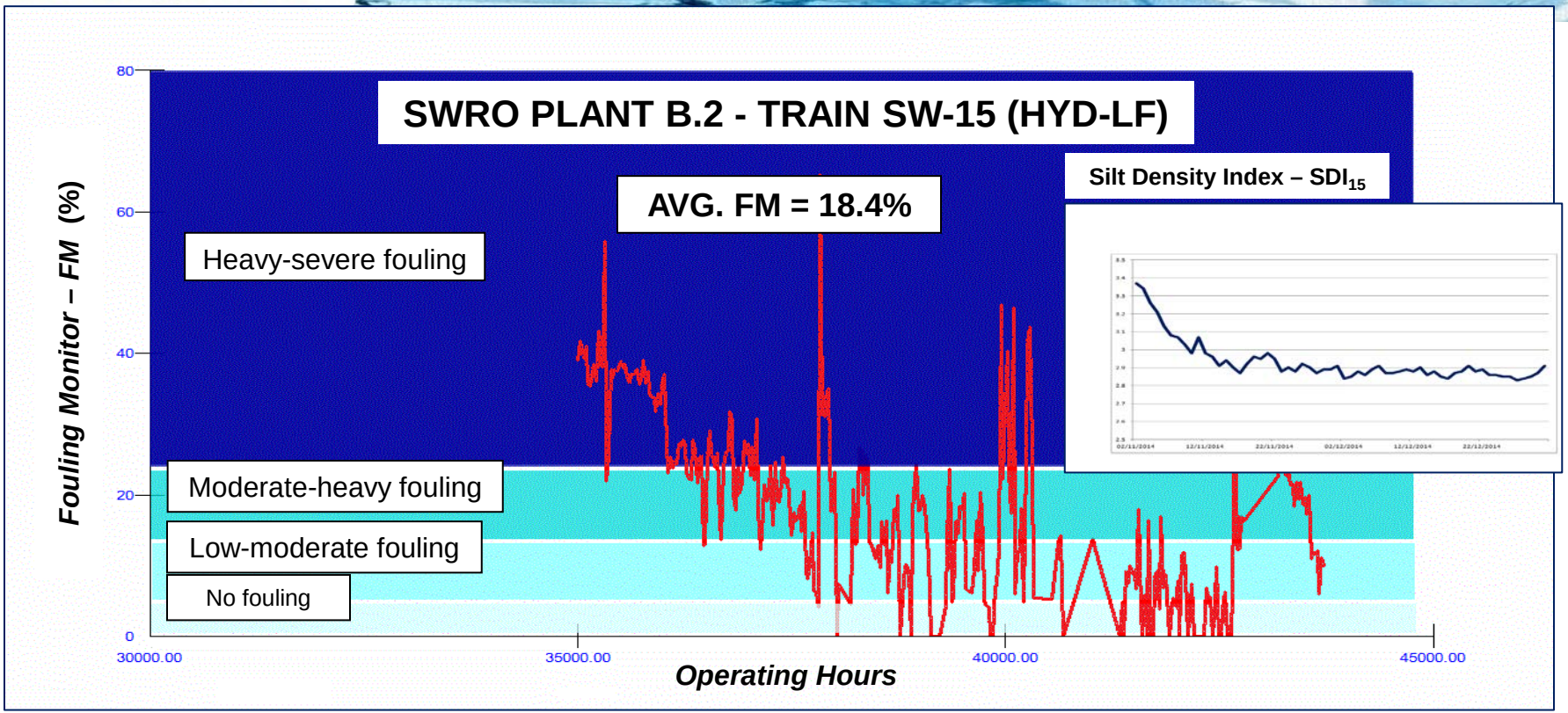


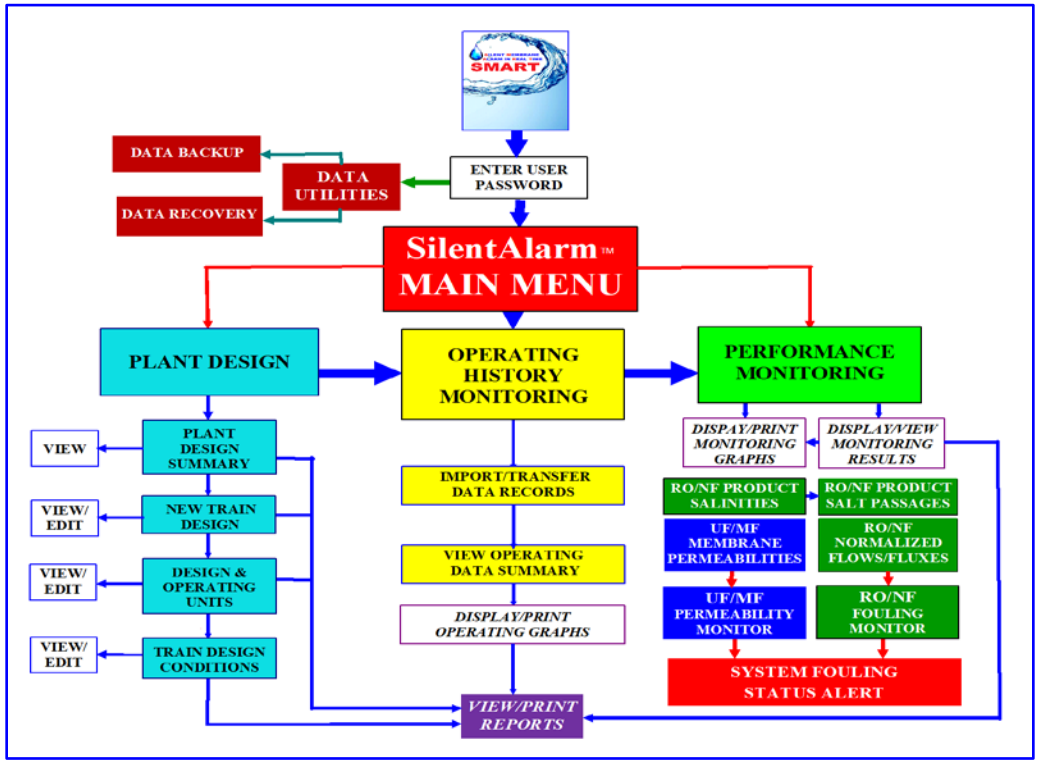



SWRO PLANT B.1 - TRAIN SW-11 (FT-HR)
700.00
600.00
500.00
400.00
300.00
200.00
30000.00
35000.00
40000.00
45000.00
Operating Hours
Normalized Flux (lmh)
LEGEND
operating
ASTM
SMART
design


SWRO PLANT B.1 - TRAIN SW-11 (FT-HR)
AVG. FM = 21.5%
Heavy-severe fouling
Moderate-heavy fouling
Low-moderate fouling
Fouling Monitor – FM (%)
80
60
40
20
0
30000.00
35000.00
40000.00
45000.00
Operating Hours
Silt Density Index – SDI15


SWRO PLANT B.2 - TRAIN SW-15 (HYD-LF)
Normalized Flux (lmh)
25
20
15
10
5
0
30000.00
35000.00
40000.00
45000.00
Operating Hours
LEGEND
operating
ASTM
SMART
design


SWRO PLANT B.2 - TRAIN SW-15 (HYD-LF)
AVG. FM = 18.4%
Silt Density Index – SDI15
Heavy-severe fouling
Moderate-heavy fouling
Low-moderate fouling
No fouling
Fouling Monitor – FM (%)
80
60
40
20
0
30000.00
35000.00
40000.00
45000.00
Operating Hours



