NOVEL ULTRAFILTRATION OPERATING PROCESS FOR SILICON WAFER PRODUCTION WASTEWATER REUSE

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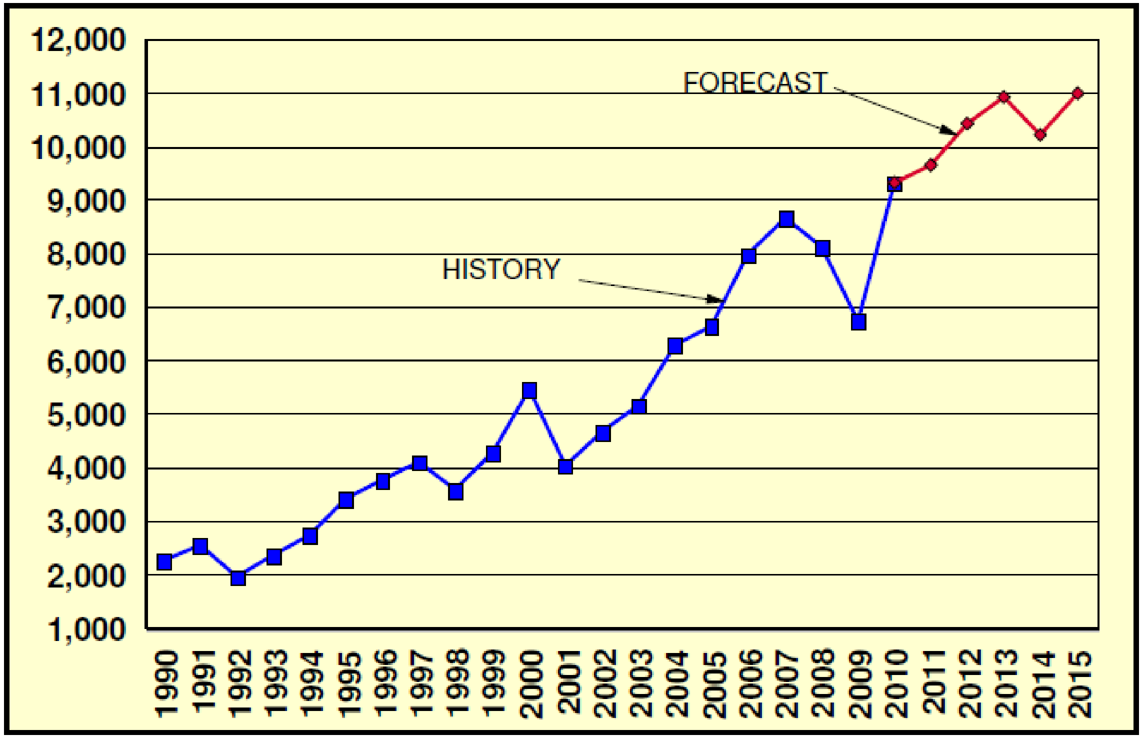
Outline

