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Benefits of high flux thin-film nanocomposite low surface area reverse osmosis elements

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GECAMIN
Conferences for Mining

LG NanoH_2O - Overview

- Licensed original technology in 2005 from University of California, Los Angeles
- Intellectual property includes 43 patents and patent applications
- Headquarters, manufacturing and R&D facility located in Los Angeles, California, USA
- Approximately 100 employees
- Membranes installed in over 400 plants across 40 countries, producing more than 300,000 cubic meters per day of fresh water
- **In April 2014, LG Chem acquired NanoH_2O**

LG NanoH2O

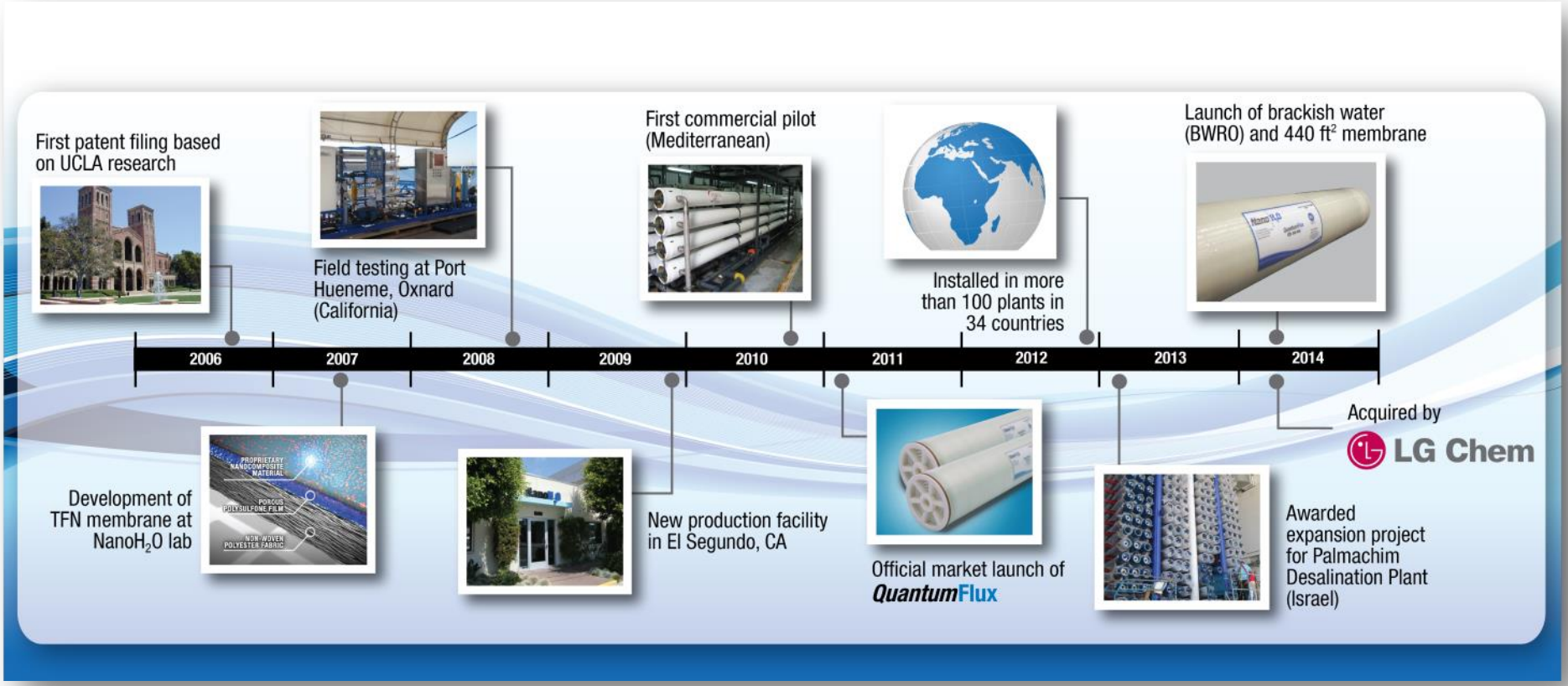
LG Chem - Overview

- LG Chem, founded in 1947, is ranked in the TOP 3 of the largest chemical companies in Asia and 13th globally*
- Headquartered in Seoul, Korea, with annual revenues of $22 billion (USD)
- 22,000 employees across 30 global subsidiaries, representative offices and R&D centers
- LG Chem is a market leader in film and coating technology with mass production know-how
- LG NanoH_2O will accelerate RO membrane product development, production capacity and global commercial presence

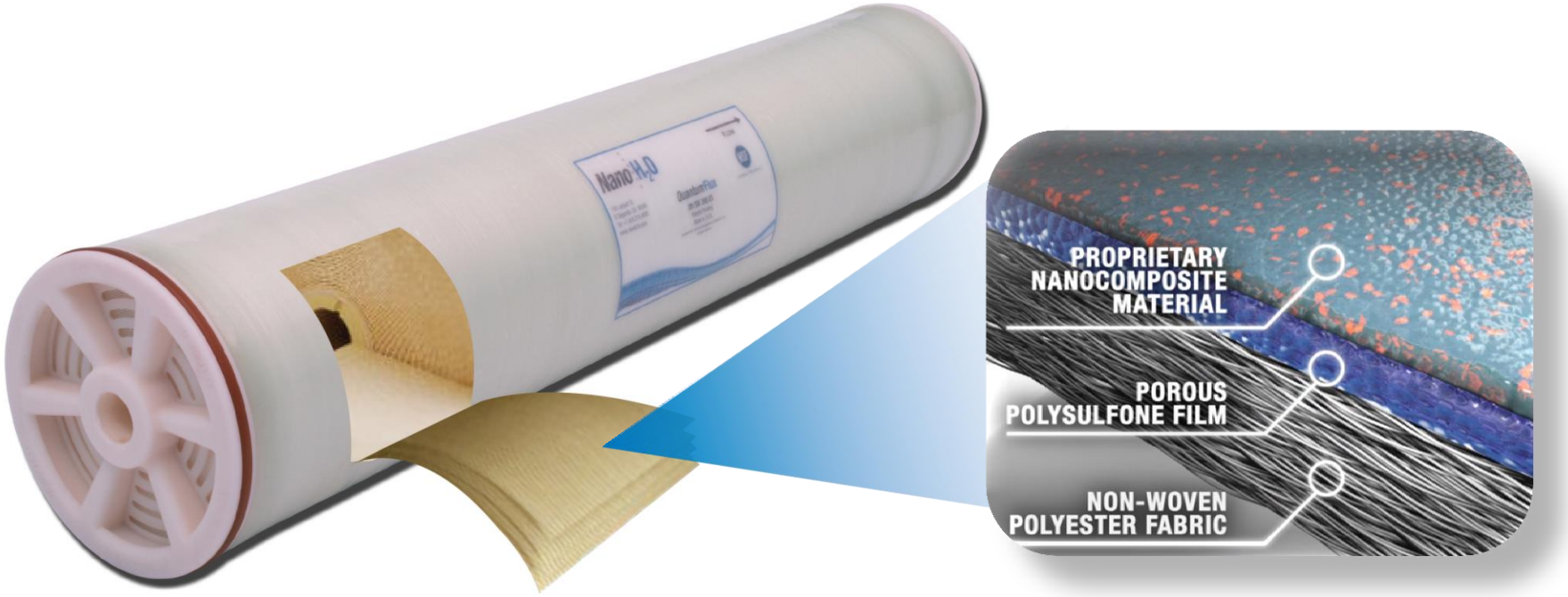
LG Chem

*Source: ICIS (www.icis.com, 2013)

