

Minimizing Water Footprint by Implementing Semi-Batch Reverse Osmosis

Arizona Water Reuse 2015

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Presenter: Michael Boyd



Agenda

- The State of Water
- Multistage Reverse Osmosis
- Simple or Dead-End Filtration
- Closed-Circuit Desalination™
- ReFlex™ Product Line
- Case Studies
- Questions & Answers

The State of Water

The World is
Running Out of
Water

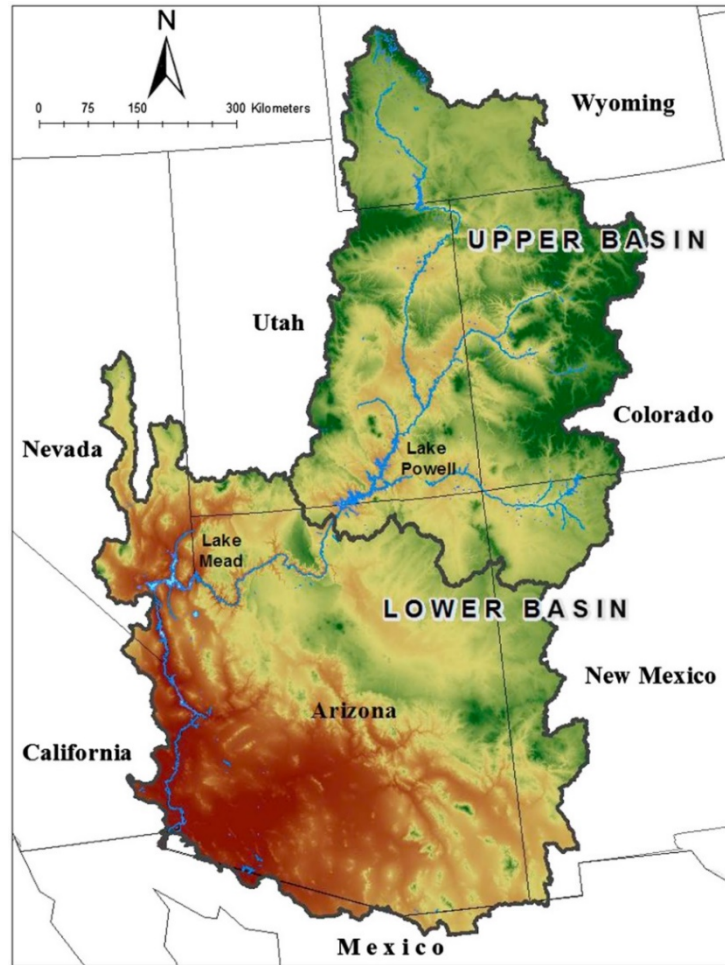
- Population growth, rising economies and climate change are accelerating the demand for water globally.
- **New sources** of water are needed today.
- Desalination and reuse are the only sustainable water resources.

Industrial &
Municipal
Consumption
Accounts for 70% of
Freshwater
Withdrawals in
Developed
Economies

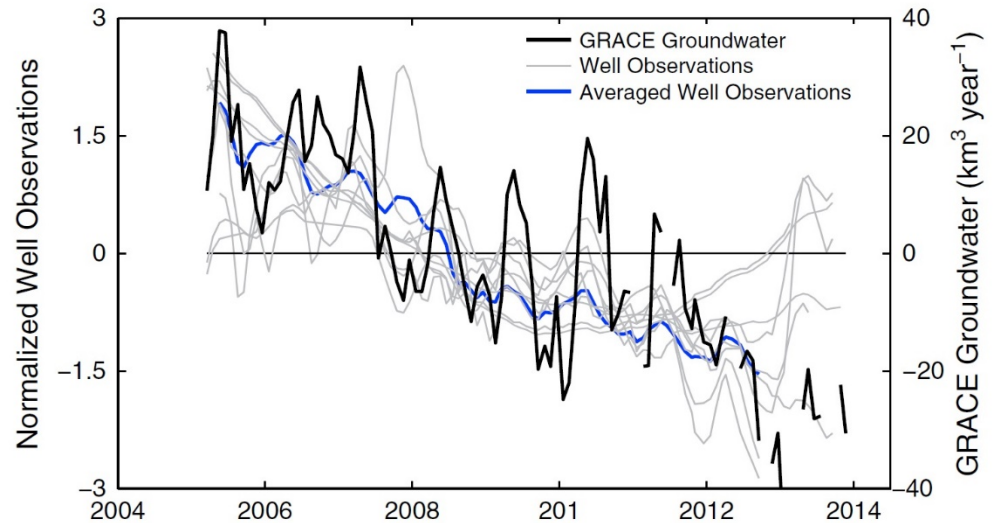
- By 2050, residential water consumption will increase 2X, while industrial water consumption will increase 5X.
- Wastewater disposal can account for up to 80% of the total cost of ownership of a water treatment plant.
- In many industrial plants, water resources limit the maximum achievable output for production.
- **High efficiency** water treatment and reuse are the inevitable future of the industry.

