

“Pulse Flow RO” for Extremely High Recovery

Without Scaling
Without Fouling

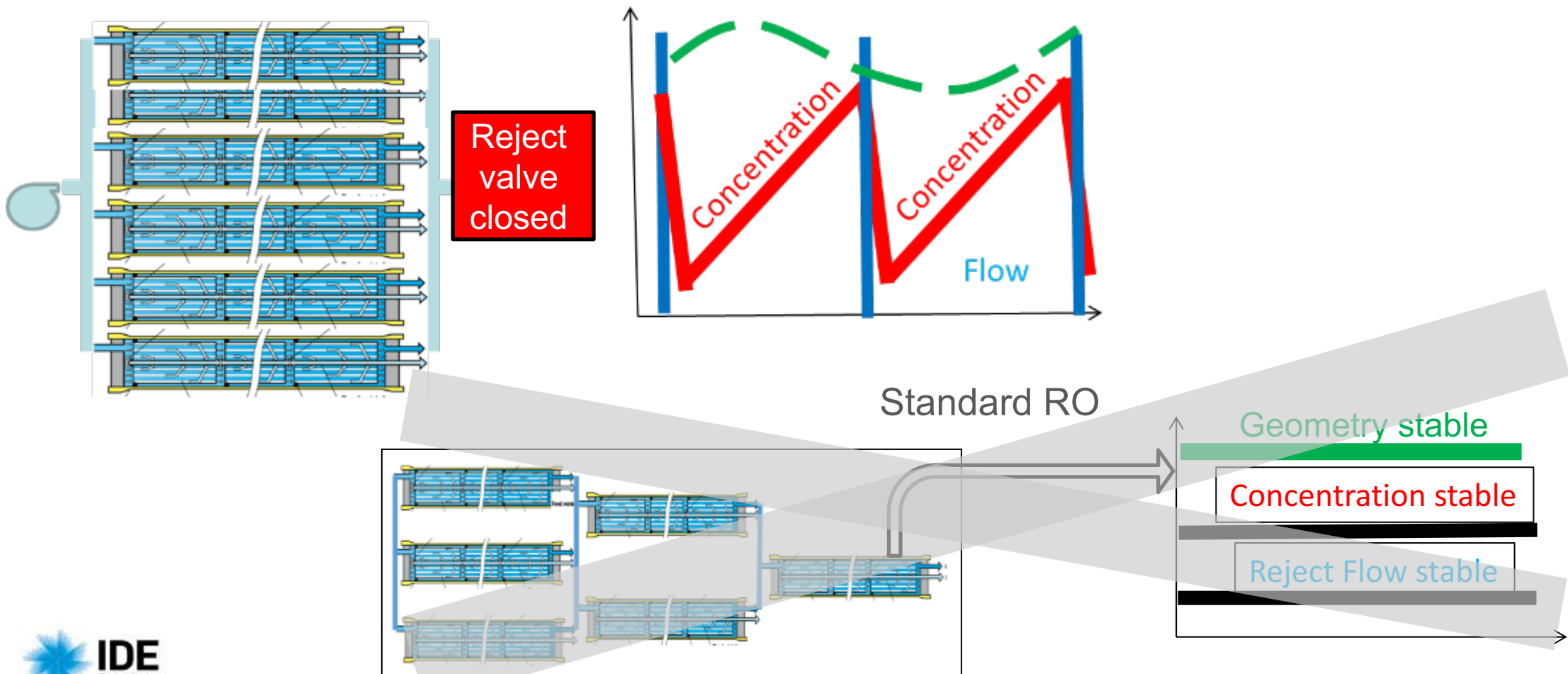
Dr. B. Liberman | September 2017



Pulse Flow RO Works

› Operation

- › Production: Dead End, 100% recovery, about 200 seconds, followed by
- › Flushing: High shearing velocity reject flow discharge, about 4 seconds