- Introduction
- Case Study 1
- Case Study 2
- Conclusions

Introduction

SEMICONDUCTOR SILICON WAFER FORECAST



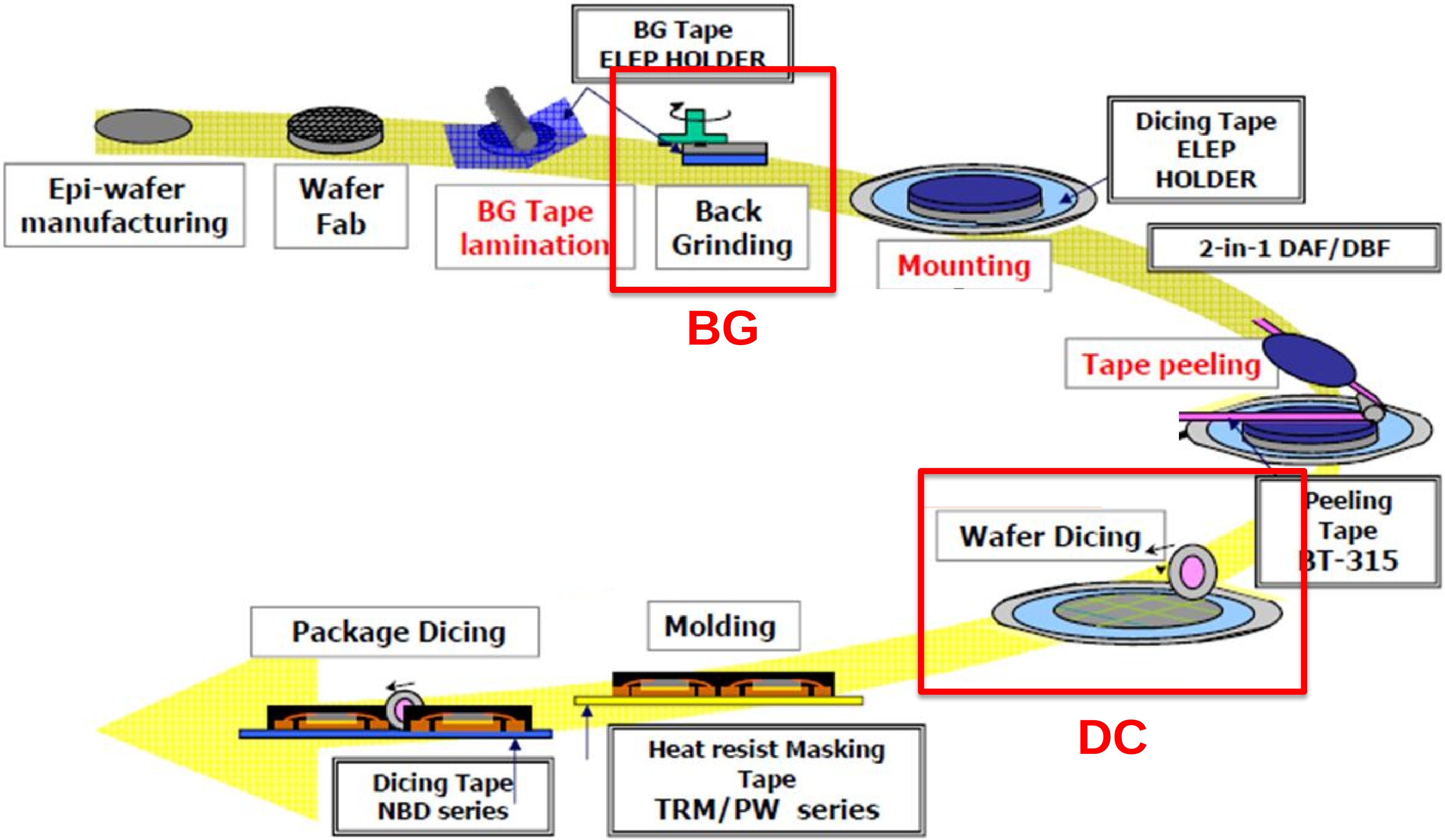
GLOBAL SILICON WAFER SALES FORECAST IN MILLIONS OF SQUARE INCHES

Source: Sage Concepts Market Report

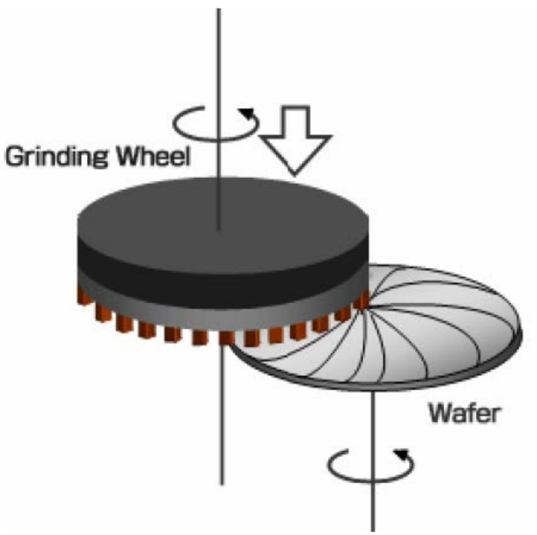
- ***2010 Water Consumption = 450 MGD****
- ***2015 Projected Water Consumption = 533 MGD****

* Assumes production of single 300 mm silicon wafer requires ~2000 gallons of water.

Semiconductor Manufacturing Process (Back side)



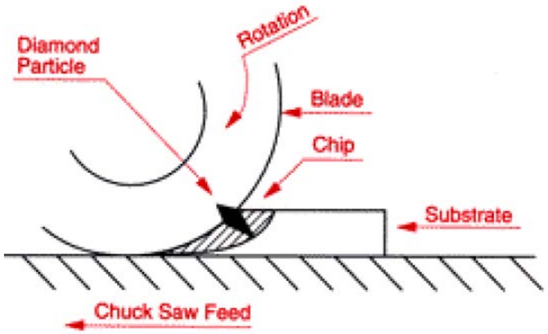
Back grinding (BG) and Dicing (DC)



Source: GRINDING OF SILICON WAFERS: WAFER SHAPE MODEL AND ITS APPLICATONS (Sun, 2005)

Back grinding WW Characteristics	
Particle Size (µm)	0.1 - 0.3
Turbidity (NTU)	>1,000

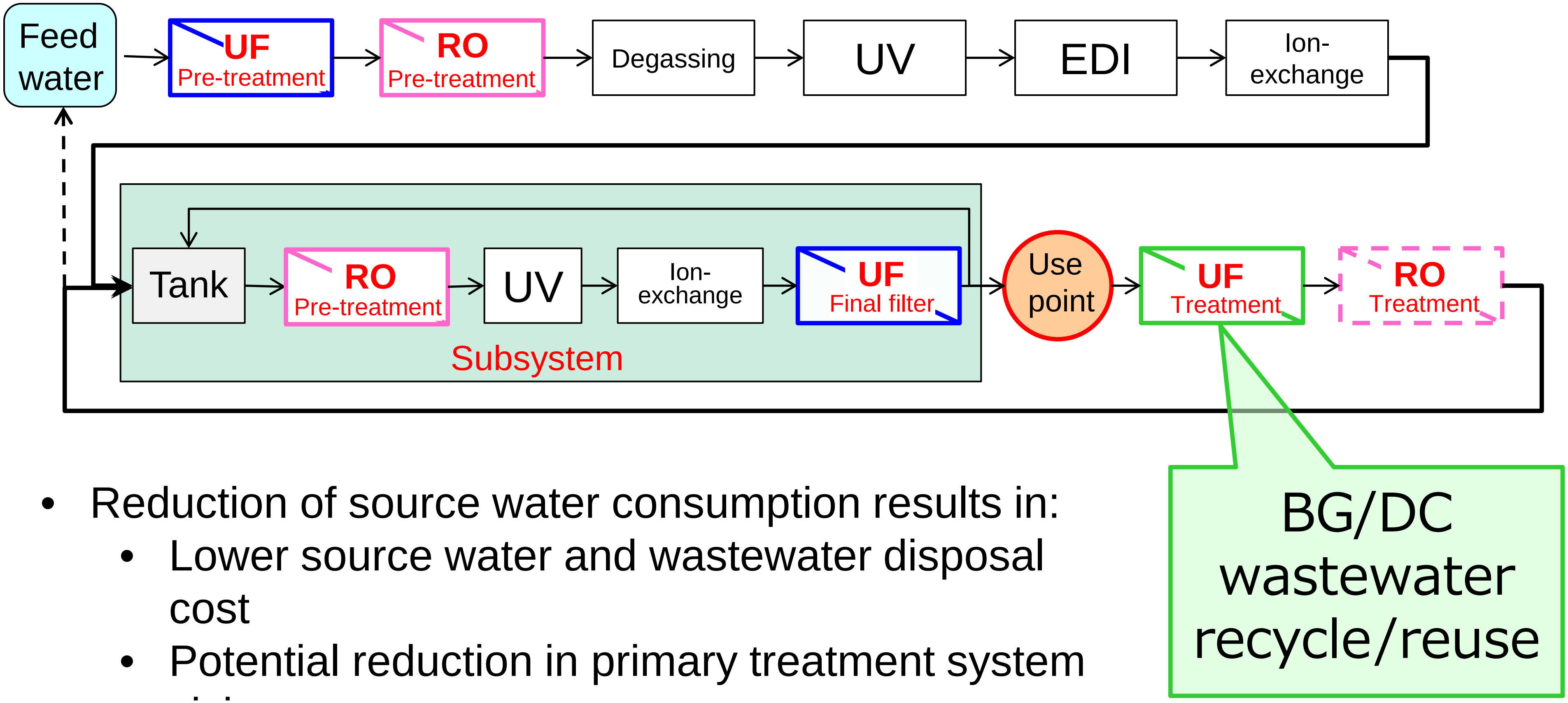
Backgrinding + Dicing WW (left) and Dicing WW only (right)