Company Timeline

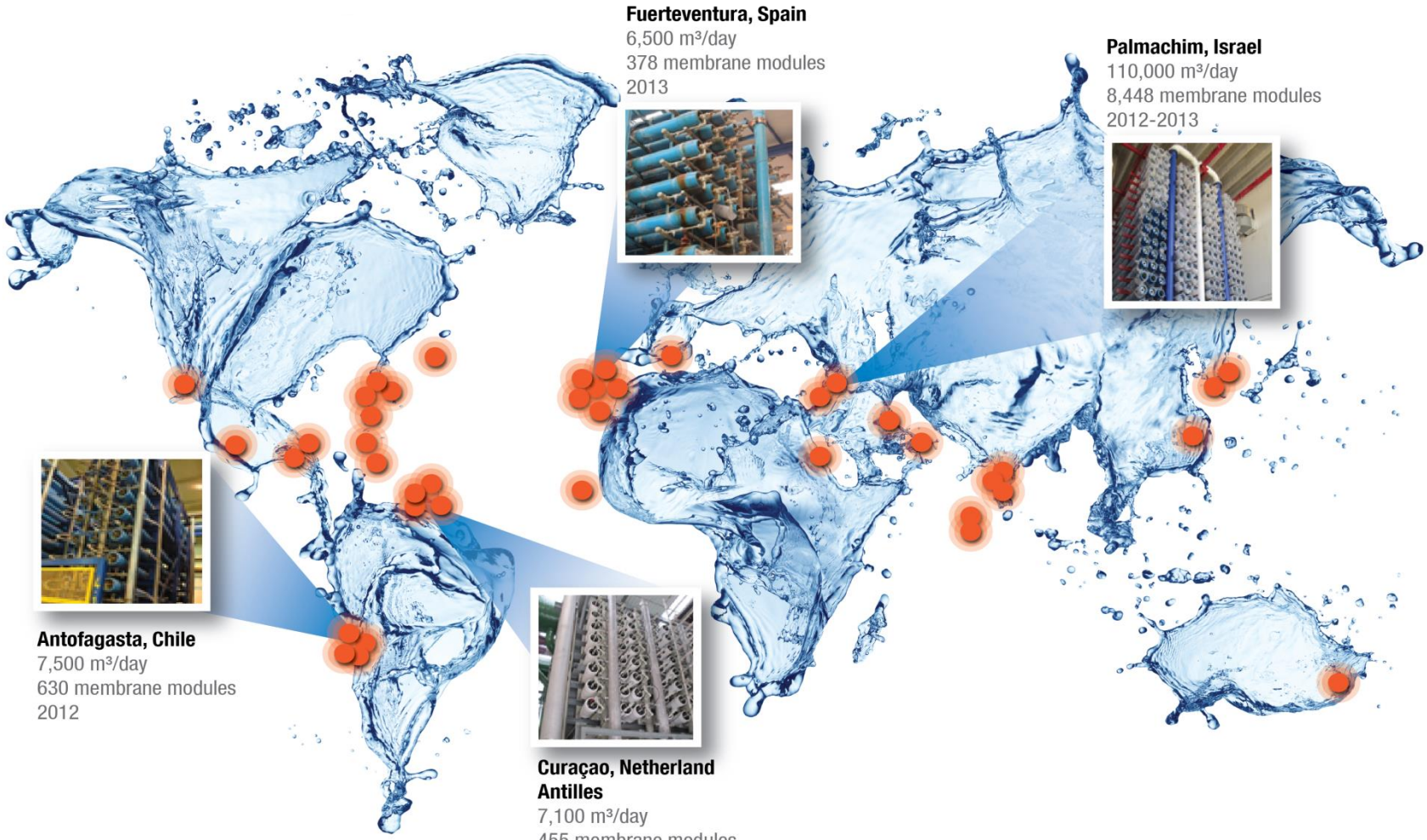


Thin-Film Nanocomposite Membrane Technology



- ✓ First RO membrane innovation in 25 years
- ✓ 50-100% more permeable than existing polymer technology
- ✓ Improves best-in-class salt rejection
- ✓ Drop-in replacement for existing membranes
- ✓ 16 Patents / 27 Applications in 11 Countries