Pulse Flow Operation

- › Three successful pilots



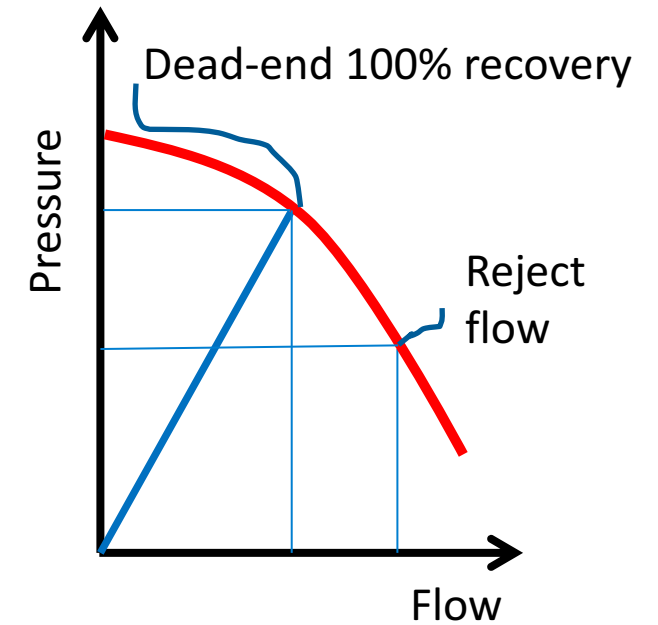
HP Pump Operation Regime



Reject discharge



Permeate production



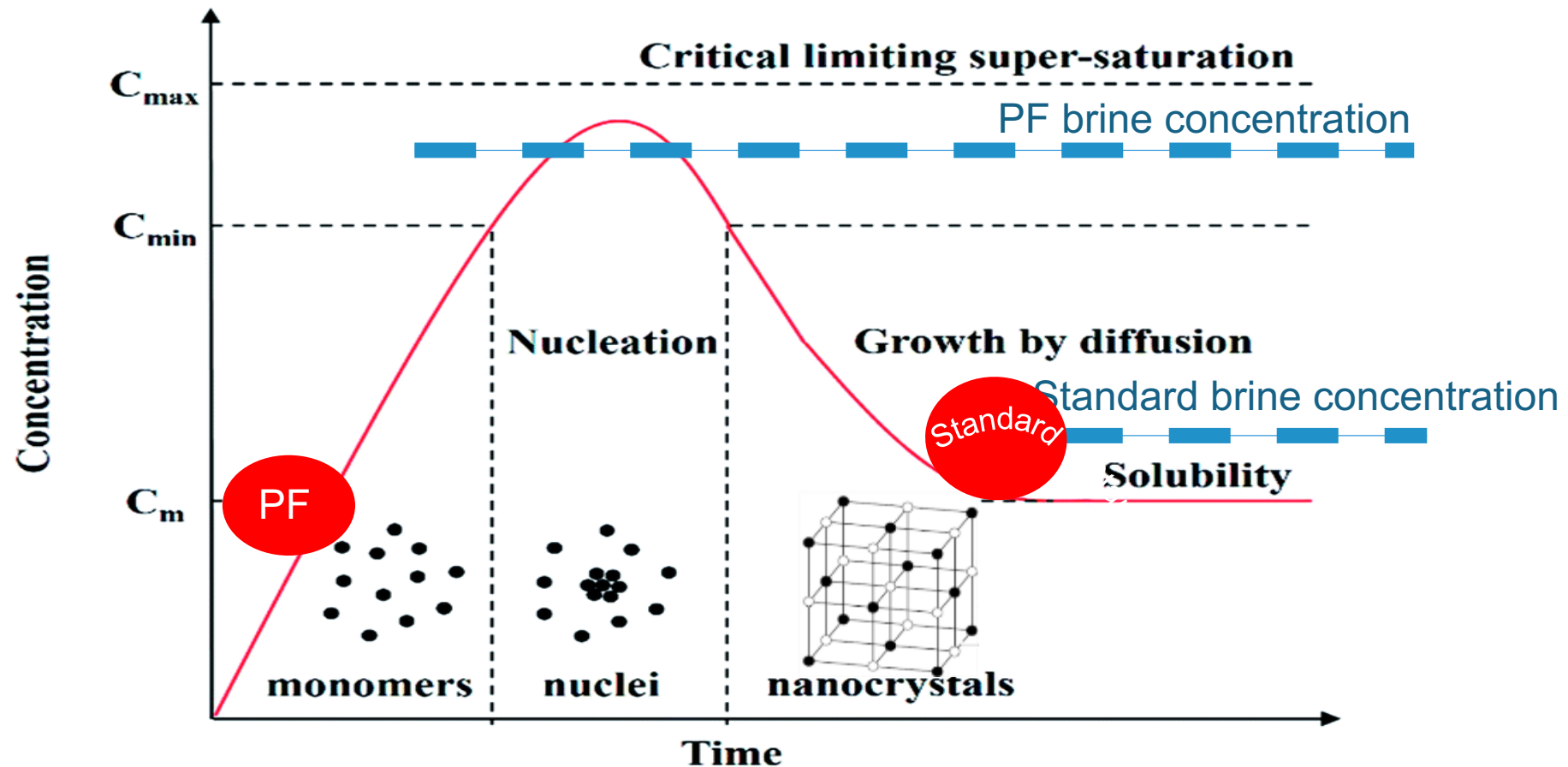
Pat. GB2519880;
PCT/IB2015/055665;
WO 2016024179 A1

