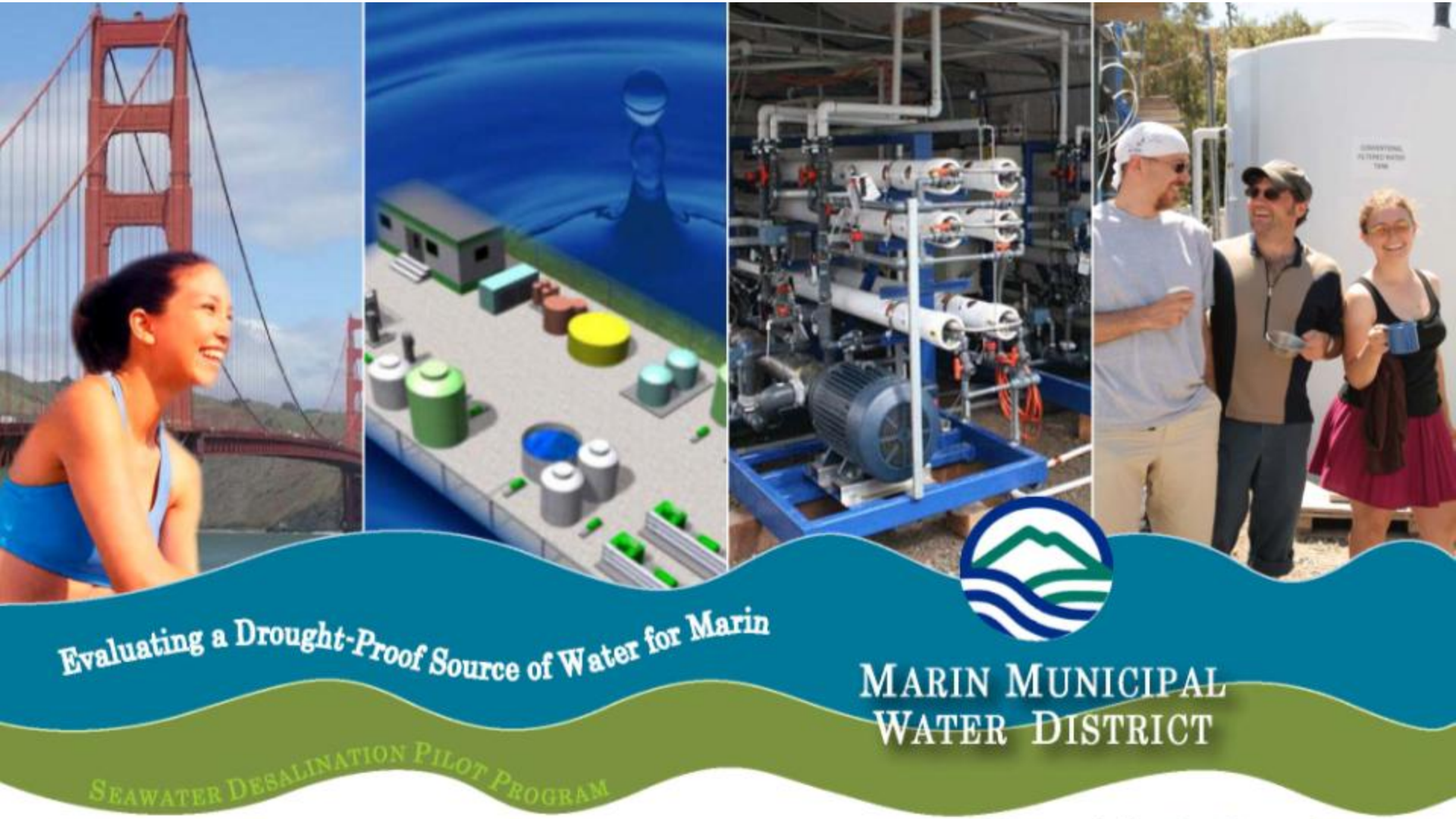
Conventional vs MF/UF Pretreatment for SWRO Desalination



PNWS AWWA Annual Conference
8 May, 2009

Kennedy/Jenks Consultants
Engineers & Scientists
in association with
CH2MHILL

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- Co-Authors
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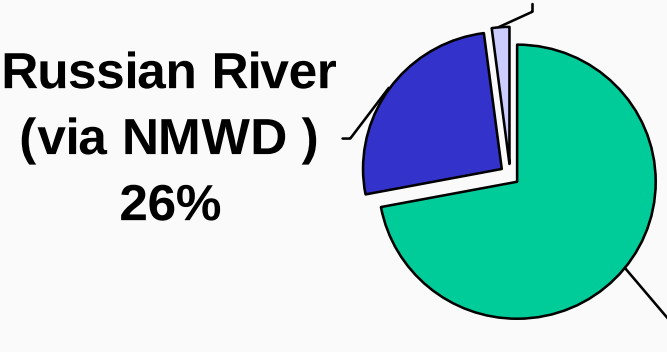
- Marin Municipal Water District
  - Bob Castle, PE – Water Quality Manager
  - Paul Sellier, PE - Water Quality Engineer