The Agricultural Industry Accounts for the Other 30% of Freshwater Withdrawals

The State of Water



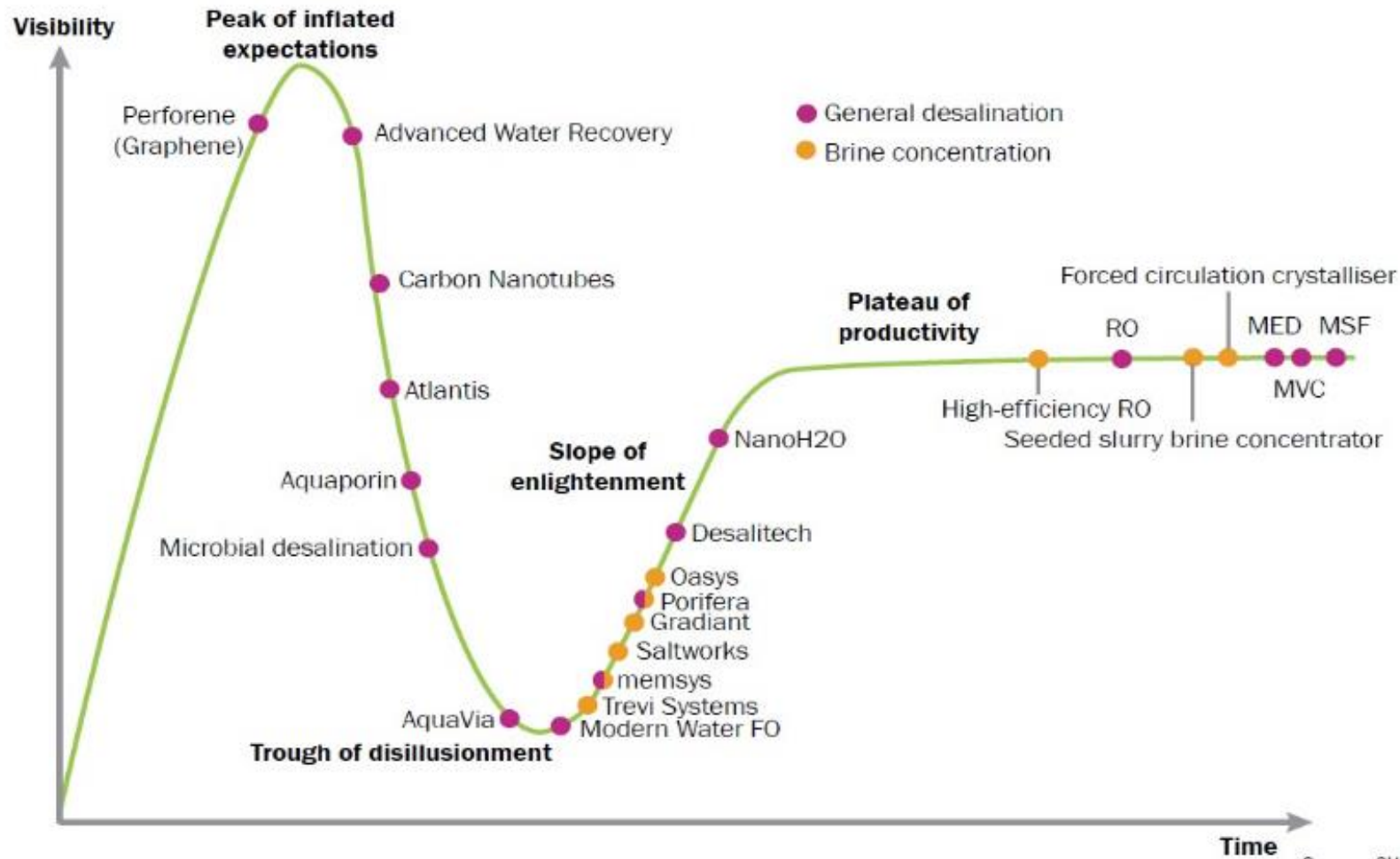
AGU Geophysical Research Letters



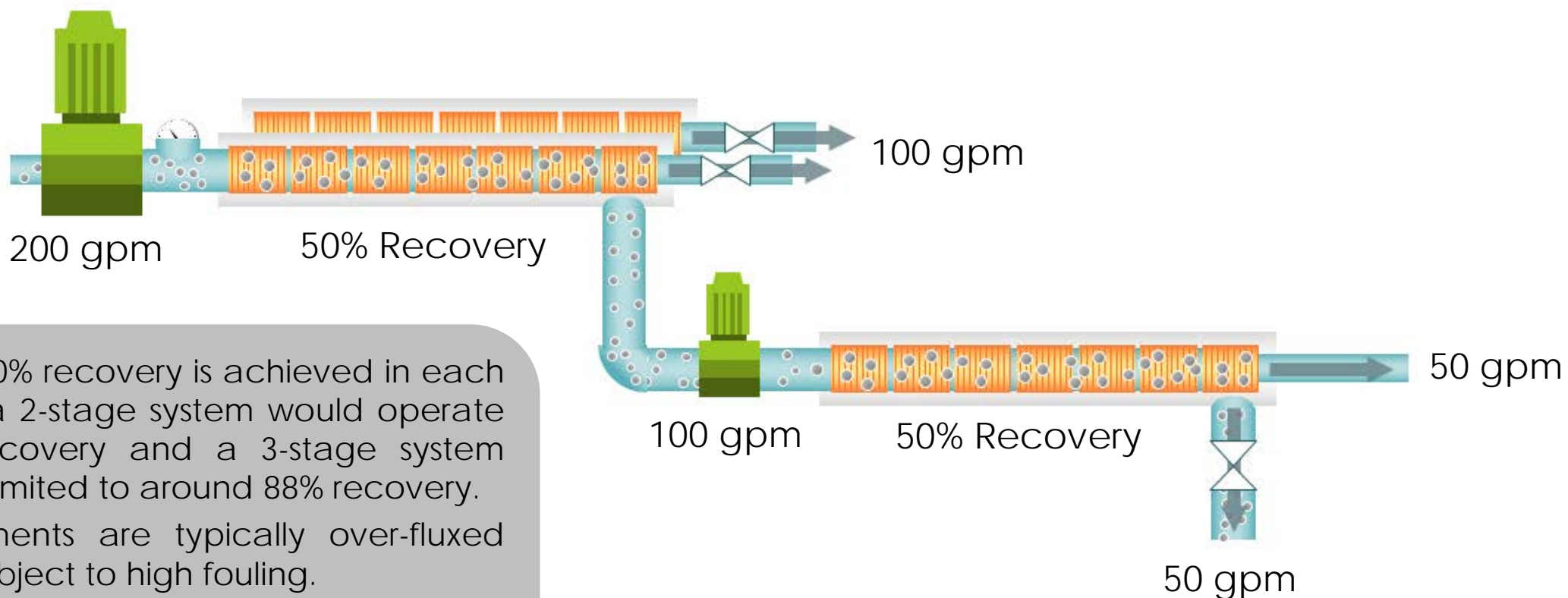
"We find that during the 108 month study period, the entire Colorado River Basin lost a total of 64.8 km^3 of freshwater with a more severe rate of loss since February 2010..."

We hope that the heightened awareness of the rates of the Basin groundwater depletion highlighted here will foster urgent discussion on conjunctive management solutions required to ensure a sustainable water future for the Colorado River Basin and for the western United States."