Pulse Flush Pilot in Hadera RO Plant



Short Stay in an Extremely High Concentration allows reaching Extremely High Recovery

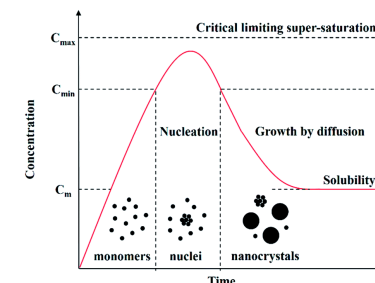
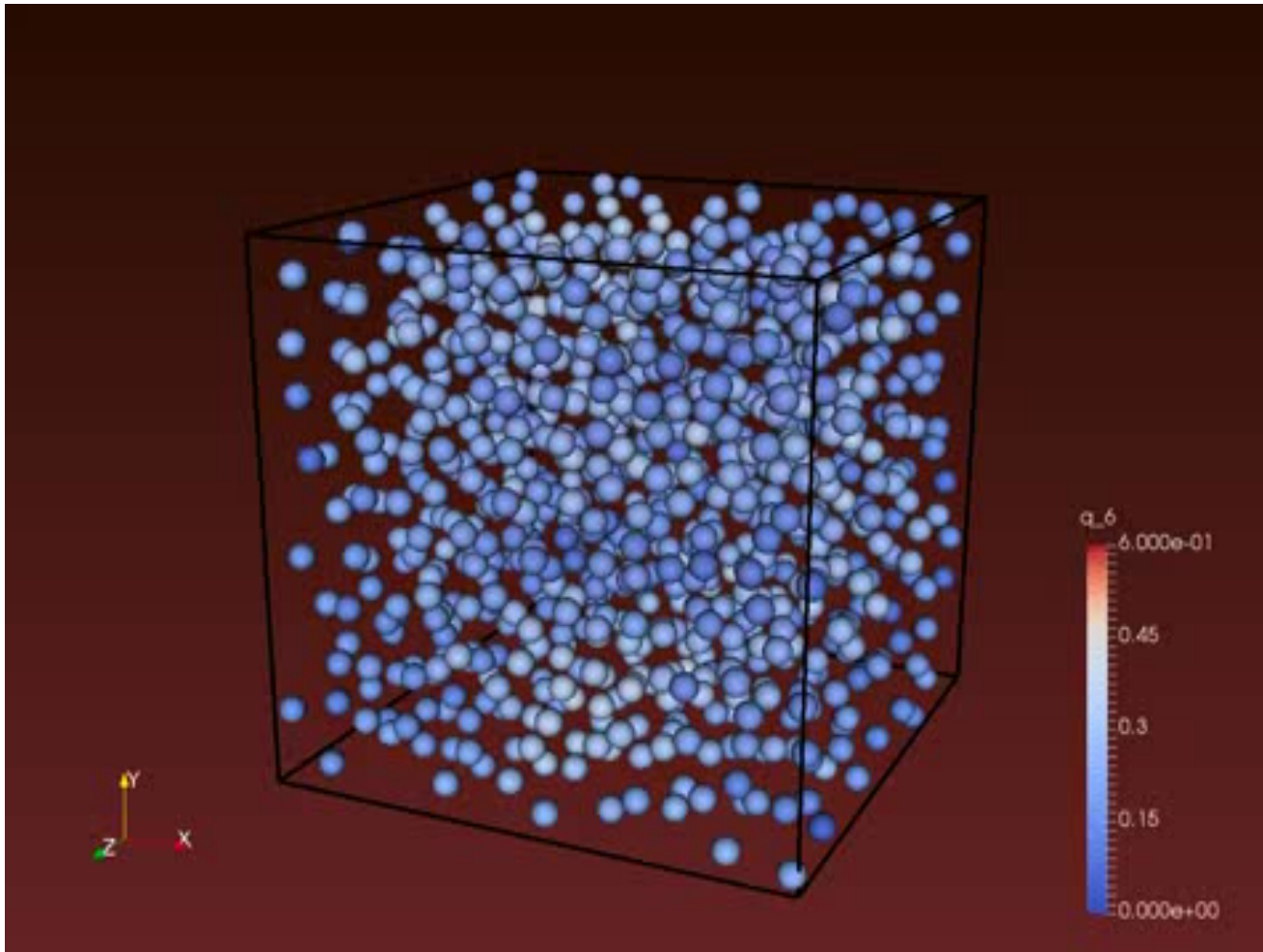
- › The pulse flow RO process
 - › Fast increase of brine flow concentration during Production (Dead-End 100% recovery)
 - › Fast decrease of brine flow concentration during short time reject flush