Source: www.adt-dicing.com

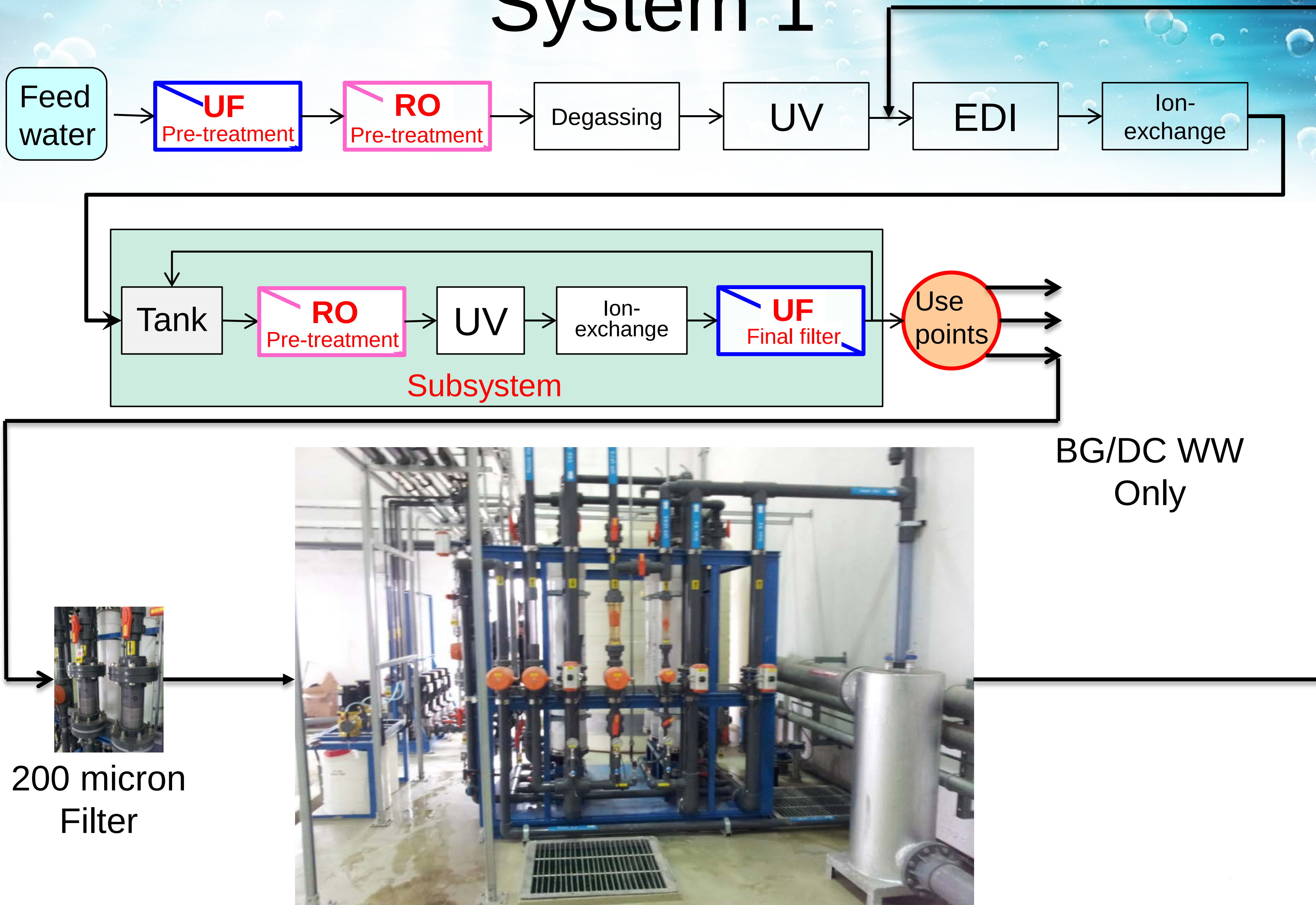
Dicing WW Characteristics	
Particle Size (µm)	0.2 - 2
Turbidity (NTU)	>100

Ultrapure Water Process



- Reduction of source water consumption results in:
  - Lower source water and wastewater disposal cost
  - Potential reduction in primary treatment system sizing