The State of Water



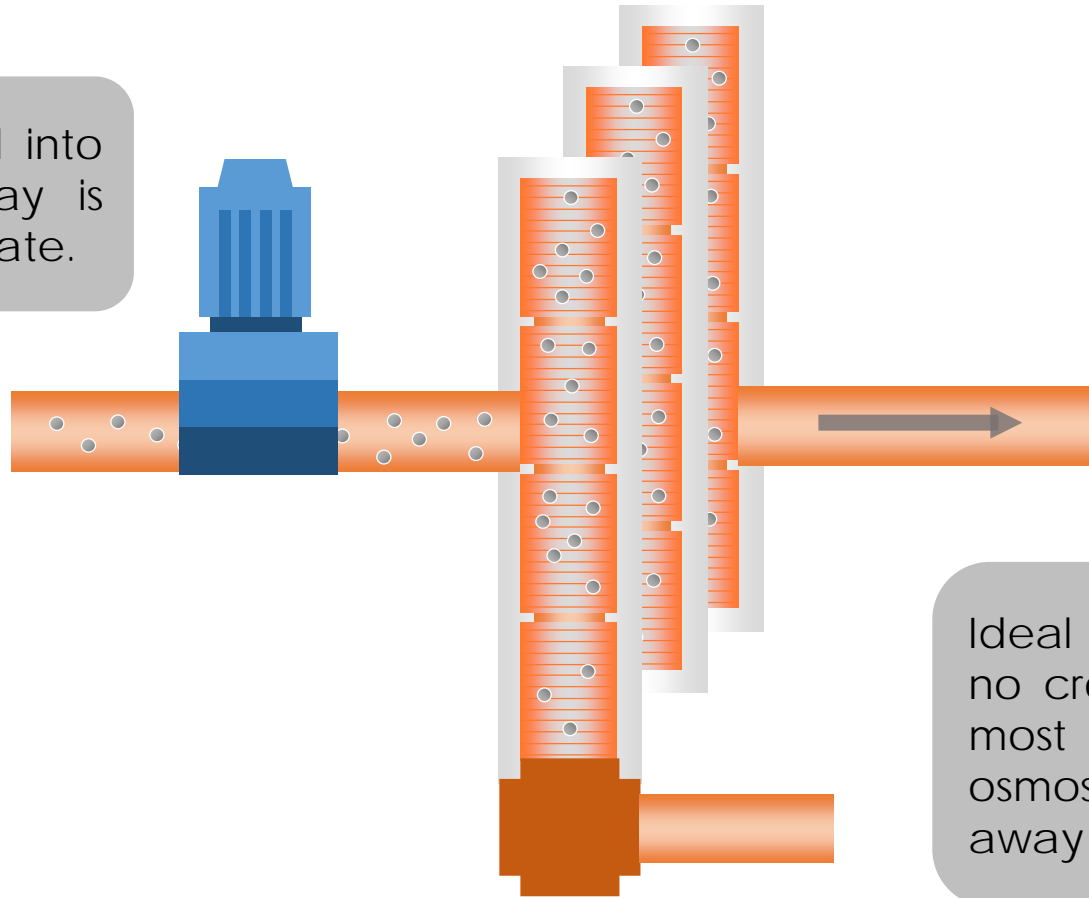
Multi-Stage Reverse Osmosis



- Typically 50% recovery is achieved in each stage, so a 2-stage system would operate at 75% recovery and a 3-stage system would be limited to around 88% recovery.
- Lead elements are typically over-fluxed and are subject to high fouling.
- Tail elements are subject to low cross-flows and high salinity concentrations, making them highly susceptible to scaling.

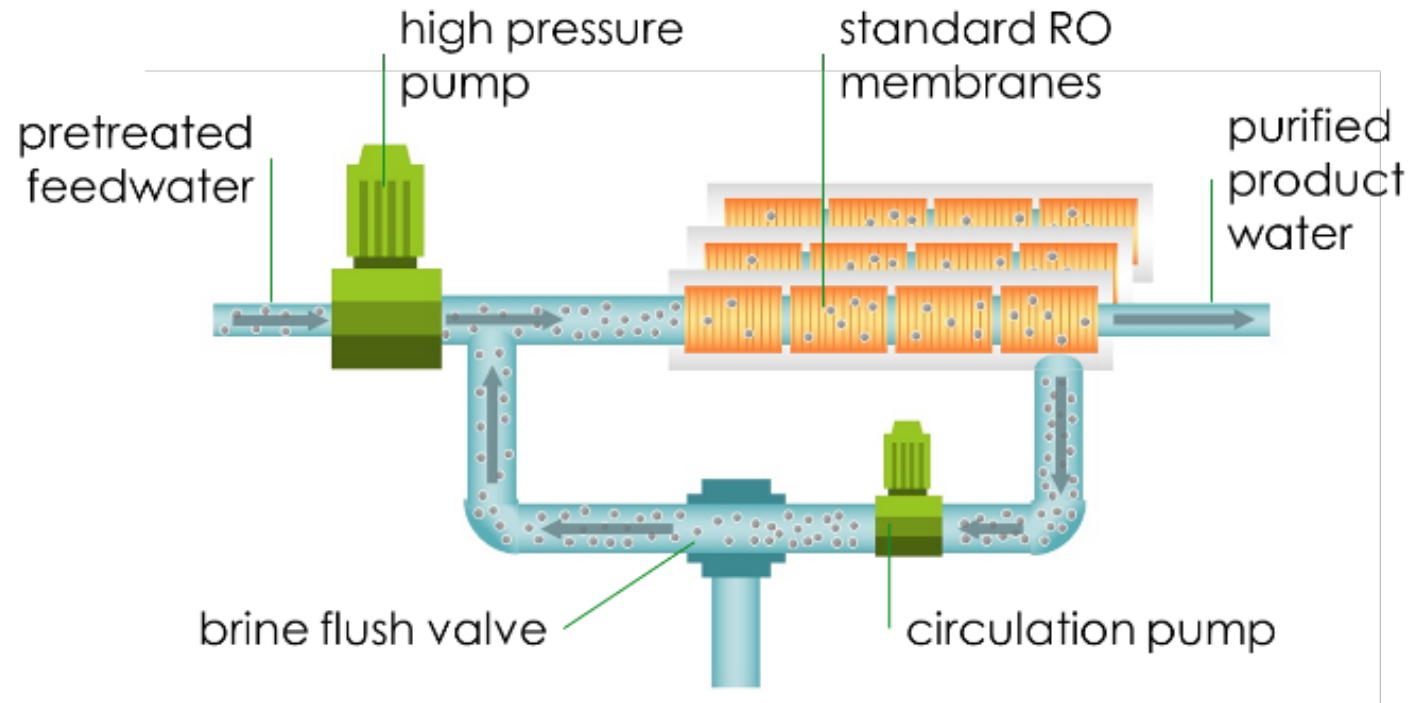
Simple or Dead End Filtration

All of the water fed into the membrane array is recovered as permeate.



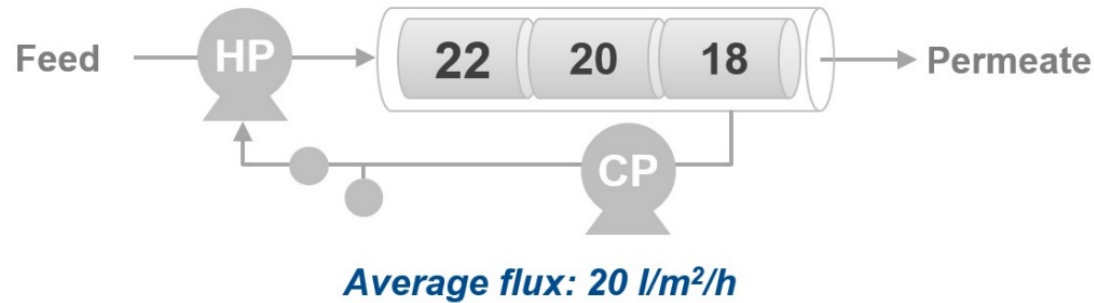
Ideal for high recovery, but provides no crossflow. Crossflow is one of the most important principles in reverse osmosis as this is what sweeps the salts away from the membrane surface.

Closed-Circuit Desalination (CCD™)



- Recoveries from 75%-98% set at the control panel, independent of flux and crossflow.
- Fouling/scaling limited by normalized flux distribution and higher cross-flows independently controlled by a circulation pump.
- Up to 35% reduction in energy as compared to a conventional RO operating at the same recovery.

Closed-Circuit Desalination (CCD™)



- Reduces Lead Element Flux
- Reduces Cleaning Frequency
- Increases Membrane Life

- Allows for Higher Average Flux
- Better Utilization of Tail Elements
- Increases System Output

ReFlex™ Product Line



Standard off-the-shelf membranes from industry-leading suppliers, approved for use in ReFlex products.

Permeate/Clean in Place (CIP) tank



Manufactured and assembled in the USA.

Control Panel – Automatically controls and monitors system performance, and provides full internet connectivity.