SilentAlarm™ Architecture

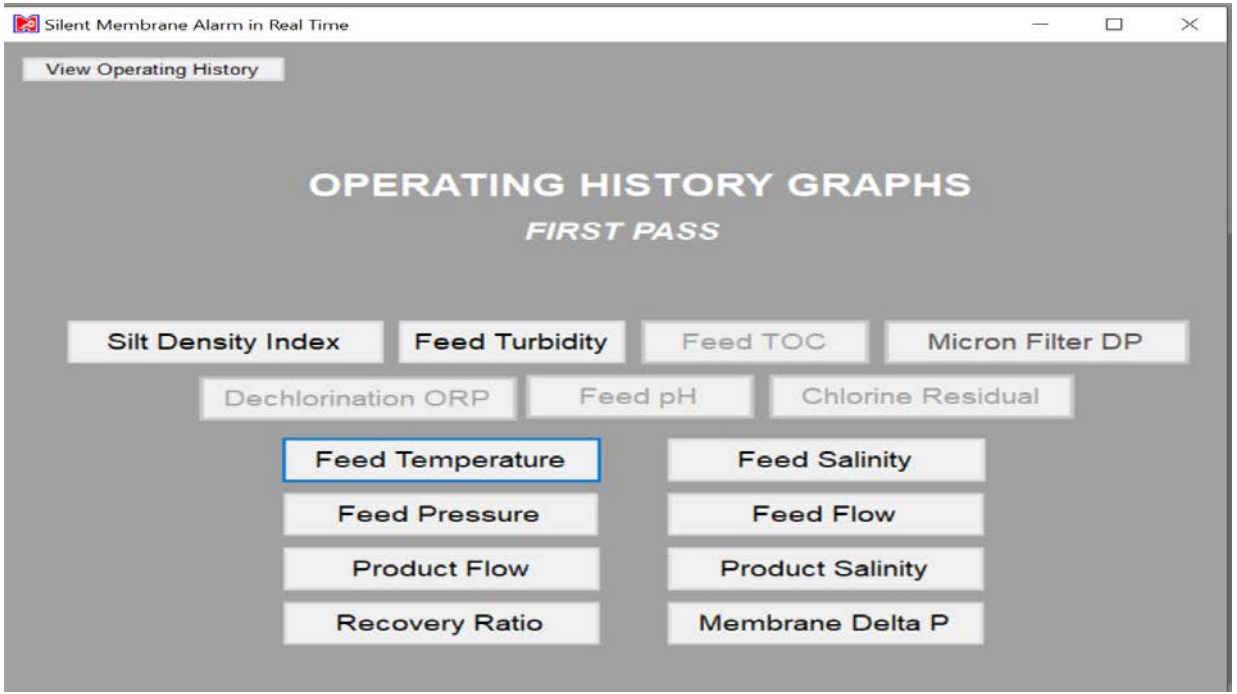
Serving as a complete membrane plant operational data and performance monitoring, management and reporting system