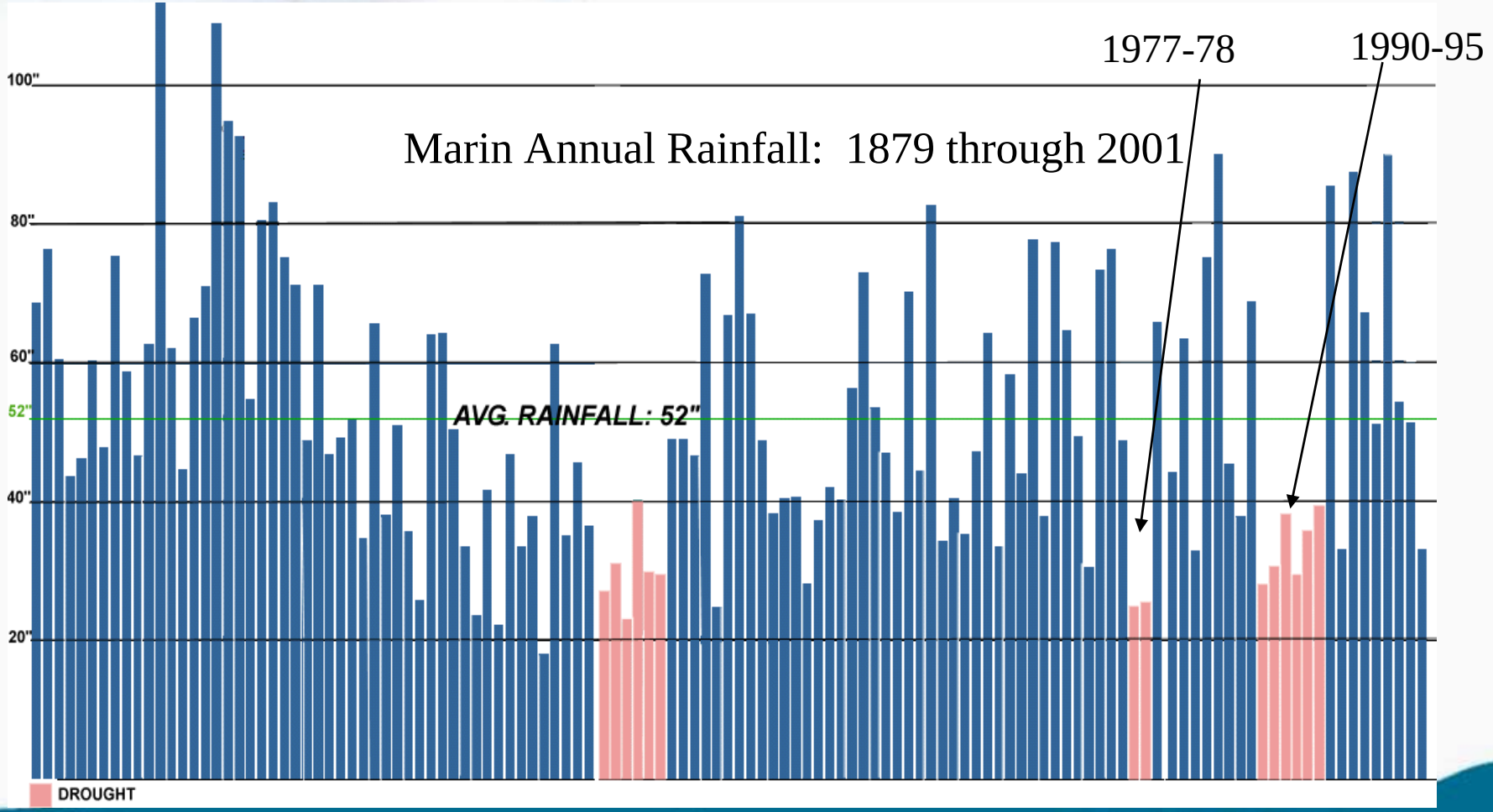
Presentation Overview

- Project Background
- Overview of Desalination Pilot Program
- Source Water Quality
- Intake and Strainer System
- Conventional Pretreatment
- MF/UF Pretreatment
- Comparison of Pretreatment