System 1



6 HYDRAcap MAX 60

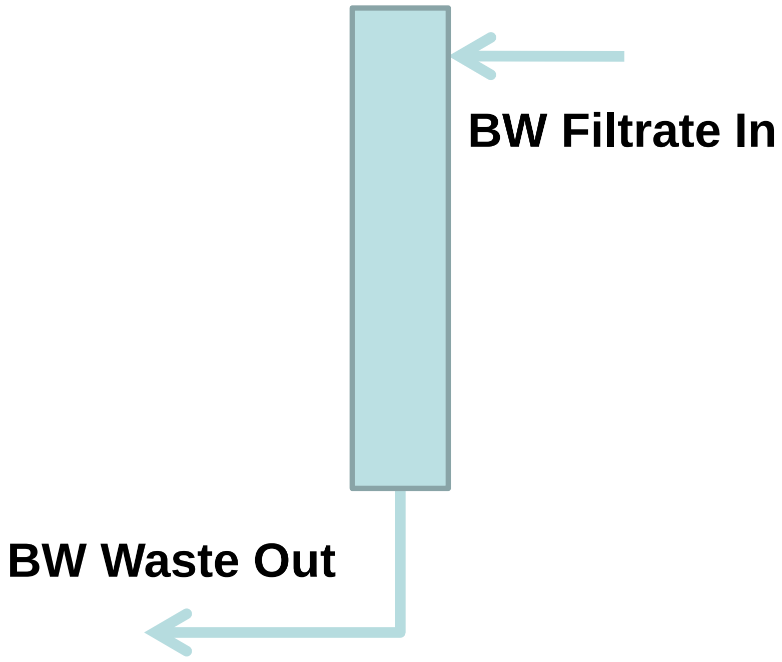
System 1

Parameter	Unit	Value
System capacity	m3/hr	15
Module type		Hydranautics HYDRAcap® MAX 60
Number of racks		1
Number of modules per rack		6
Gross operating filtration flux	LMH	32
Concentrate bleed flow	m3/hr	1.5
Filtration cycle duration	min	45
Physical cleaning method		Air scour without backwash
Air scour flow rate per module	m3/hr	4
Chemical cleaning frequency		Two 0.1% NaOH maintenance cleans per day
System Recovery	%	90

HYDRAcap® MAX 60 Overview	
Flow path	Outside to inside
Membrane material	TIPS PVDF
Membrane configuration	Hollow fiber
Membrane area	840 ft^2 (78 m^2)
Fiber ID/OD	0.6/1.2 mm
Pore size	0.08 µm