Slow Dynamics of the Nucleation Process

Relatively Slow Dynamics of the Nucleation Process, compare to short time stay of PFRO brine in membranes, allows reach extremely high recovery

The mathematical model represents the actual time required for formation of a CaCO_3 layer on the existing proto-crystals

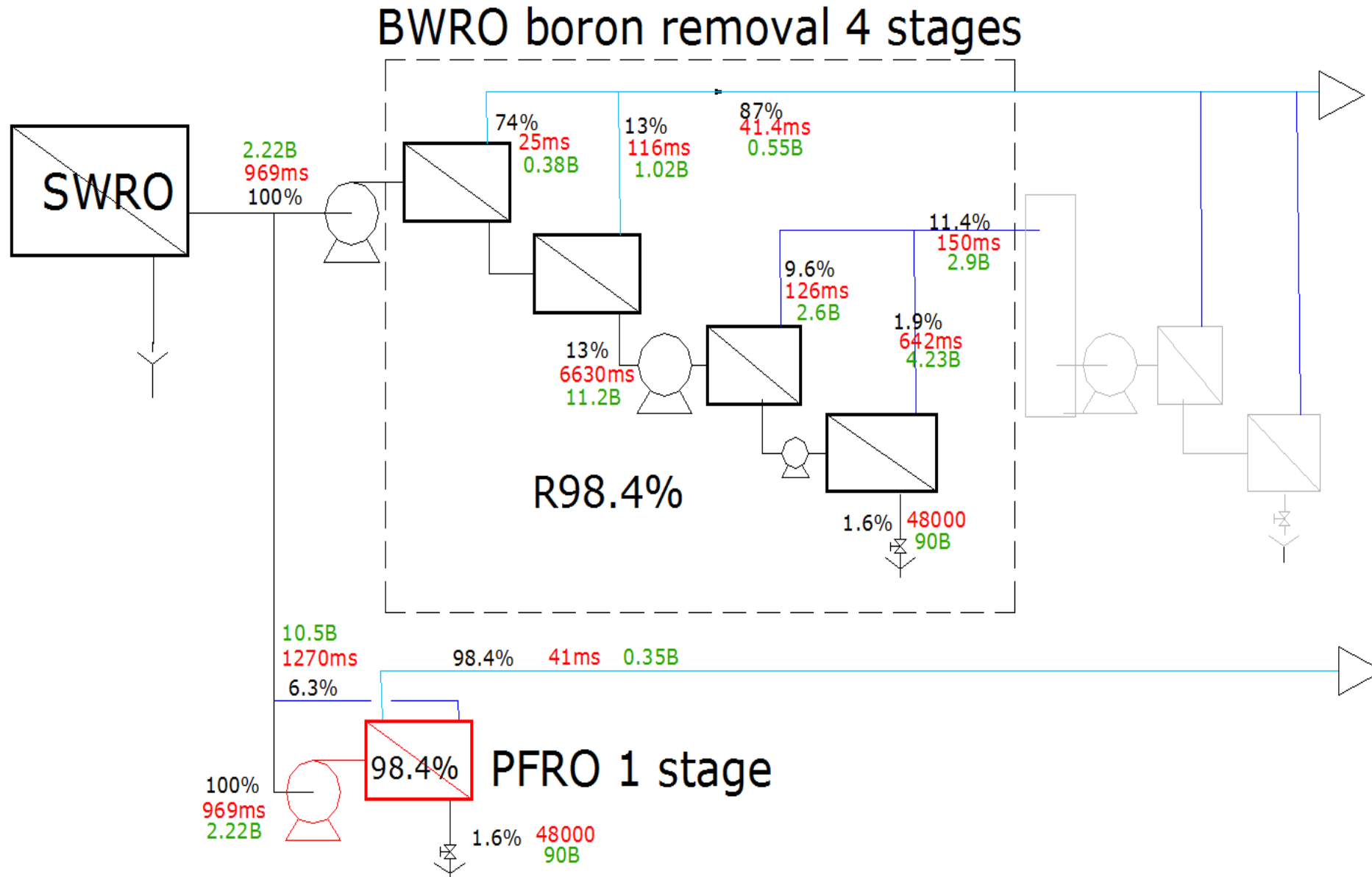


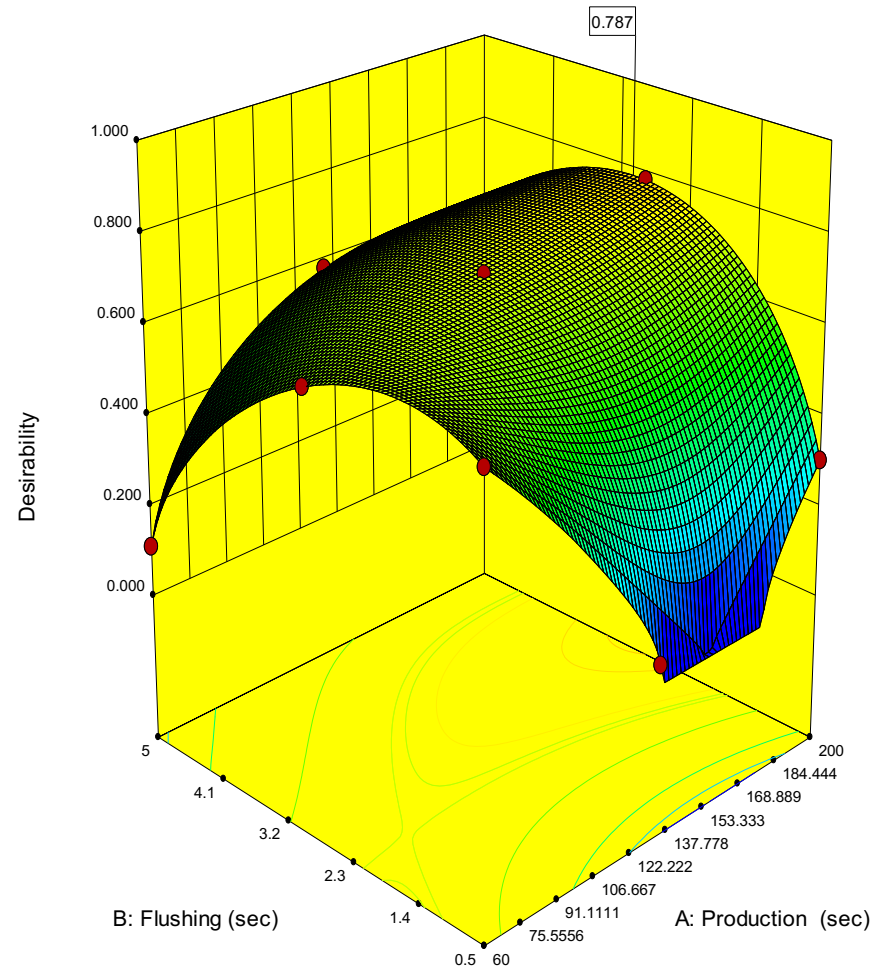
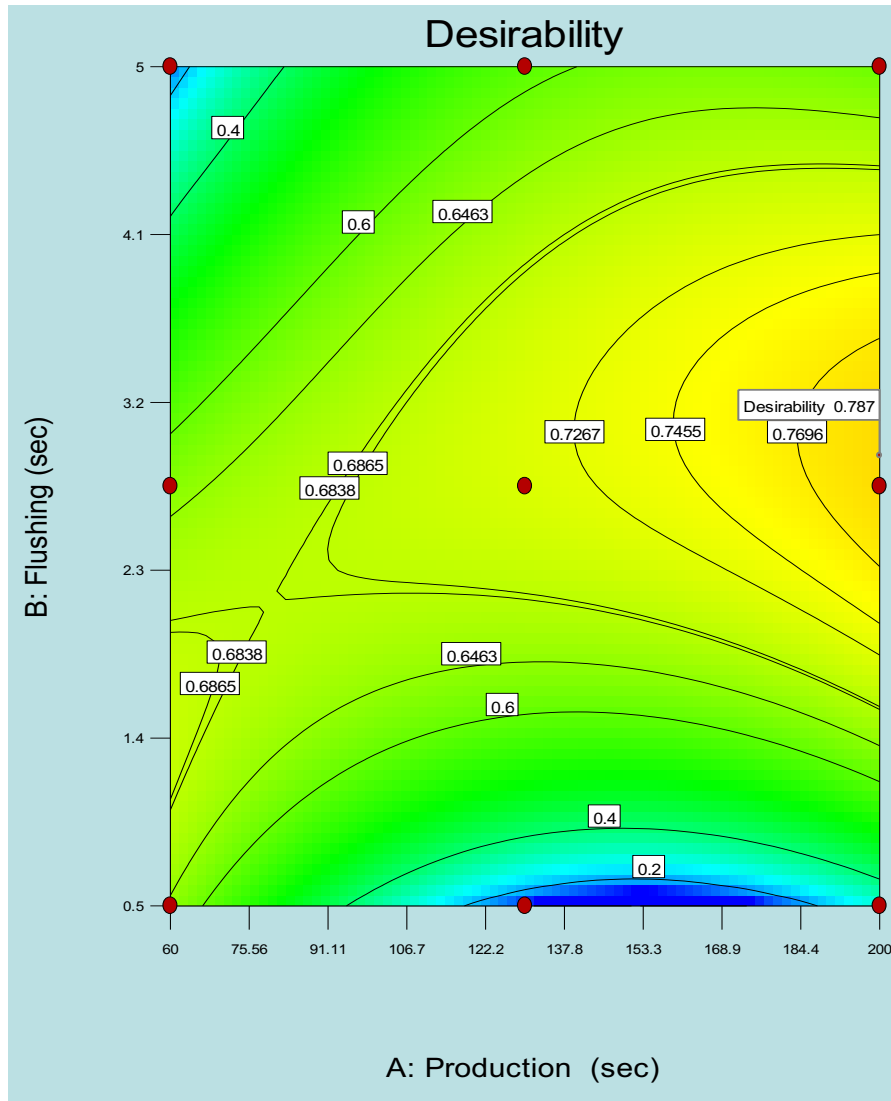
Expert Design Model