SilentAlarm™ Screens

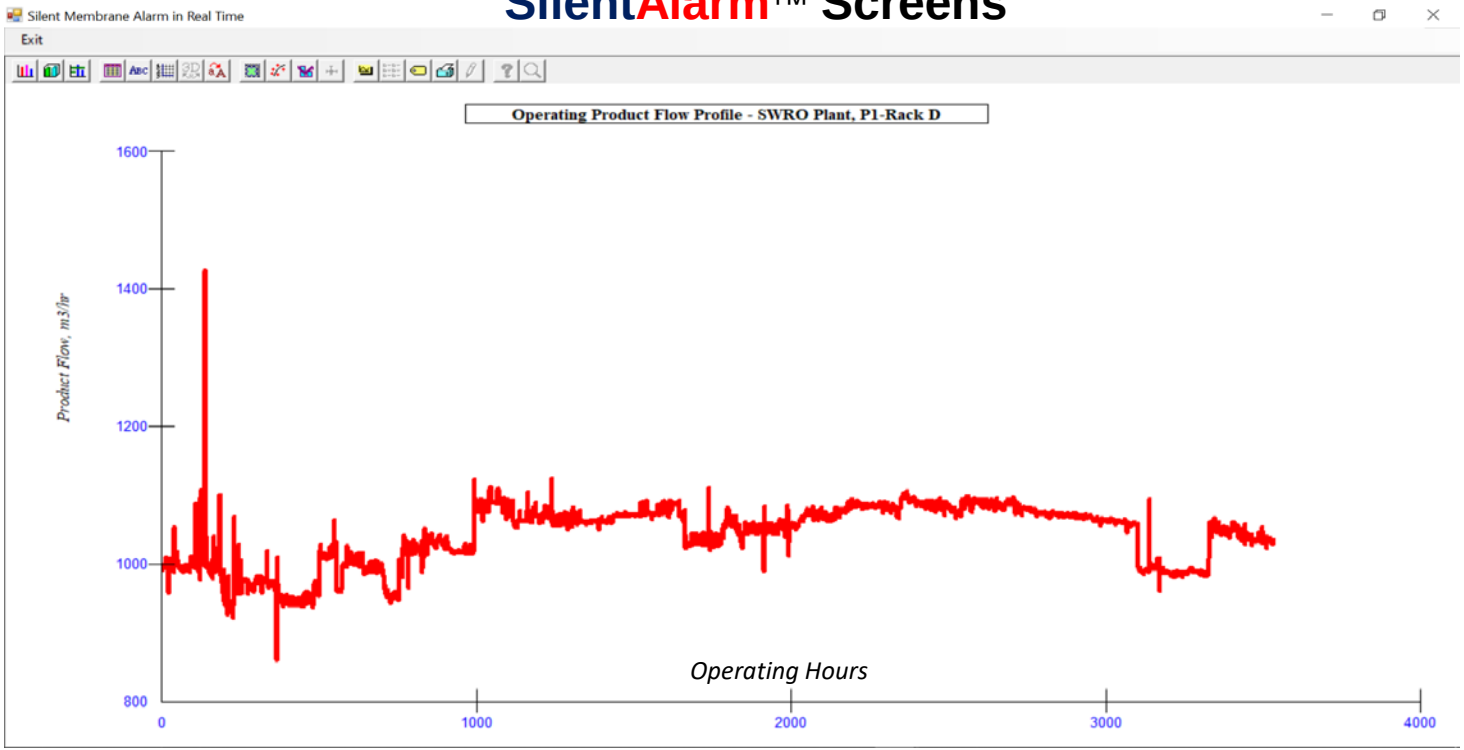
SilentAlarm™ Screens

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
1	Wednesday, April 11, 2018	1	33.1	56	57.2	1168	991	1	963	45.9	1736
2	Wednesday, April 11, 2018	2	33.1	56	57.2	1164.4	997.8	1	961	46.1	1736
3	Wednesday, April 11, 2018	3	33	56	57.2	1162.8	998.3	1	963	46.2	1736
4	Wednesday, April 11, 2018	4	32.9	56	57.3	1158.4	996	1	959	46.2	1736
5	Wednesday, April 11, 2018	5	33	56	57.4	1154.7	993.1	1	969	46.2	1736
6	Wednesday, April 11, 2018	6	33.2	54	57.4	1161.7	1000.6	1	964	46.3	1736
7	Wednesday, April 11, 2018	7	33.4	56	57.8	1163	998.1	1	973	46.2	1736
8	Wednesday, April 11, 2018	8	33.5	56	57.6	1170.4	997.9	1	962	46	1736
9	Wednesday, April 11, 2018	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	1	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