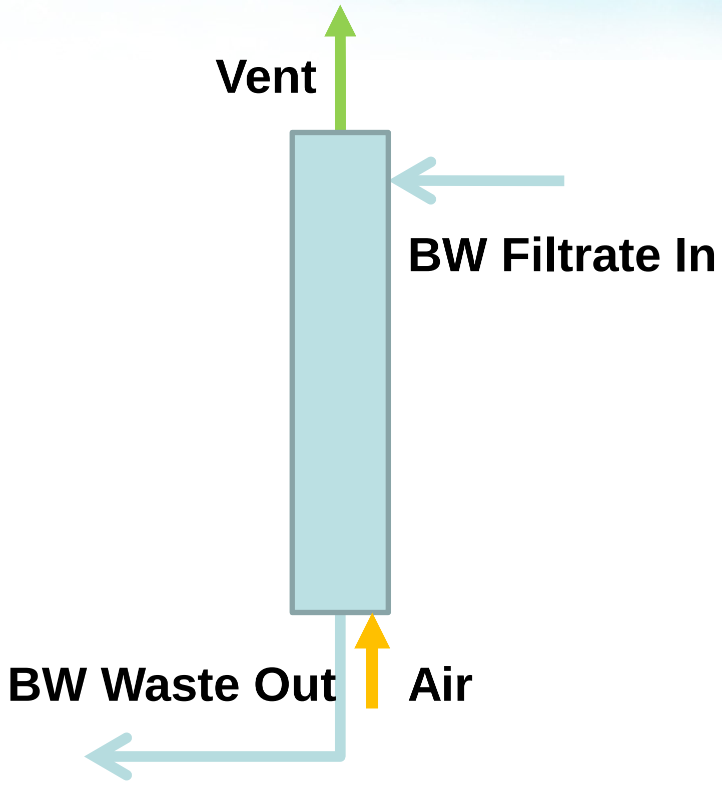
Physical Cleaning Methods

1. Backwash



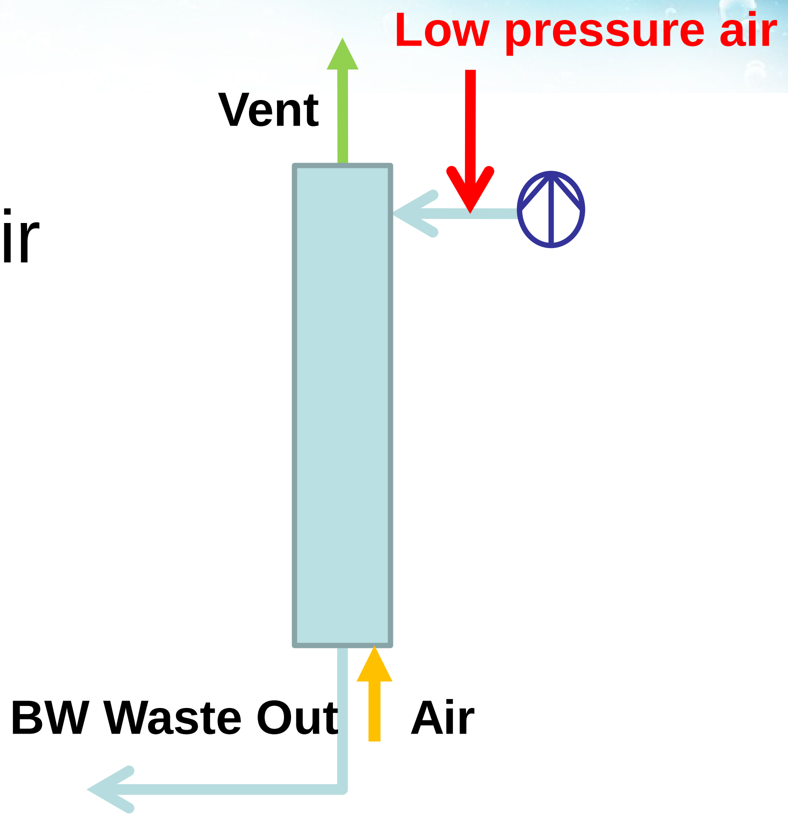
Physical Cleaning Methods

1. Backwash
2. Backwash + Air Scour



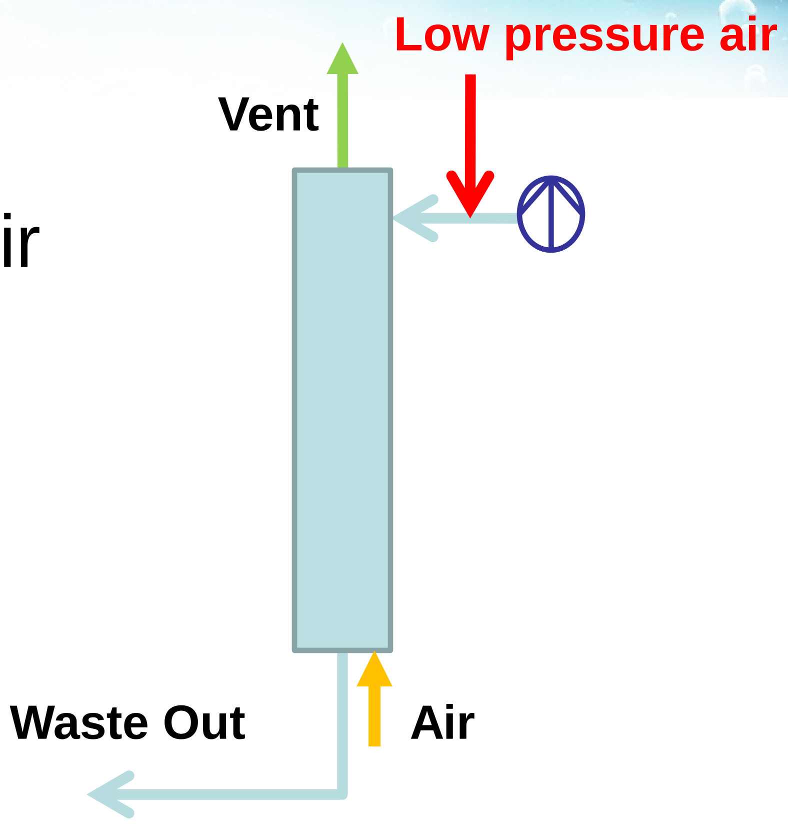
Physical Cleaning Methods

1. Backwash
2. Backwash + Air Scour
3. Air Assisted Liquid BW + Air Scour



Physical Cleaning Methods

1. Backwash
2. Backwash + Air Scour
3. Air Assisted Liquid BW + Air Scour
4. Air Scour



System 1 – Physical Cleaning Process

	Air Scour Step	Typical Duration (s)
1	**Stop Filtration**	0
2	Air Scour	60
3	Air Scour and Drain	60
4	Refill	60
5	Resume Filtration	0

System 1 – Physical Cleaning Process

	Air Scour Step	Typical Duration (s)
1	Stop Filtration	0
2	**Air Scour**	60
3	Air Scour and Drain	60
4	Refill	60
5	Resume Filtration	0

Air flow: 12 – 15 m3/h per module
Air pressure: 0.7 bar

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2	Air Scour	60
3	**Air Scour and Drain**	60
4	Refill	60
5	Resume Filtration	0