Proven Technology



*Quantum*Flux Product Line

Product Specifications	Qfx SW 400 ES	Qfx SW 400 R	Qfx SW 400 SR
Permeate Flow Rate, m^3/d (gpd)	52 (13,700)	34 (9,000)	24.6 (6,500)
Minimum NaCl Rejection, %	99.7	99.75	99.75
Stabilized NaCl Rejection, %	99.8	99.85	99.85
Active Membrane Area, m^2 (ft^2)	37 (400)	37 (400)	37 (400)
Feed Spacer, mil	28	28	28
Stabilized Boron Rejection: %	89	93	93

Performance differentiation of the membrane enables energy savings, OR flux increase, OR enhanced water quality

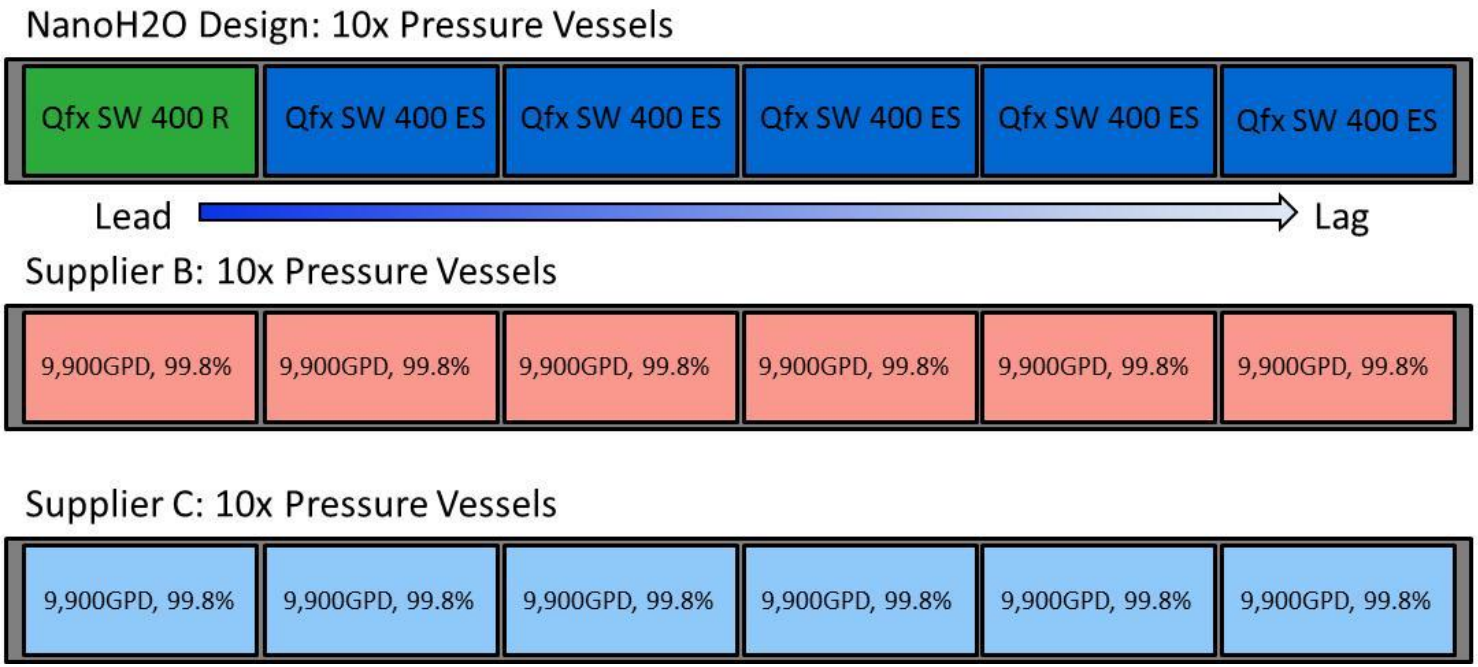
La Chimba Desalination Plant - Antofagasta, Chile