ReFlex™ Product Line

MODEL	ReFlex 50	ReFlex 100	ReFlex 150	ReFlex 200
Average Permeate Flow	72,000 gpd 50 gpm 11 m³/h	144,000 gpd 100 gpm 23 m³/h	216,000 gpd 150 gpm 34 m³/h	288,000 gpd 200 gpm 45 m³/h
Maximum Permeate Flow	108,000 gpd 75 gpm 17 m³/h	201,600 gpd 140 gpm 32 m³/h	273,600 gpd 190 gpm 43 m³/h	403,200 gpd 280 gpm 64 m³/h
Pumps and Motors				
<u>High Pressure Pump</u>				
Motor Power and Type	20 HP (15 kW) TEFC	40 HP (30 kW) TEFC	60 HP (45 kW) TEFC	60 HP (45 kW) TEFC
Design Flow Rate	68 gpm (16 m³/h)	132 gpm (30 m³/h)	182 gpm (41 m³/h)	227 gpm (52 m³/h)
Design boost pressure	297 psi (21 bar)	377 psi (26 Bar)	348 psi (25 bar)	235 psi (16 bar)
<u>Circulation pump</u>				
Motor Power and type	4 HP (3 kW) TEFC	10 HP (7.5 kW) TEFC	20 HP (15 kW) TEFC	25 HP (18.6 kW) TEFC
Design Flow Rate	101 gpm (23 m³/h)	194 gpm (44 m³/h)	308 gpm (70 m³/h)	396 gpm (90 m³/h)
Design boost pressure	30 psig (2 bar)	30 psi (2 bar)	30 psi (2 Bar)	30 psi (2 bar)
<u>Booster pump (optional)</u>				
Motor Power and type	7.4 HP (5.5 kW) TEFC	14.75 HP (11 kW) TEFC	14.75 HP (11 kW) TEFC	40 HP (30 kW) TEFC
Design Flow Rate	68 gpm (16 m³/h)	132 gpm (30 m³/h)	209 gpm (48 m³/h)	227 gpm (52 m³/h)
Design boost pressure	116 psi (8 bar)	102 psi (7 bar)	87 psi (6 bar)	116 psi (8 bar)
Membrane Elements and Housings				
Element Quantity	12	20	32	40
Element Size	8 inch, 440 ft²	8 inch, 440 ft²	8 inch, 440 ft²	8 inch, 440 ft²
Housing Quantity	3	5	8	10
Housing Type	5 elements, 4 ports	5 elements, 4 ports	5 elements, 4 ports	5 elements, 4 ports
Cartridge Filtration				
Housing Quantity	1	1	1	1
Cartridge Filter Rating	1 micron	1 micron	1 micron	1 micron
Cartridge Filter Length	30"	30"	30"	30"
Cartridge Filter Qty	7	12	19	25
Installation and Utility Requirements				
Inlet	2" Flange	3" Flange	4" Flange	4" Flange
Permeate	2" Flange	3" Flange	3" Flange	4" Flange
Concentrate	2" Flange	3" Flange	4" Flange	6" Flange
Inlet Water Pressure	10-60 psi	10-60 psi	10-60 psi	10-60 psi
Drain to be Sized for	70 gpm (16 m³/h)	116 gpm (26 m³/h)	186 gpm (42 m³/h)	233 gpm (53 m³/h)
Power	60Hz, 480VAC, 3Φ	60Hz, 480 VAC, 3 ph	60Hz, 480VAC, 3Φ	60Hz, 480VAC, 3Φ
Control Circuit	24 VDC	24 VDC	24 VDC	24 VDC
Amperage Requirements	50	90	130	155
Footprint and Weight				
Width	232" (590 cm)	232" (590 cm)	232" (590 cm)	232" (590 cm)
Depth	65" (165 cm)	65" (165 cm)	73" (185 cm)	73" (185 cm)
Height	83" (210 cm)	92" (234 cm)	89" (225 cm)	92" (234 cm)
Weight w/o Membranes	4,000 lb (1,800 kg)	5,000 lb (2,300 kg)	7,500 lb (3,400 kg)	9,000 lb (4,000 kg)
Weight of Membranes	500 lb (250 kg)	700 lb (300 kg)	1,200 lb (550 kg)	1,500 lb (700 kg)
Wet Weight	5,000 lb (2,300 kg)	7,000 lb (3,200 kg)	10,500 lb (4,700 kg)	12,800 lb (5,800 kg)

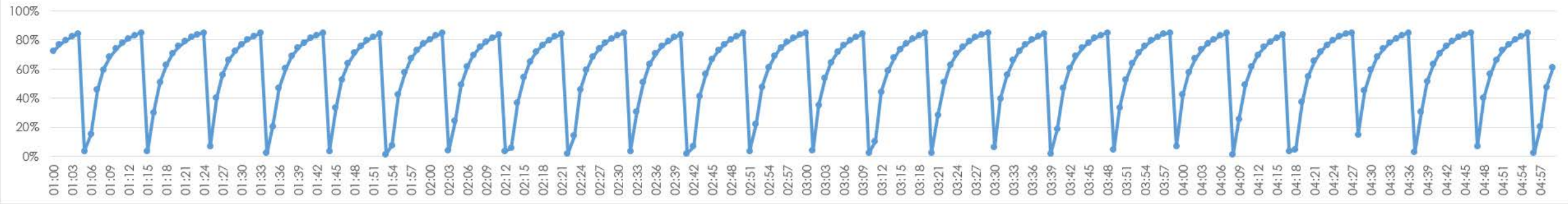
MODEL	ReFlex 300	ReFlex 450	ReFlex 600	ReFlex 900
Average Permeate Flow	432,000 gpd 300 gpm 68 m³/h	648,000 gpd 450 gpm 102 m³/h	863,000 gpd 600 gpm 136 m³/h	1,294,474 gpd 900 gpm 204 m³/h
Maximum Permeate Flow	504,000 gpd 350 gpm 79 m³/h	807,000 gpd 560 gpm 127 m³/h	1,008,000 gpd 700 gpm 159 m³/h	1,614,000 gpd 1,120 gpm 255 m³/h
Pumps and Motors				
<u>High Pressure Pump</u>				
Motor Power and Type	100 HP (75 kW) TEFC	150 HP (110 kW) TEFC	200 HP (150 kW) TEFC	300 HP (220 kW) TEFC
Design Flow Rate	341 gpm (78 m³/h)	487 gpm (110 m³/h)	650 gpm (150 m³/h)	974 gpm (221 m³/h)
Design boost pressure	271 psi (19 bar)	200 psi (14 bar)	210 psi (15 bar)	200 psi (14 bar)
<u>Circulation pump</u>				
Motor Power and type	25 HP (18.6 kW) TEFC	37.5 HP (27 kW) TEFC	50 HP (37 kW) TEFC	75 HP (55 kW) TEFC
Design Flow Rate	528 gpm (120 m³/h)	595 gpm (135 m³/h)	794 gpm (180 m³/h)	1190 gpm (270 m³/h)
Design boost pressure	30 psi (2 bar)	30 psi (2 bar)	30 psi (2 bar)	30 psi (2 bar)
<u>Booster pump (optional)</u>				
Motor Power and type	40 HP (30 kW) TEFC	60 HP (45 kW) TEFC	80 HP (60 kW) TEFC	120 HP (90 kW) TEFC
Design Flow Rate	341 gpm (78 m³/h)	487 gpm (110 m³/h)	650 gpm (150 m³/h)	974 gpm (221 m³/h)
Design boost pressure	116 psi (8 bar)	90 psi (6 bar)	90 psi (6 bar)	90 psi (6 bar)
Membrane Elements and Housings				
Element Quantity	60	96	120	192
Element Size	8 inch, 440 ft²	8 inch, 440 ft²	8 inch, 440 ft²	8 inch, 440 ft²
Housing Quantity	15	24	30	48
Housing Type	5 elements, 4 ports	5 elements, 4 ports	5 elements, 4 ports	5 elements, 4 ports
Cartridge Filtration				
Housing Quantity	1	1	1	1
Cartridge Filter Rating	1 micron	1 micron	1 micron	1 micron
Cartridge Filter Length	40"	40"	40"	40"
Cartridge Filter Qty	25	40	52	81
Installation and Utility Requirements				
Inlet	6" Flange	6" Flange	8" Flange	10" Flange
Permeate	6" Flange	6" Flange	6" Flange	8" Flange
Concentrate	6" Flange	6" Flange	6" Flange	8" Flange
Inlet Water Pressure	10-60 psi	10-60 psi	10-60 psi	10-60 psi
Drain to be Sized for	350 gpm (79 m³/h)	380 gpm (87 m³/h)	506 gpm (115 m³/h)	760 gpm (173 m³/h)
Power	60Hz, 480VAC, 3Φ	60Hz, 480VAC, 3Φ	60Hz, 480VAC, 3Φ	60Hz, 480VAC, 3Φ
Control Circuit	24 VDC	24 VDC	24 VDC	24 VDC
Amperage Requirements	200	282	383	565
Footprint and Weight				
Width	445" (1130 cm)	445" (1130 cm)	470" (1190 cm)	533" (1354 cm)
Depth	65" (165 cm)	65" (165 cm)	92" (234 cm)	92" (234 cm)
Height	100" (254 cm)	106" (269 cm)	117" (297 cm)	114" (290 cm)
Weight w/o Membranes	10,500 lb (4,700 kg)	14,600 lb (6,600 kg)	24,300 lb (11,000 kg)	29,800 lb (13,500 kg)
Weight of Membranes	2,200 lb (1,000 kg)	3,386 lb (1,536 kg)	4,230 lb (1,920 kg)	6,770 lb (3,072 kg)
Wet Weight	16,500 lb (7,500 kg)	26,000 lb (11,800 kg)	42,500 lb (19,300 kg)	58,000 lb (26,300 kg)