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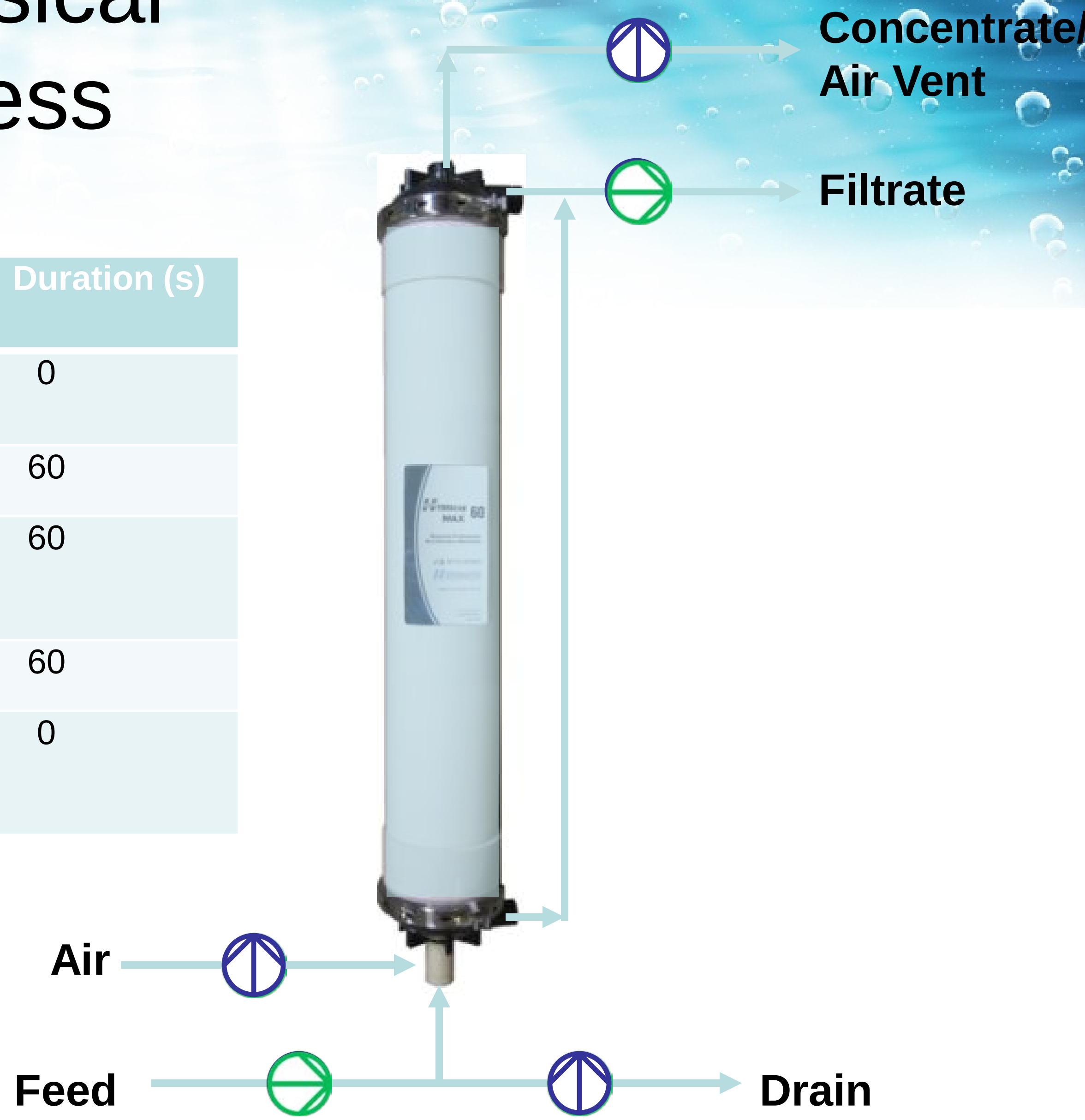
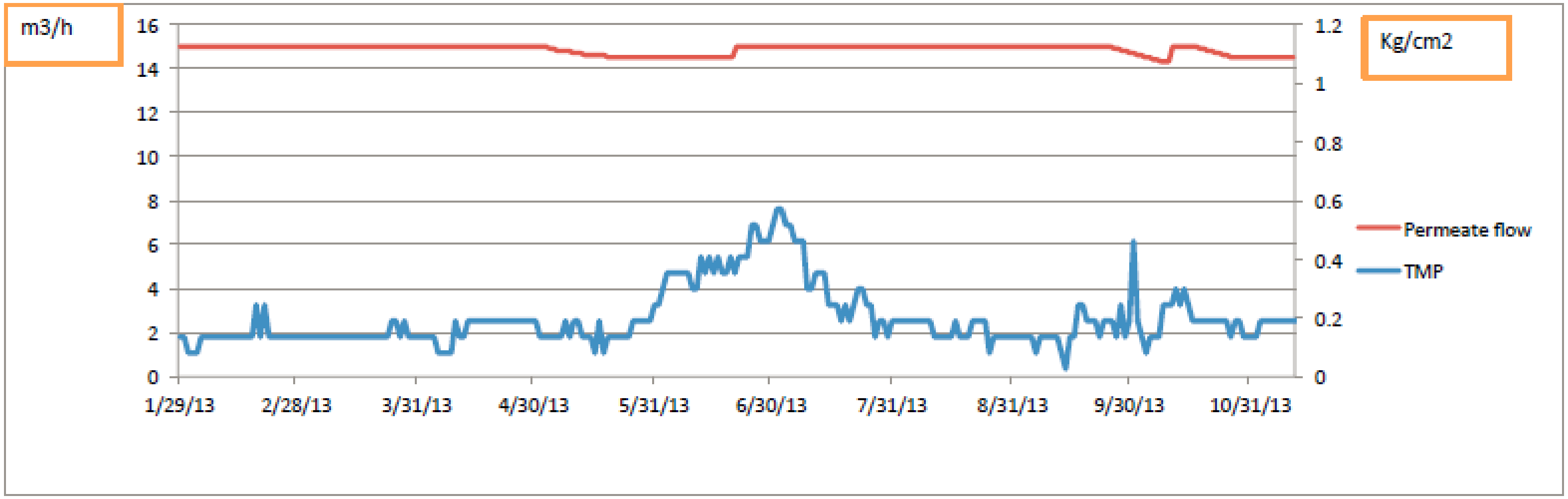
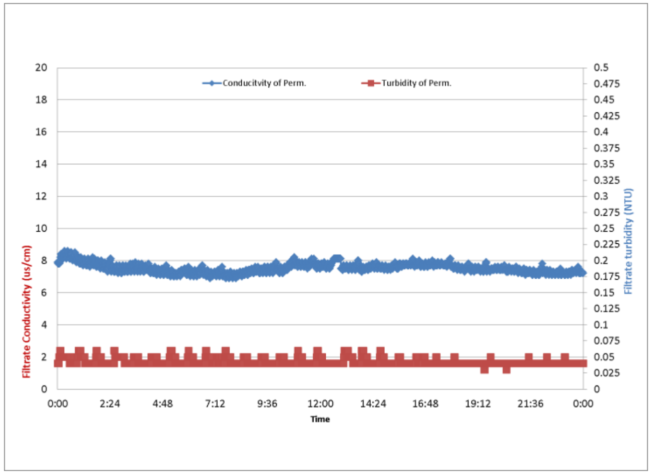