- Background:
  - To increase plant capacity, AWT installed high flux thin-film nanocomposite (TFN) elements in one existing train, and another manufacturer's membranes in five other existing trains.
  - AWT also added three new 1,000 m^3/d skids (provided through Xylem) each equipped with 60 elements supplied by LG NanoH_2O, Supplier B and Supplier C and utilize the existing intake and pre-treatment systems.
  - Pretreatment: 20 sand filters and 8 cartridge filters.

Study Objective:

- To assess the benefits of utilizing high flux 400 ft^2 TFN SWRO elements in an appropriate array compared to industry standard 440 ft^2 element arrays

Pressure Vessel Array Comparison



- Flux 18.7 LMH (11 gfd) for LG NanoH_2O Qfx Elements
- Flux 17 LMH (10 gfd) for Supplier B and C

Competitive Comparison - Pressure

- Utilizing high flux membranes appropriately, delivers significant pressure savings over standard higher flux (9,900 gpd) membrane array designs

- Percent Performance Deviation Based on Pumping Pressure Required

% Deviation		
Temp	Supplier B	Supplier C
14° C (57° F)	9.5%	8.3%
21° C (70° F)	5.2%	7.0%

Element Loading

Competitive Comparison

Supplier		TFN Hybrid	Supplier B	Supplier C
Input				
Est. RO Feed TDS	ppm	36,105	36,105	36,105
Temp	°C	20	20	20
Year of operation		0	0	0
Permeate	m^3/h (gpm)	39.9 (175.4)	39.6 (174.2)	39.4 (160)
Recovery based on flows		43.4%	43.3%	41.6%
Design				
Element Specification		34m^3/day, 99.75-99.85	37.5 m^3/day	37.5 m^3/day
Element Specification		52m^3/day, 99.7-99.8	99.6-99.8%	99.5-99.8%
# PV per Stage		10	10	10
# Element per PV		6	6	6
Permeate Back Pressure	Bar (psi)	1.4 (20)	1.4 (20)	1.4 (20)
Output				
Est. Product TDS	ppm	228	125	140
Feed Pressure	Bar (psi)	46.7 (686)	52.3 (769)	54.4 (800)

Why is the permeate TDS higher?

- Feed solution becomes more concentrated along the pressure vessel and a greater salt transport rate is experienced.