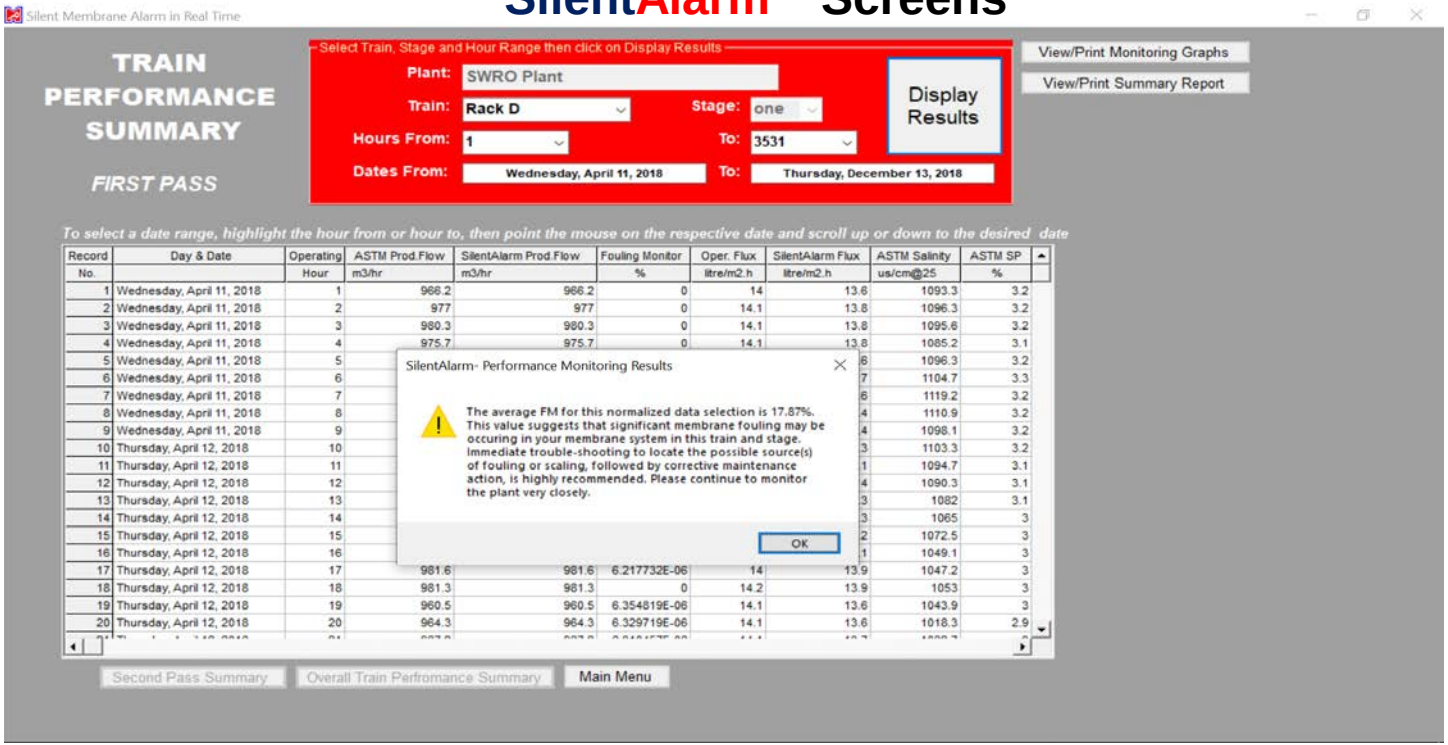
SilentAlarm™ Screens



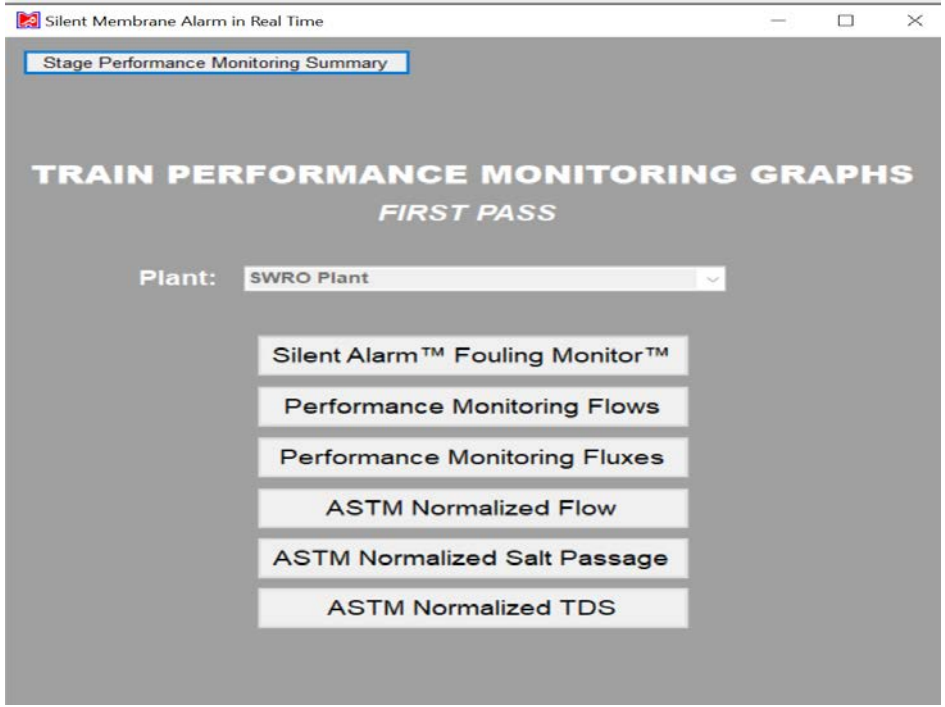
SilentAlarm™ Screens



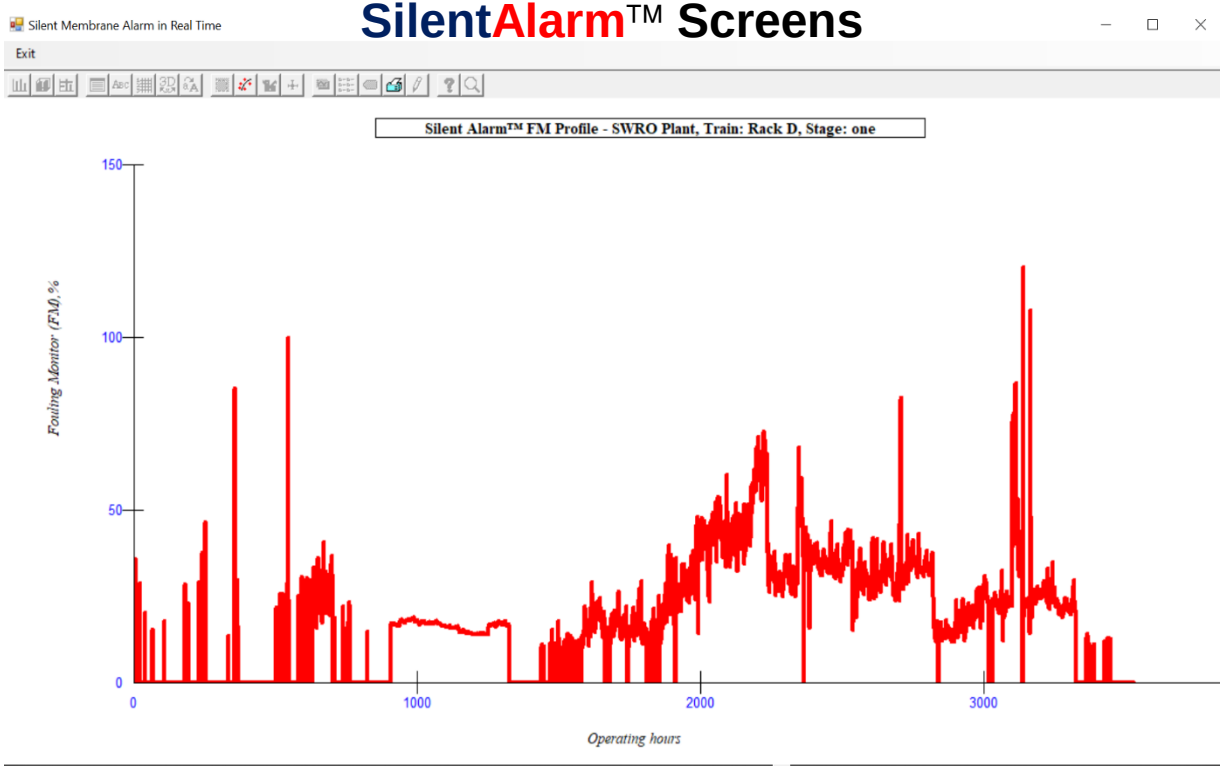
SilentAlarm™ Screens



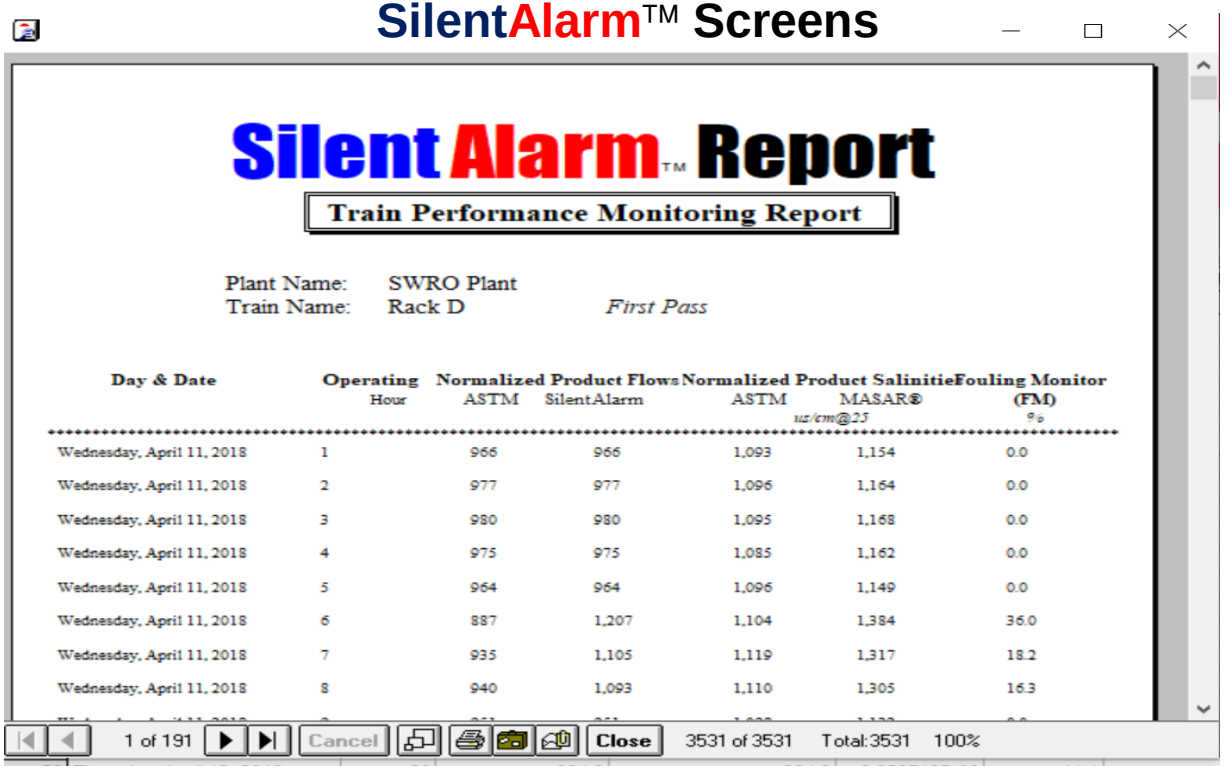
SilentAlarm™ Screens



SilentAlarm™ Screens



SilentAlarm™ Screens



Silent Alarm™ Report

Train Performance Monitoring Report

Plant Name: SWRO Plant
Train Name: Rack D *First Pass*

Day & Date	Operating Hour	Normalized Product Flows ASTM	Normalized Product Flows SilentAlarm	Normalized Product Salinitie ASTM	Normalized Product Salinitie MASAR® µs/cm@25	Fouling 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 of 191 Cancel Close 3531 of 3531 Total:3531 100%

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.