- › Pulse flow RO
- › Results of low conductivity test

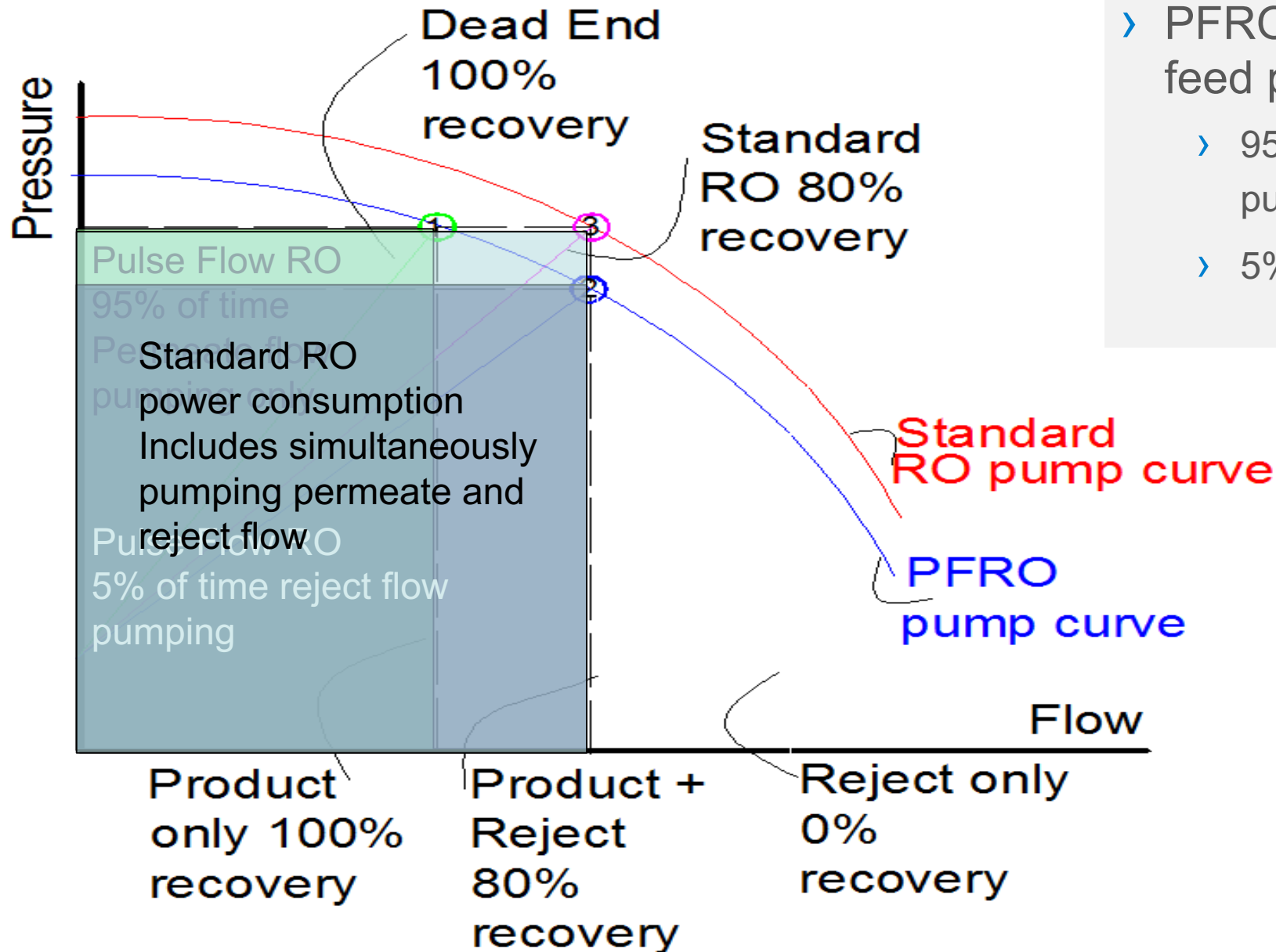
Std	Run	Factor 1 A:Production	Factor 2 B:Flushing	Factor 3 C:Cond feed	Response 1 Product flow	Response 2 Product conductivity	Response 3 Recovery	Response 4 Rejection
		T_P	T_F	C_F	Q_P avg	C_P	R	Rej
		sec	sec	mS/cm	m ³ /h	mS/cm	%	%
7	5	60	5	0.96	13.3	0.06	92.3	99.8
4	10	60	2.75	0.99	13.0	0.09	95.4	99.8
6	15	200	2.75	1.02	12.6	0.27	98.3	99.7
3	16	200	0.5	1.03	10.5	0.72	99.8	99.5
1	17	60	0.5	1.00	11.6	0.47	99.4	99.6
9	22	200	5	1.20	11.9	0.16	97.0	99.7
5	24	130	2.75	1.06	12.4	0.20	97.9	99.7
2	29	130	0.5	1.12	10.2	0.77	99.7	99.6
8	31	130	5	1.17	12.6	0.17	95.9	99.7