$$Q_s = B \times S \times \Delta C$$

$$\Delta C = C_b - C_p$$

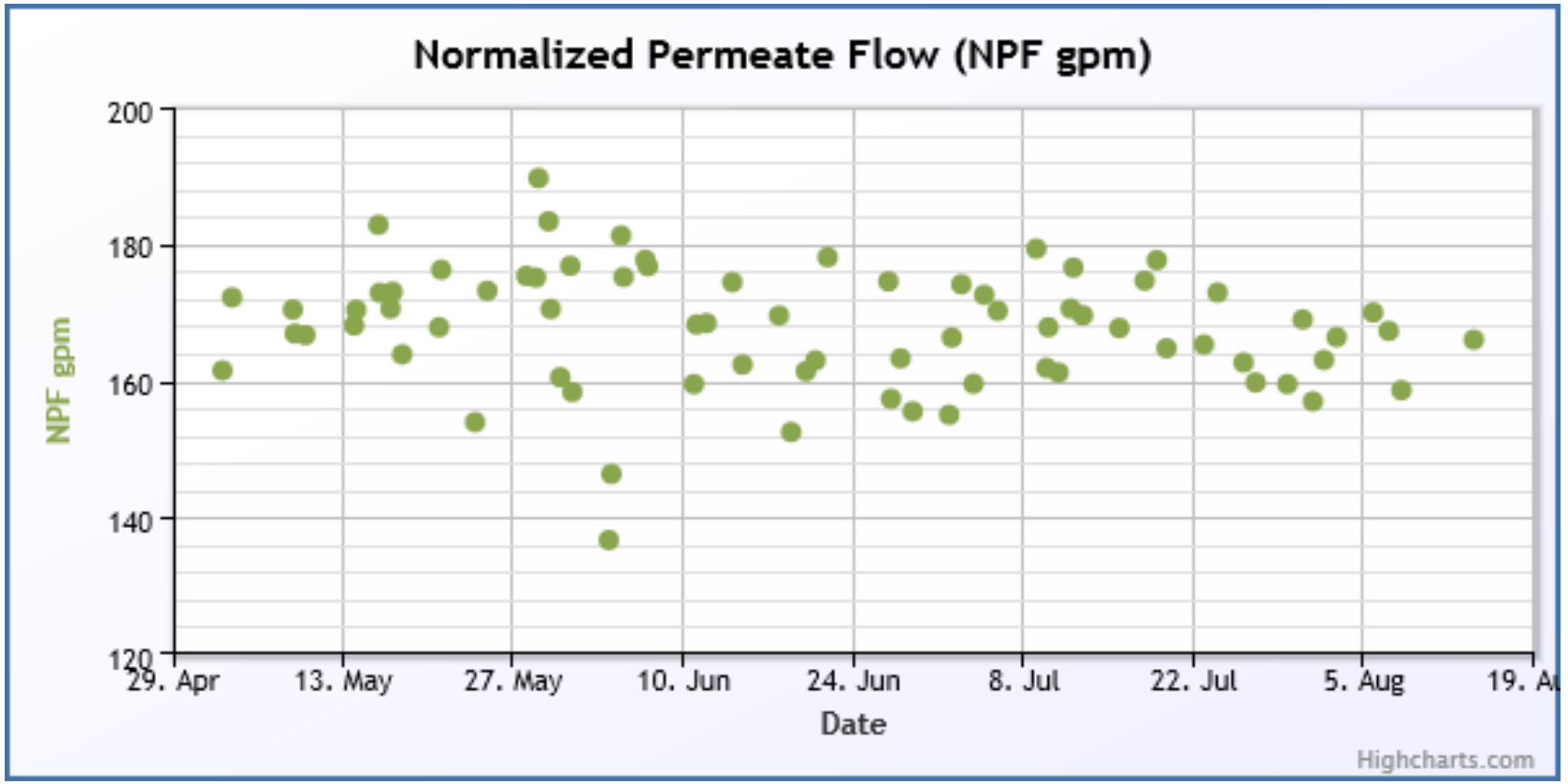
Salt transport rate (Q_s)
Salt transport coefficient or B-value (B)
Surface area (S)
Change in Salt concentration (ΔC)

Feed salt concentration (C_b)
Permeate salt concentration (C_p).

- This shows that as more water permeates the membrane with a high flux element C_b increases along the pressure vessel.

- To minimize this effect, the Qfx SW 400 ES has the highest possible element rejection at its given flow (or the lowest possible B value).