System 1 – Operating Performance

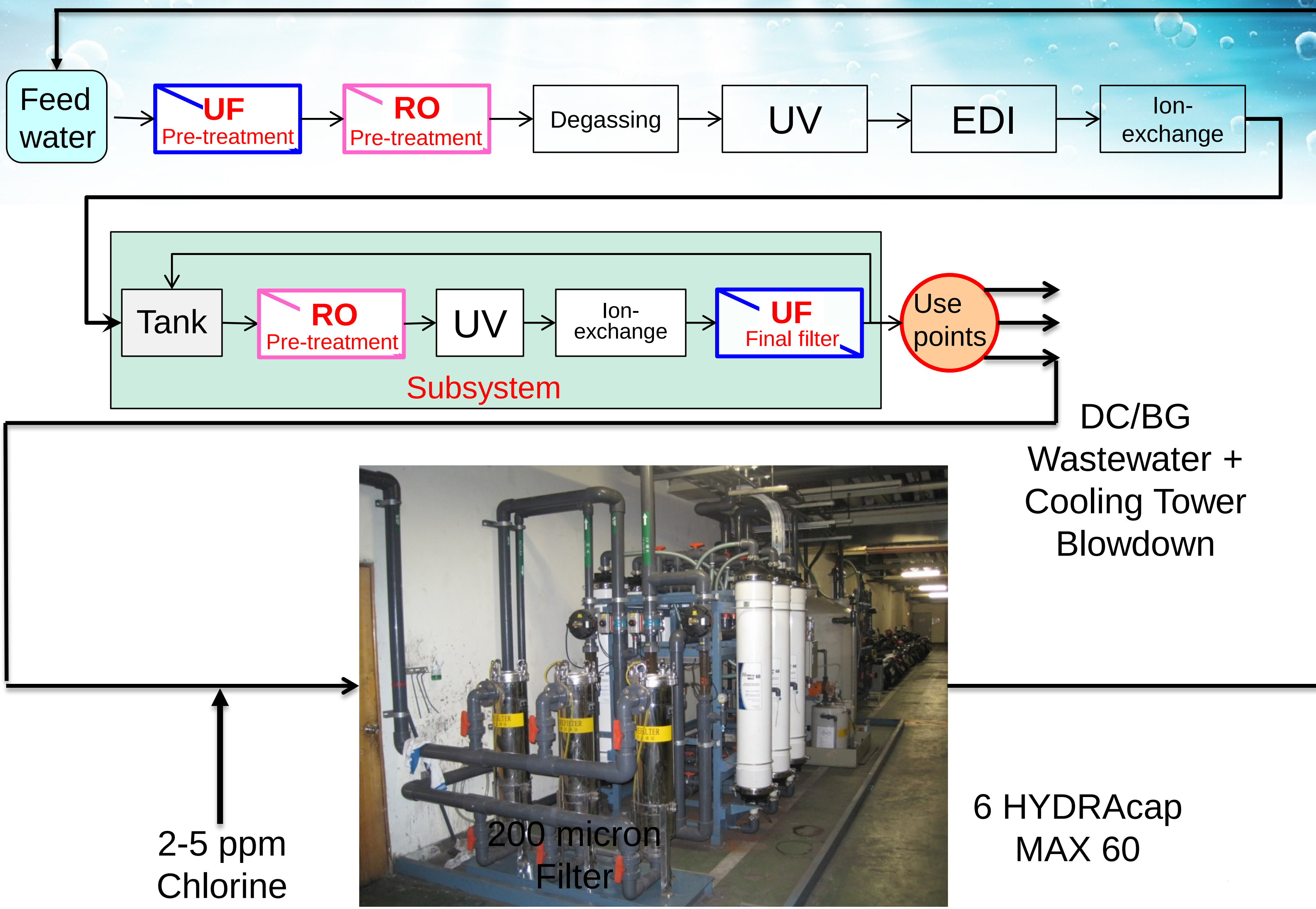


- Flux ~ 20 gfd
- Stable TMP – Avg. 4 psi
- Consistent Filtrate Turbidity

  <0.075 NTU



System 2 Overview

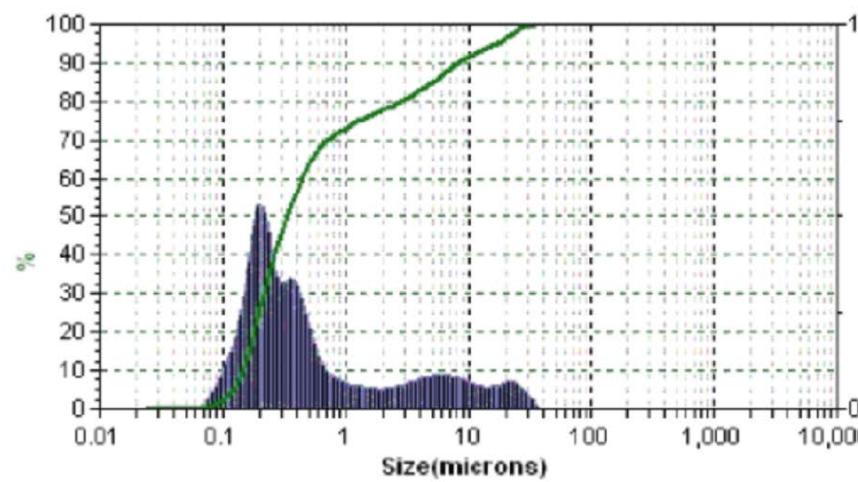


Case Study 2

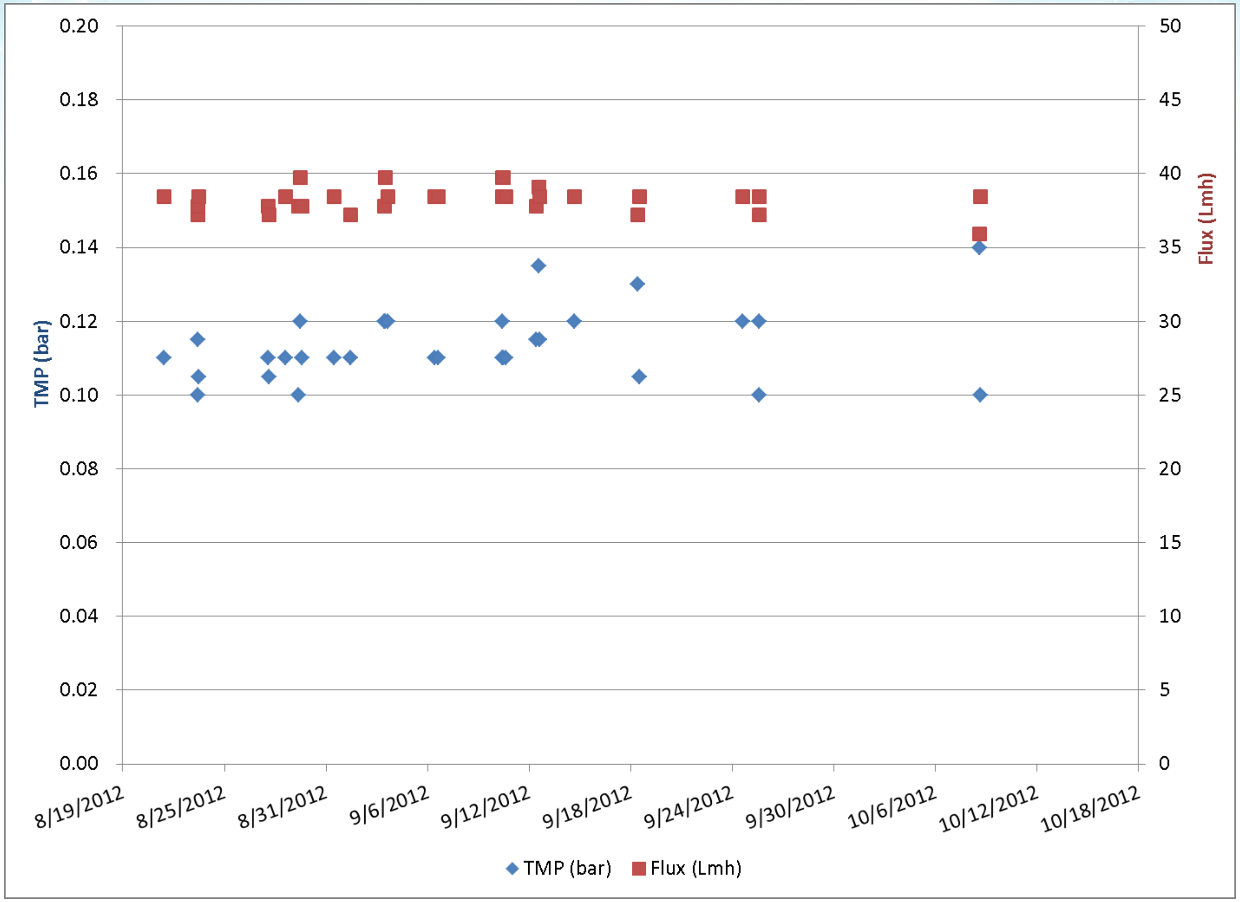
Parameter	Unit	Value
System capacity	m3/day	432
Module type		Hydranautics HYDRAcap® MAX 60
Number of racks		1
Number of modules per rack		6
Gross operating filtration flux	LMH	35-40
Concentrate bleed flow	m3/hr	1.5
Filtration cycle duration	min	45
Physical cleaning method		**Air scour with backwash**
Air scour flow rate per module	m3/hr	4
Chemical cleaning frequency		Two caustic maintenance cleans per day (0.1% NaOH)
System Recovery	%	~85

System 2 - Feed Water Quality

- Turbidity = 1100 NTU
- ~98% of particles larger than 0.1 micron



System 2 – Operating Performance



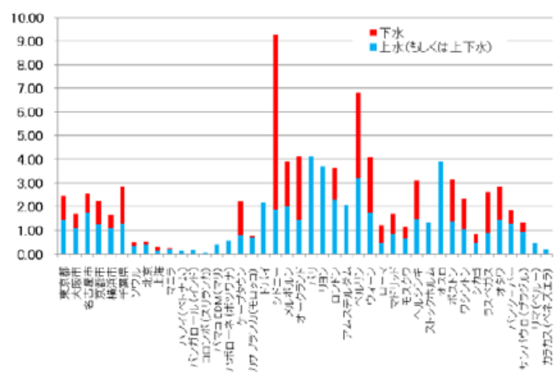
- Constant TMP ~ 2 psi
- 1st Year Filtrate Turbidity <0.1 NTU

System 2 - Module Autopsy

- After ~1 year of operation, turbidity exceed 0.1 NTU
- Tensiometry revealed slight strength decline
    - Most likely due to improper draining

System Cost Comparison

	Without Reuse	With Reuse – BW Free Operation (System 1)	With Reuse – Operation with BW (System 2)
Source Water and Sewer Cost - $/mo.	8,140.31	1,866.24	2,214.80
Chem Cost - $/mo.		128.65	128.65
Energy Cost - $/mo		129.60	129.60
Operator - $/mo		1,200.00	1,200.00
Total ($/mo)	8,140.31	3,324.50	3,673.06
Difference ($/mo)		4,815.81	4,467.25
System Cost		< $150,000	$150,000
Simple Payback Period		< 31 months	33.6 months



Conclusions

- Backwash free operation is capable of sustaining stable permeability, even when treating very high feed water turbidity
- Advantages of BW free system
  - Reduced OPEX through increased recovery
  - Reduced CAPEX through elimination of BW pump, tank, associated piping
- Proper drain piping arrangement critical

Conclusions

- BG/DC WW can be segregated from other use point wastewaters to optimize reuse potential and reduce CAPEX of primary UPW system by decreased equipment sizing
- Test operation without concentrate bleed
  – Payback period reduced by ~0.5 months for every 1% increase in recovery