SilentAlarm™ Testimonials

- 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
Permasep® Products
Glasgow – Building 200
P. O. Box 6101
Newark, DE 19714

DuPont Fabrics & Separations

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

October 27, 1998

Subject: MASAR™ Software

Dear Mr. Saad,

Our Permasep® Products technical personnel have completed their evaluation of your MASAR™ Membrane Analysis System and Automated Reporter™ software, which is used to normalize RO data and monitor plant performance. They agree with your findings, that MASAR™, 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.

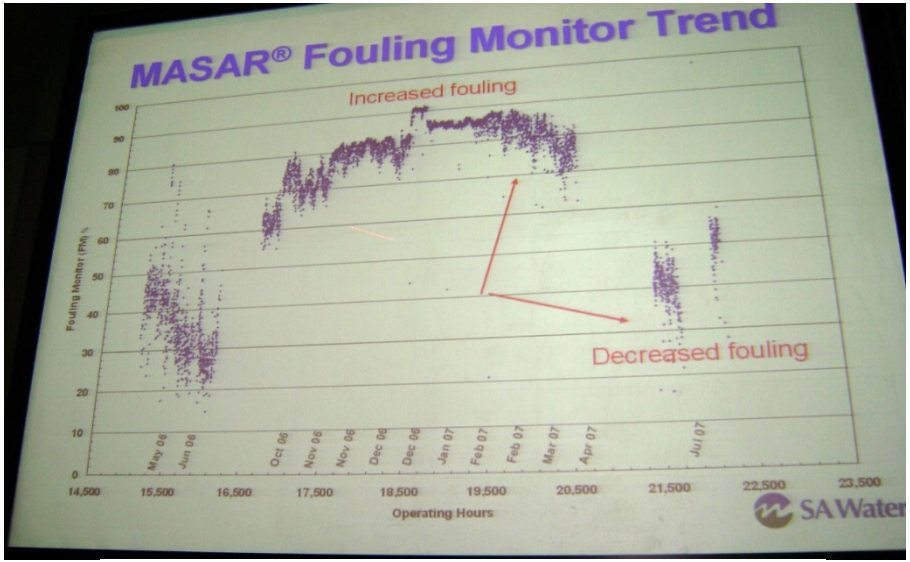
Permasep® Products approves and recommends the use of your MASAR™ software technology applied to RO plants using our membrane products.

Sincerely,

K.G.White
Product Manager
Permasep® Products

SilentAlarm™ Testimonials

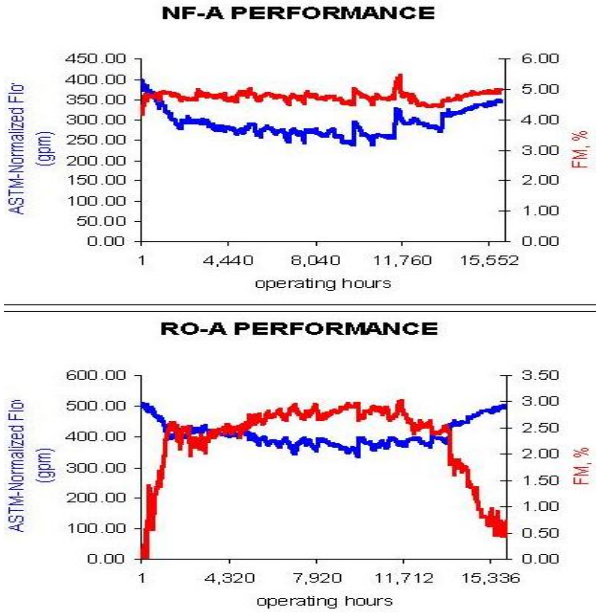
- Analysis of process performance data was performed using a proprietary software package, MASAR®, procured from MASAR Technologies, USA (www.masar.com). The software was custom-designed for **South Australia Water Corp**.'s Penneshaw SWRO plant, based upon its configuration. **MASAR®** ***is able to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



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

SilentAlarm™ Testimonials

- 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®** software.



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™ 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™" 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

GET SMART

https://masar.com/technology

SILENT MEMBRANE ALARM in REAL TIME TECHNOLOGY