La Chimba – LG NanoH_2O Train



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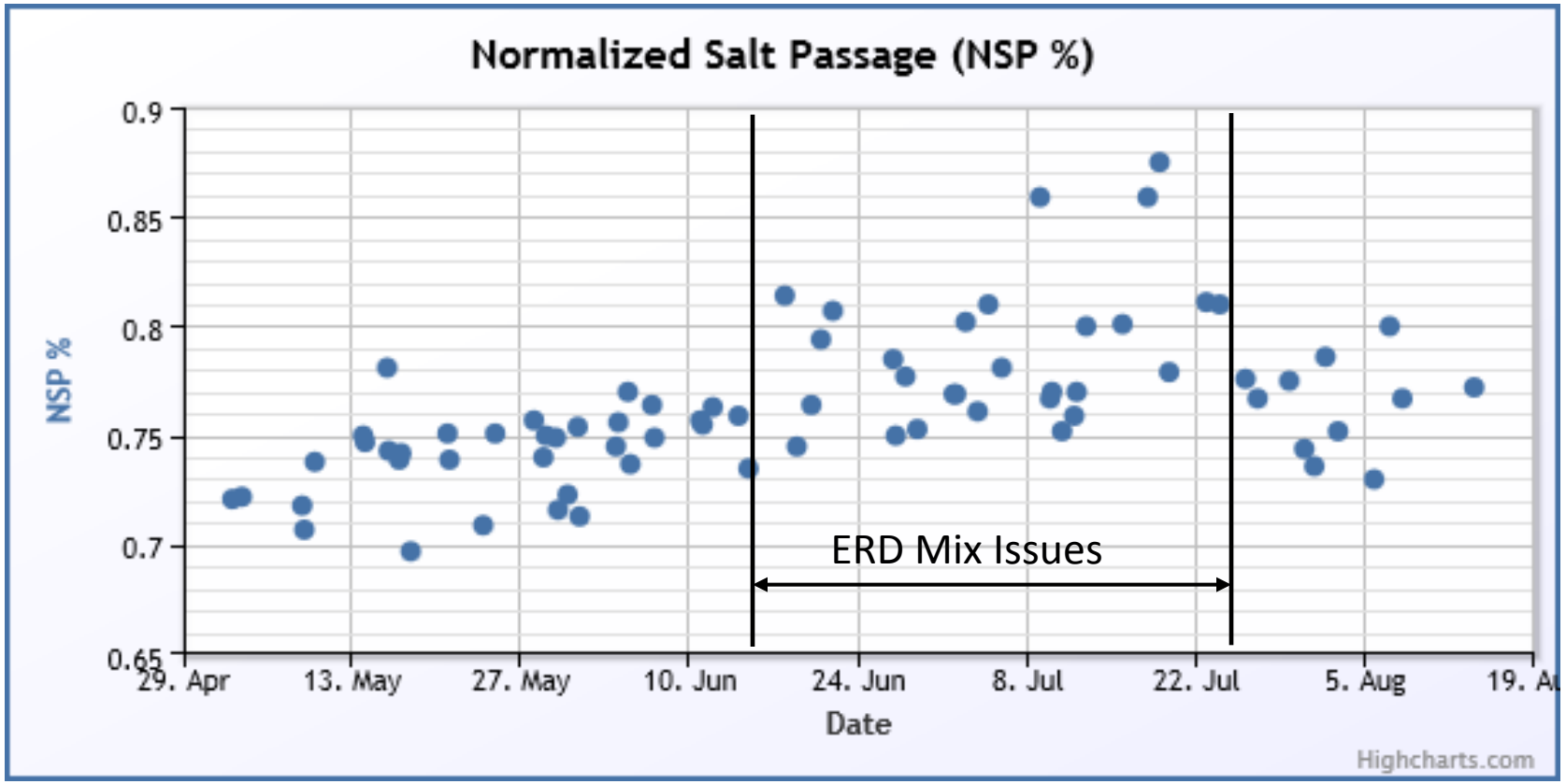
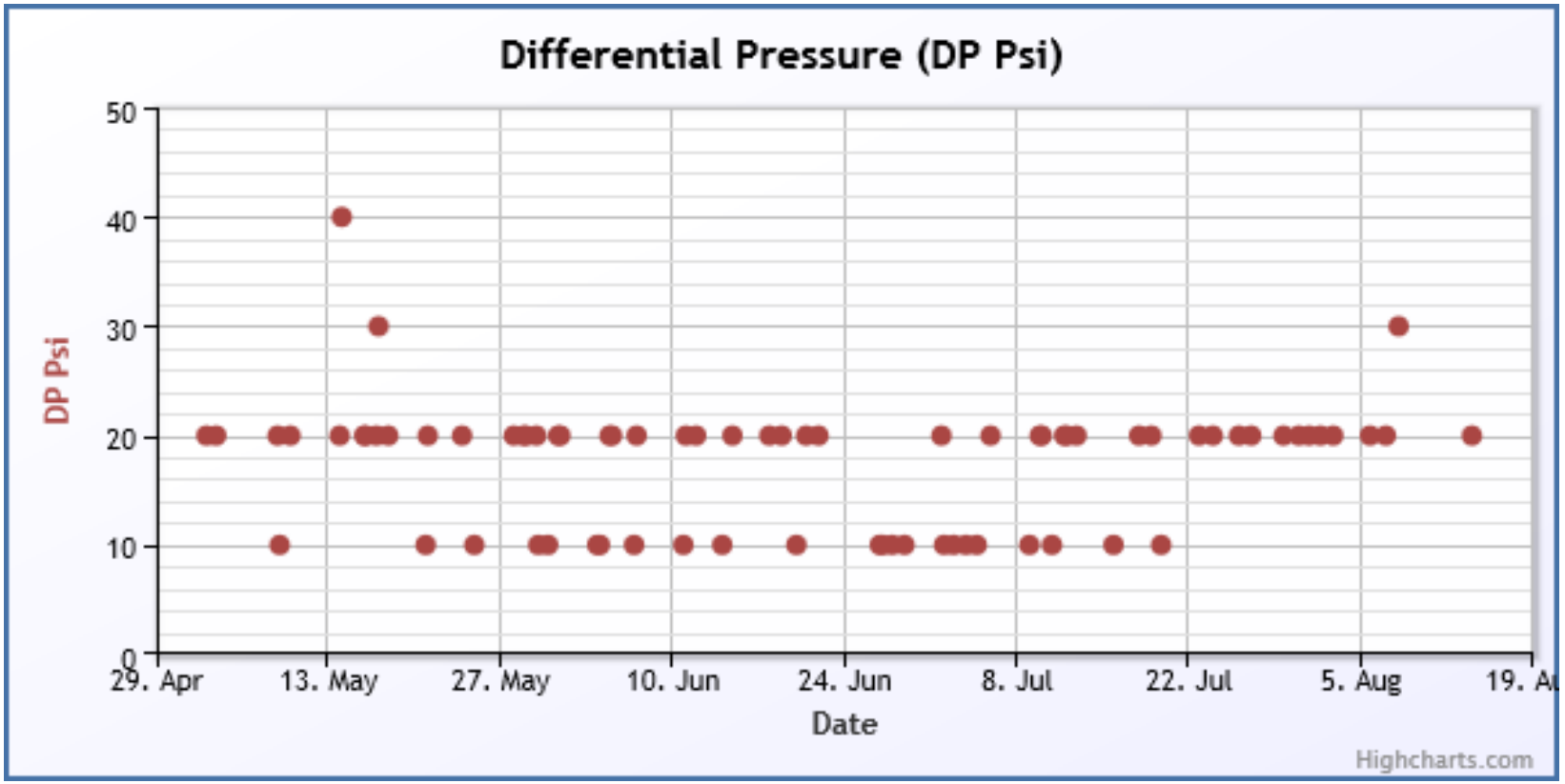


La Chimba – LG NanoH_2O Train



Summary

- LG NanoH_2O has progressed from the lab scale to become a globally recognized membrane manufacturer delivering low energy solutions for major desalination plants

- Use of high flux membranes provided up to 14% improvement in feed pressure over commonly used standard membrane array designs

- As expected, there is a trade-off between lower feed pressure and higher permeate quality (due to high flux membranes) that meets specification

- Field results showed stable permeate production and normalized salt passage without increase in differential pressure.

- Using 400 ft^2 high flux elements in a hybrid design can lower pump pressure compared to 440 ft^2 standard flux elements