Case Study 1: Pulp & Paper

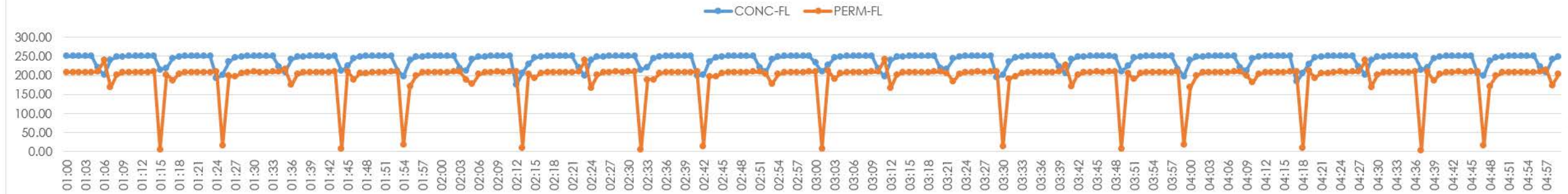
- **Location:** Gila Bend, Arizona
- **Source:** Well Water
- **Application:** Process Water & Boiler Makeup
- **Objectives:** Double Plant Capacity, while Decreasing Waste to Drain.
- **Challenges:** Geothermal Well with High Levels of Biological Activity and Silica (36 ppm)
- **Solution:** (2) ReFlex 200 Units
- **Results:** Reliable & Flexible Solution Operating as Designed.



Recovery (%)

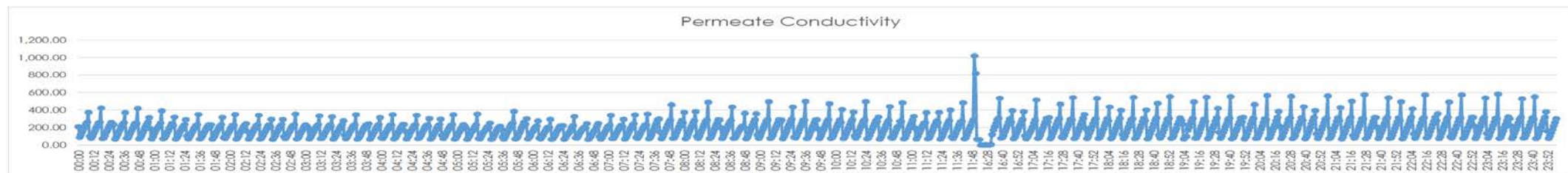
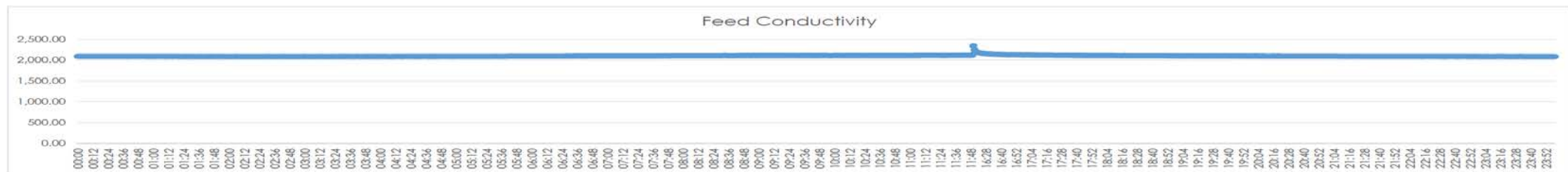
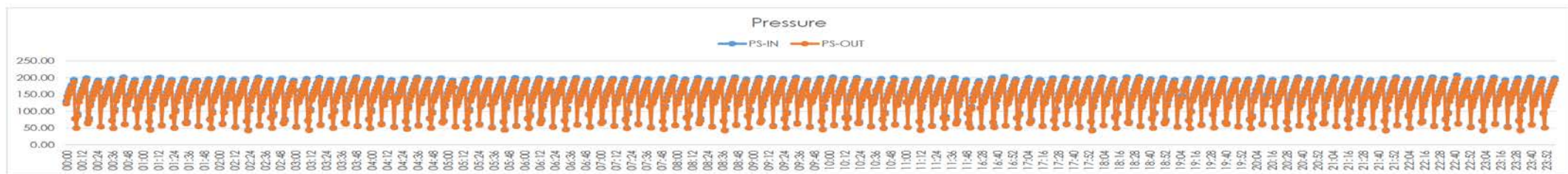
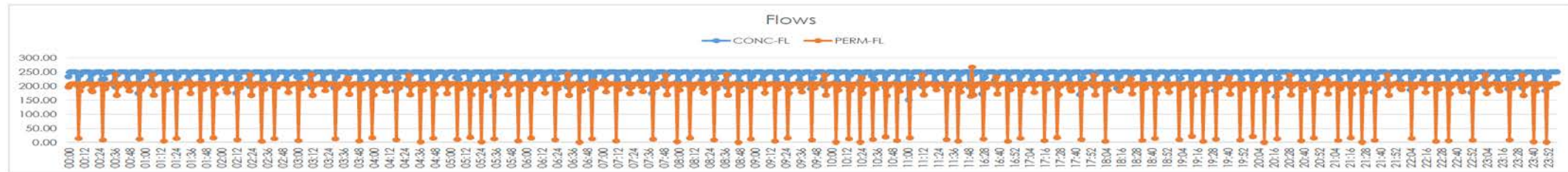
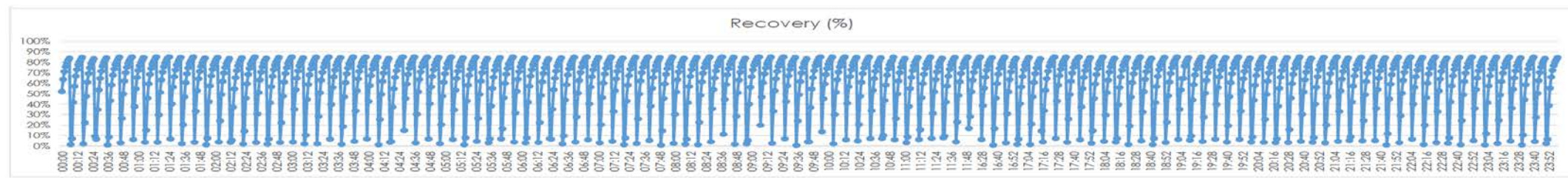