1-stage PFRO versus 4-stage BWRO





Not pumping brine flow continuously results in ~ 20% Power Saving



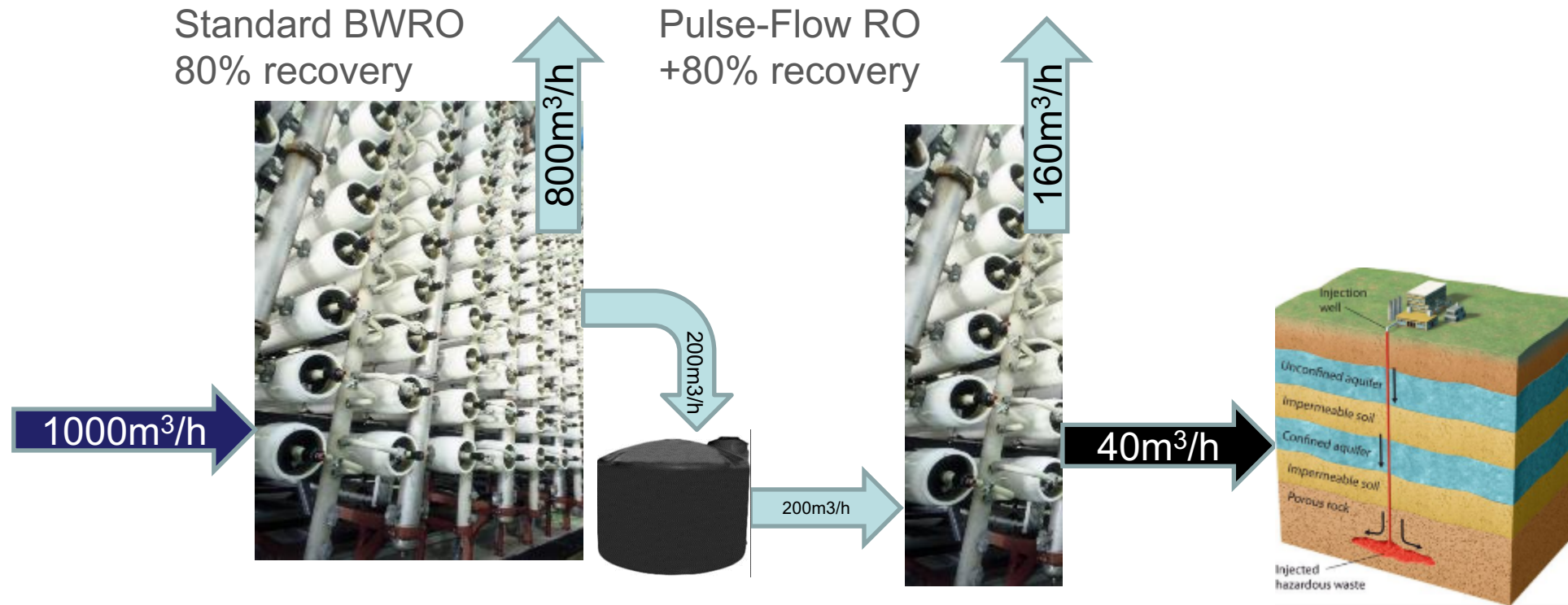
› PFRO production requires a smaller feed pump