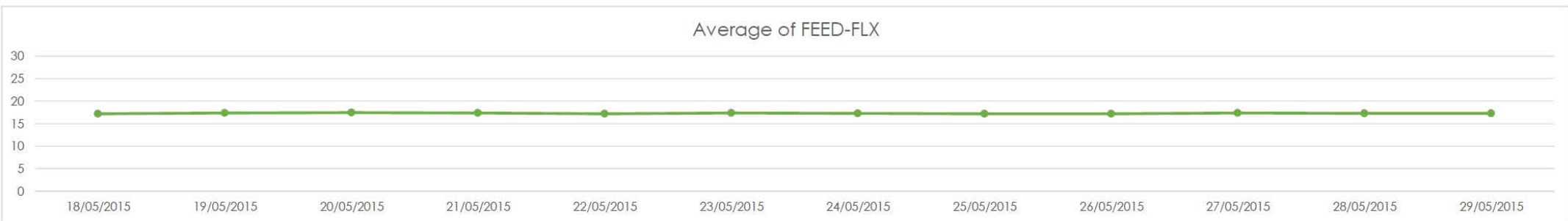
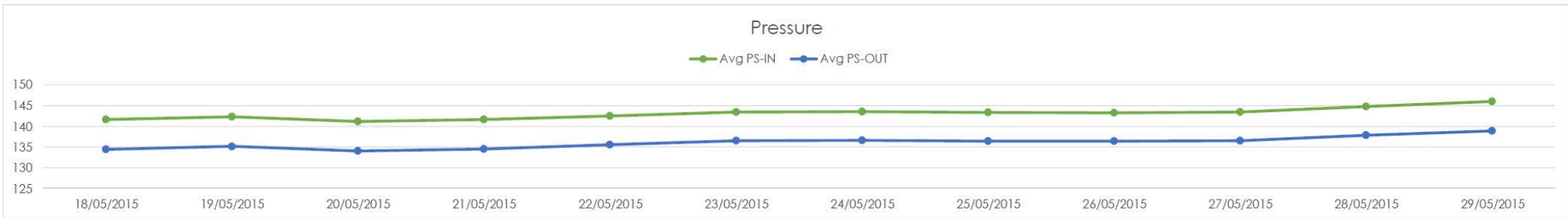
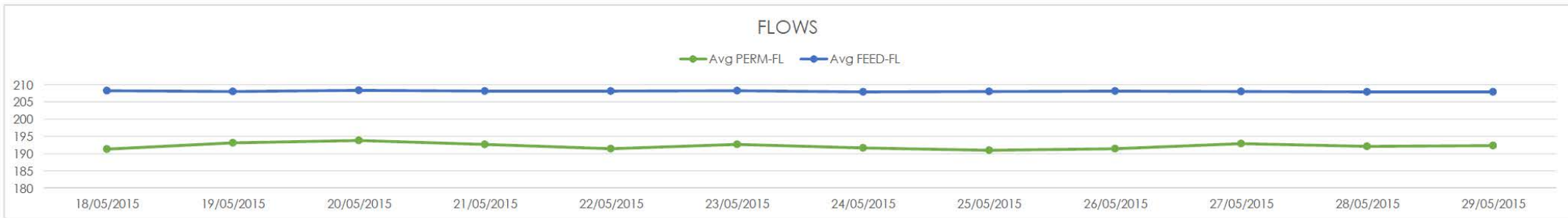
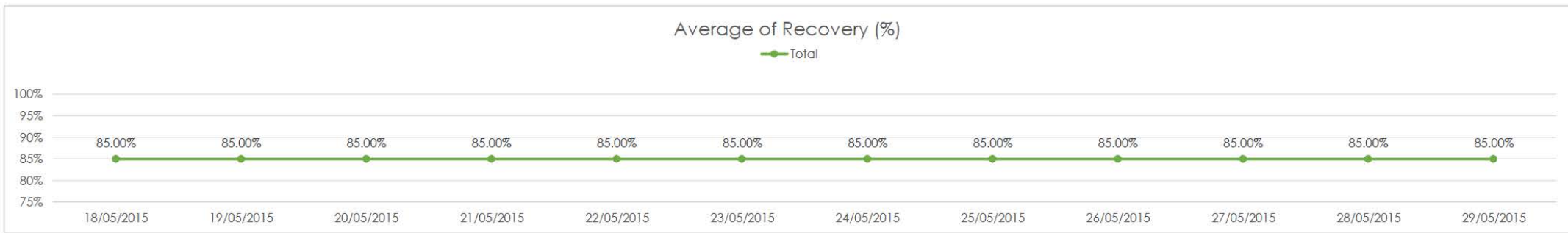
Flows