› 95% of the time only permeate is pumped

› 5% of the time reject flow is pumped

Practical Implementation of Pulse Flow RO

- › Retrofit existing RO train or an additional Pulse-Flow RO stand can be installed





Brine Squeezer Micro Pilot

Equipment List

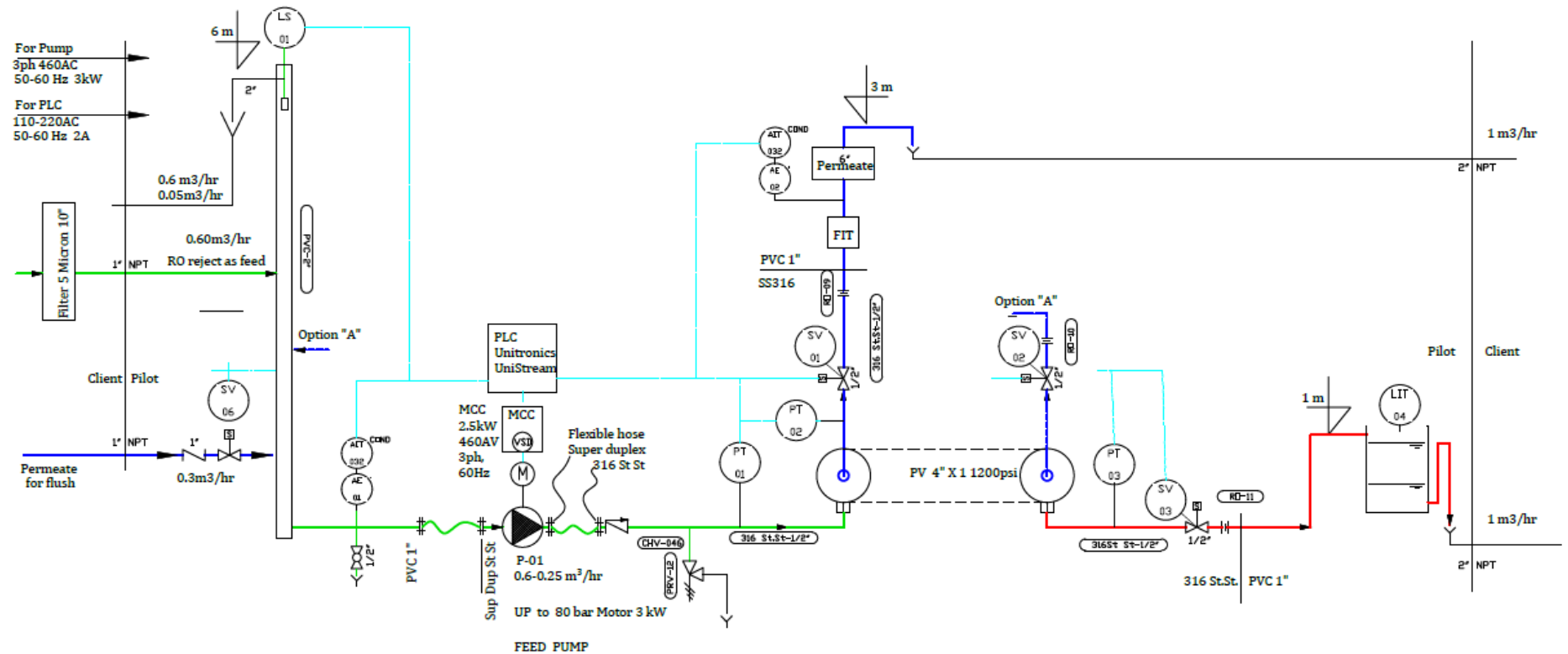
- Pressure vessel 4" 1 element
- RO membrane 4" x 1
- Pump Danfoss APP-0.6
- Motor 2.5kW
- VSD
- Coax Solenoid valve x 3
- Tanks 100L x 2

Instrument List

- Pressure Transmitters 01; 02; 03; 0-100 bar
- Level switch on/off 01; 02; 03; 04; 05.
- Conductivity on line 01; 02.

I/O List

- Motor 2.5kW
- VSD
- Coax Solenoid valve 01; 02; 03; 24VDC
- ON/OFF PVC Solenoid valves: 04; 05. 24VDC
- Pressure Transmitters x 3
- Level switches x 5
- Conductivity on line 01; 02.



Micro Pilot - RO Reject Brine Squeezer

Capacity 2000 GPD, Recovery 50%-90%
2.5 kw motor