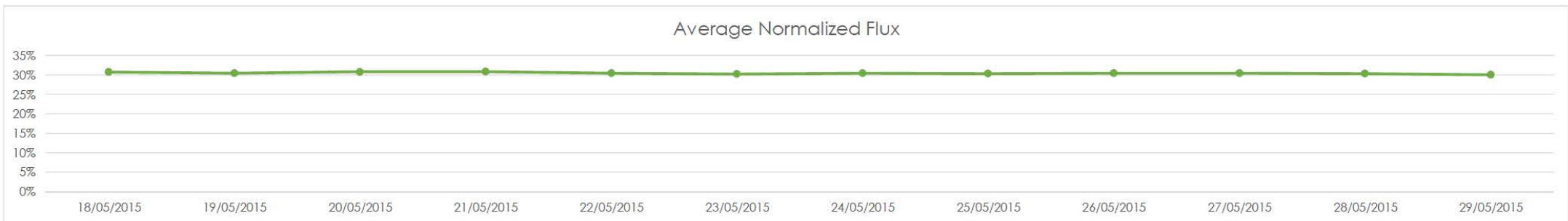
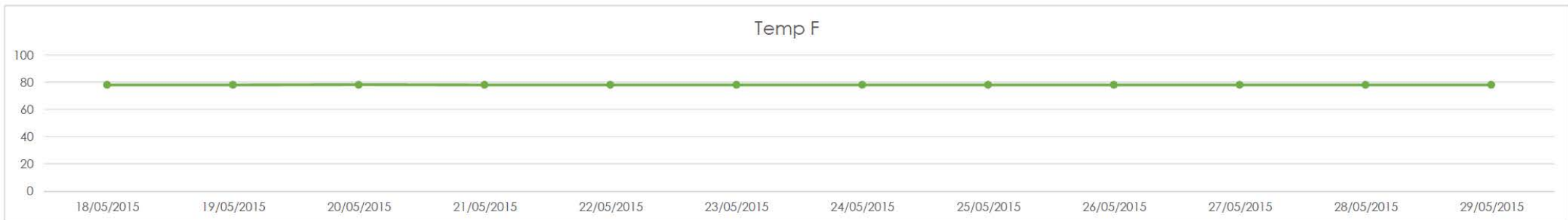
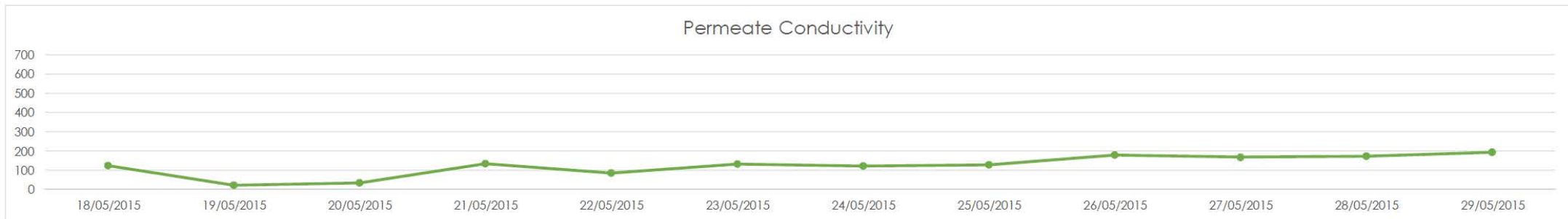
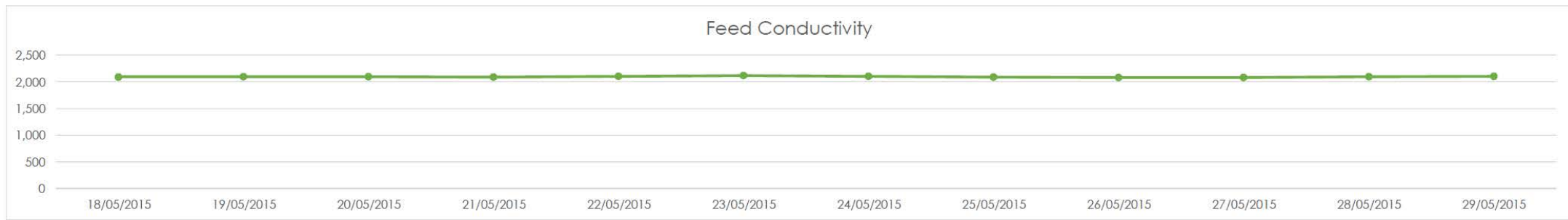


Pressure





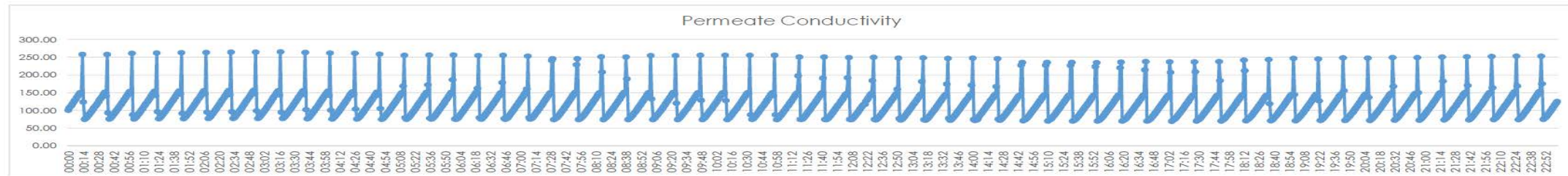
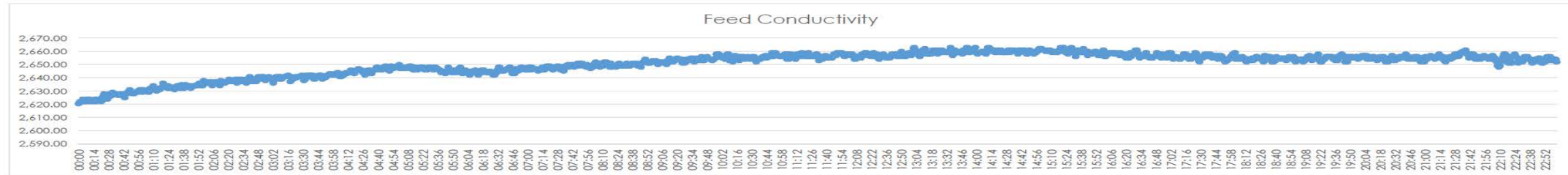
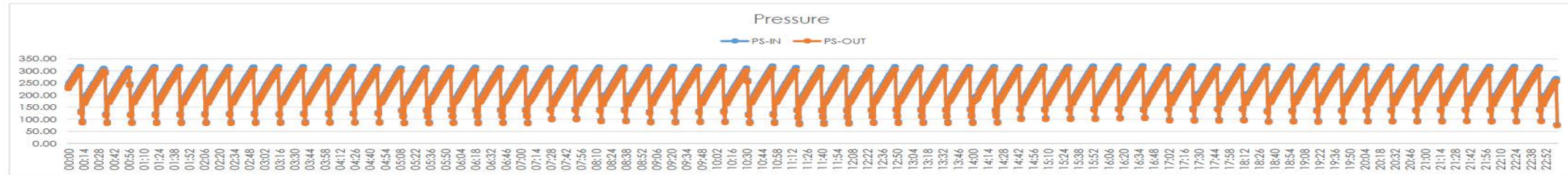
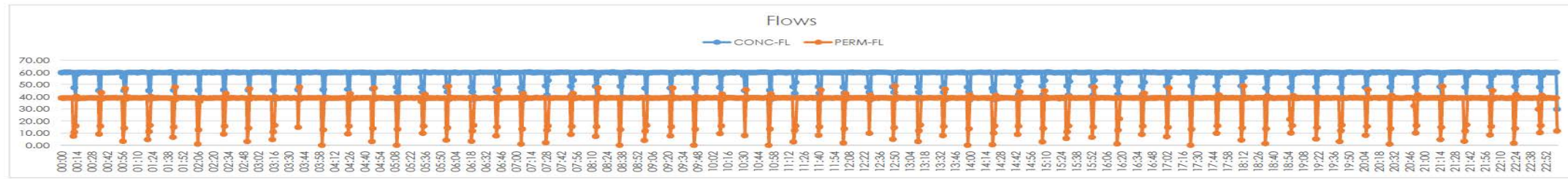
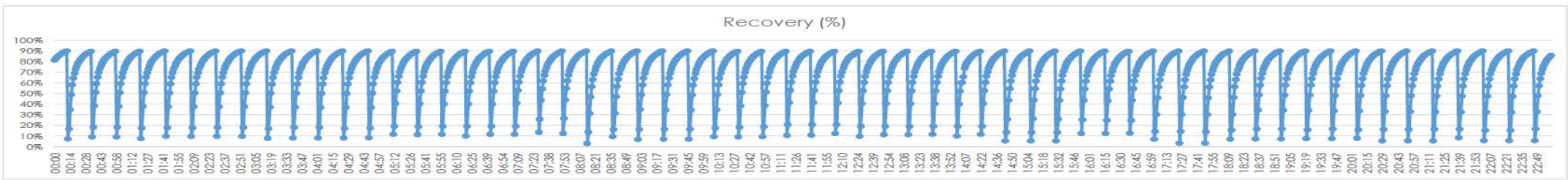


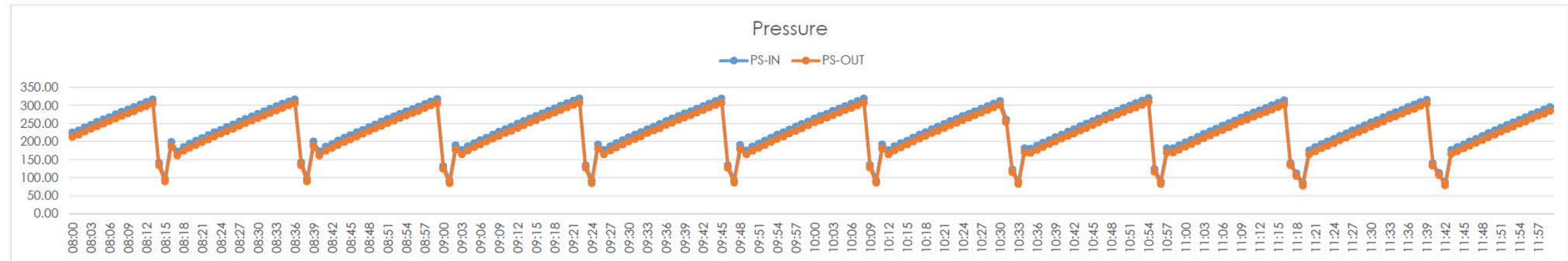
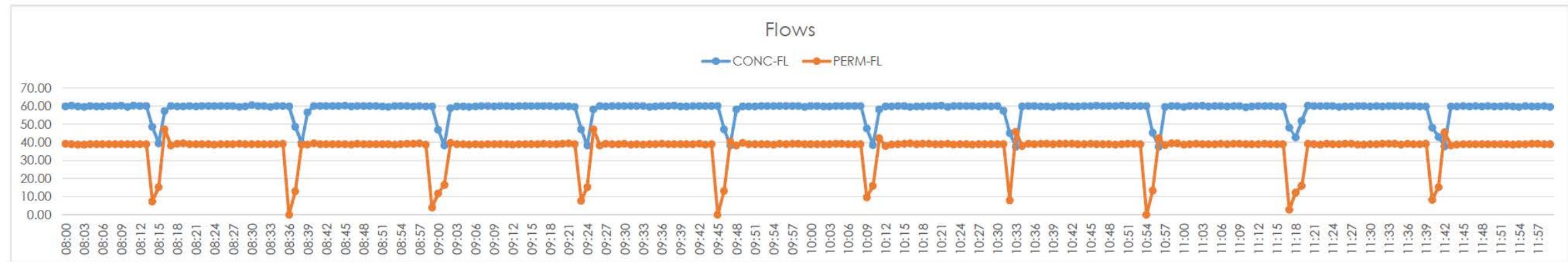
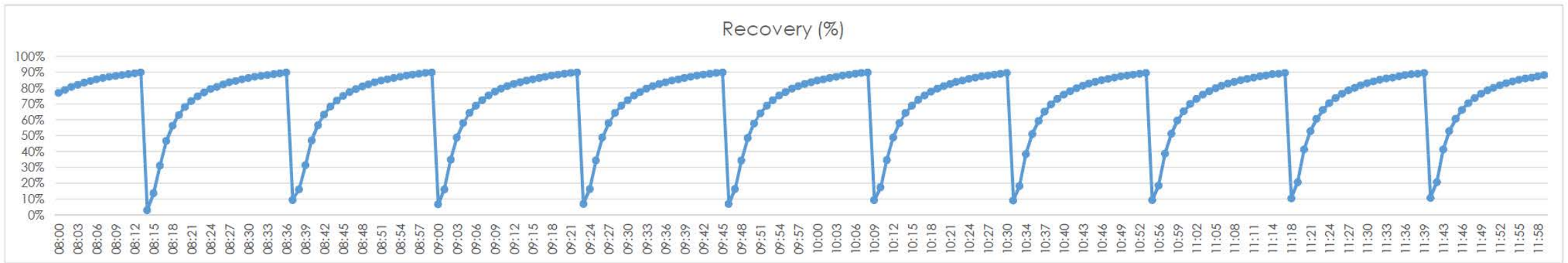


Case Study 2: ZLD Steel Manufacturing

- **Location:** Madill, Oklahoma
- **Source:** Process Wastewater & Cooling Tower Blowdown
- **Application:** Process Water & Cooling Tower Makeup
- **Objectives:** Reduce # of Trucks Hauling Wastewater
- **Challenges:** Hot Water, Variable Feed, High Biological Activity
- **Solution:** (1) ReFlex 50 Unit with Pre-Filtration Equipment
- **Results:** 4 Month ROI

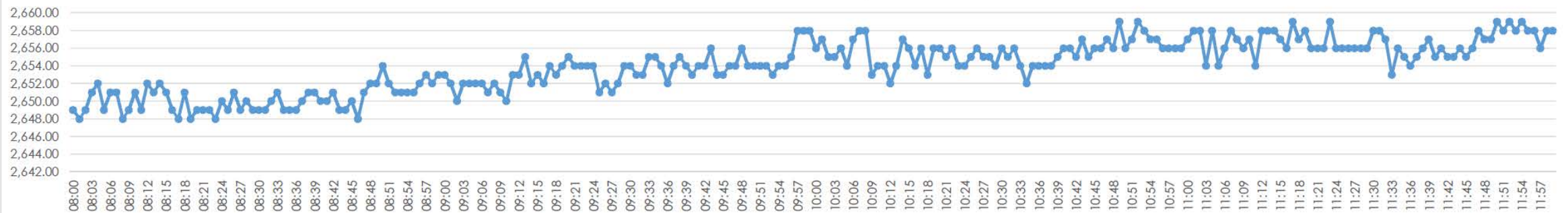




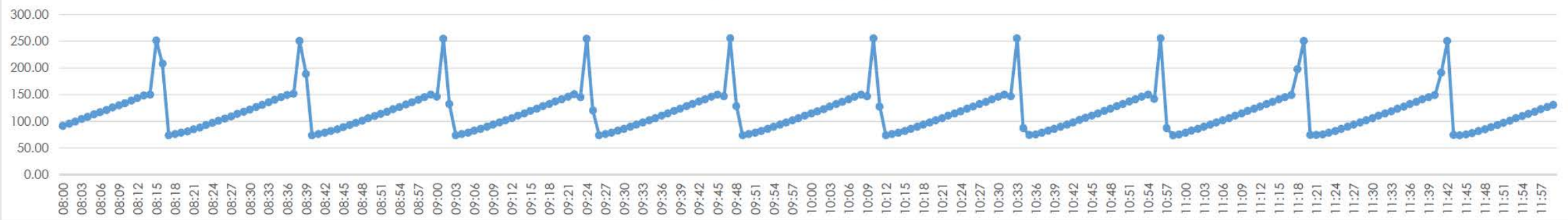




Feed Conductivity



Permeate Conductivity



Summary

- The State of Water
- Multistage Reverse Osmosis
- Simple or Dead-End Filtration
- Closed-Circuit Desalination™
- ReFlex™ Product Line
- Case Studies
- Questions & Answers



Michael Boyd – Senior Sales Manager

Email: mike.boyd@desalitech.com

Cell: 909.821.0195