MMWD's Current Water Supplies



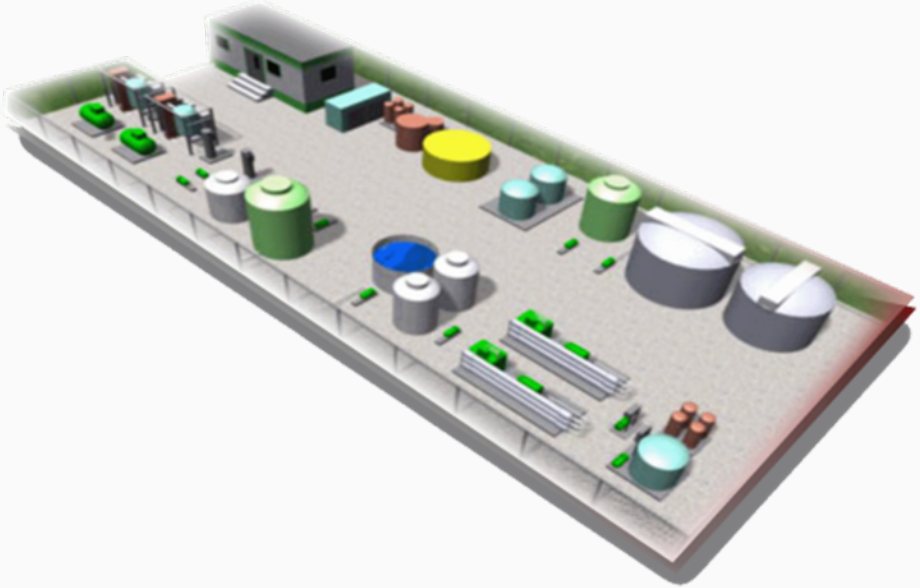
All MMWD Water Supplies are Impacted by Drought



Desalination is a Drought-Proof Water Source

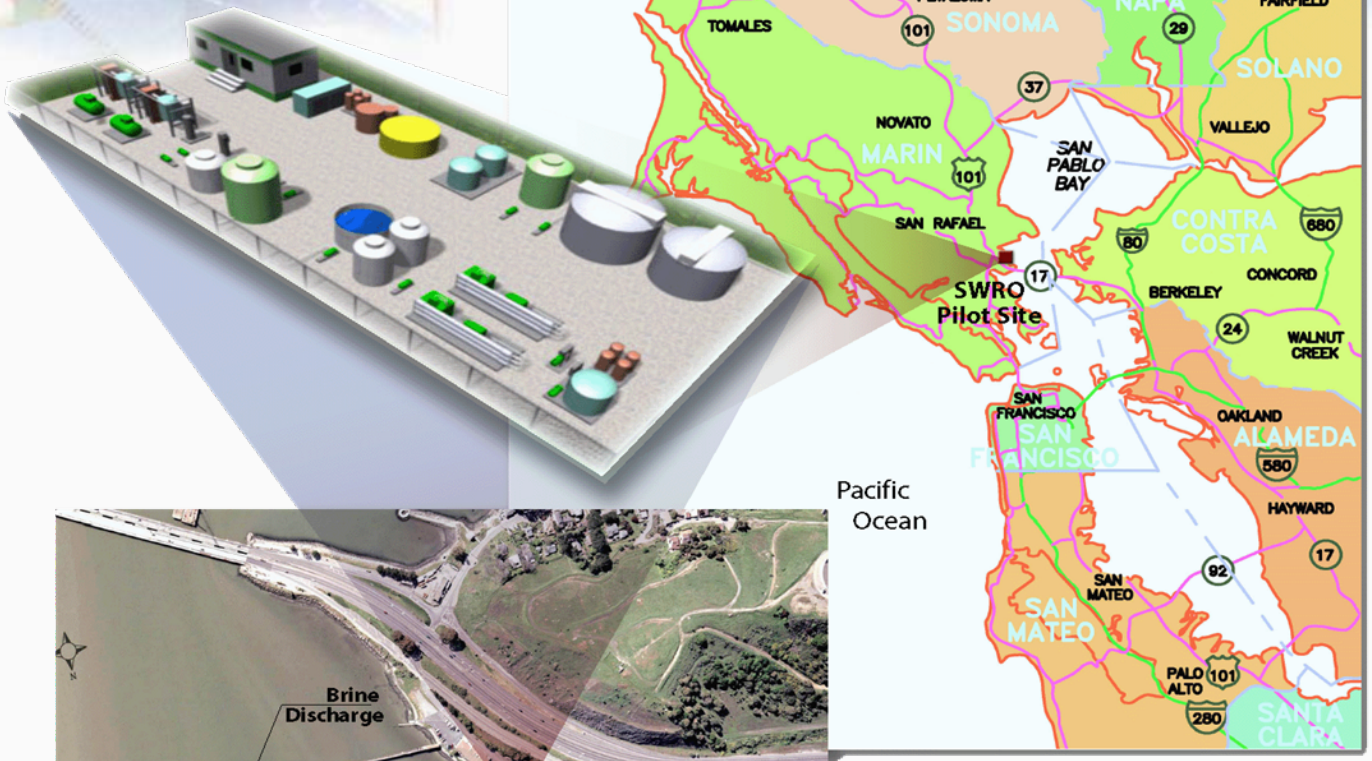
MMWD Seawater Desalination Pilot Program Objectives

- Demonstrate high quality drinking water
- Conduct environmental studies
- Evaluate advanced treatment technologies
- Familiarize the public with desalination



Marin Municipal Water District

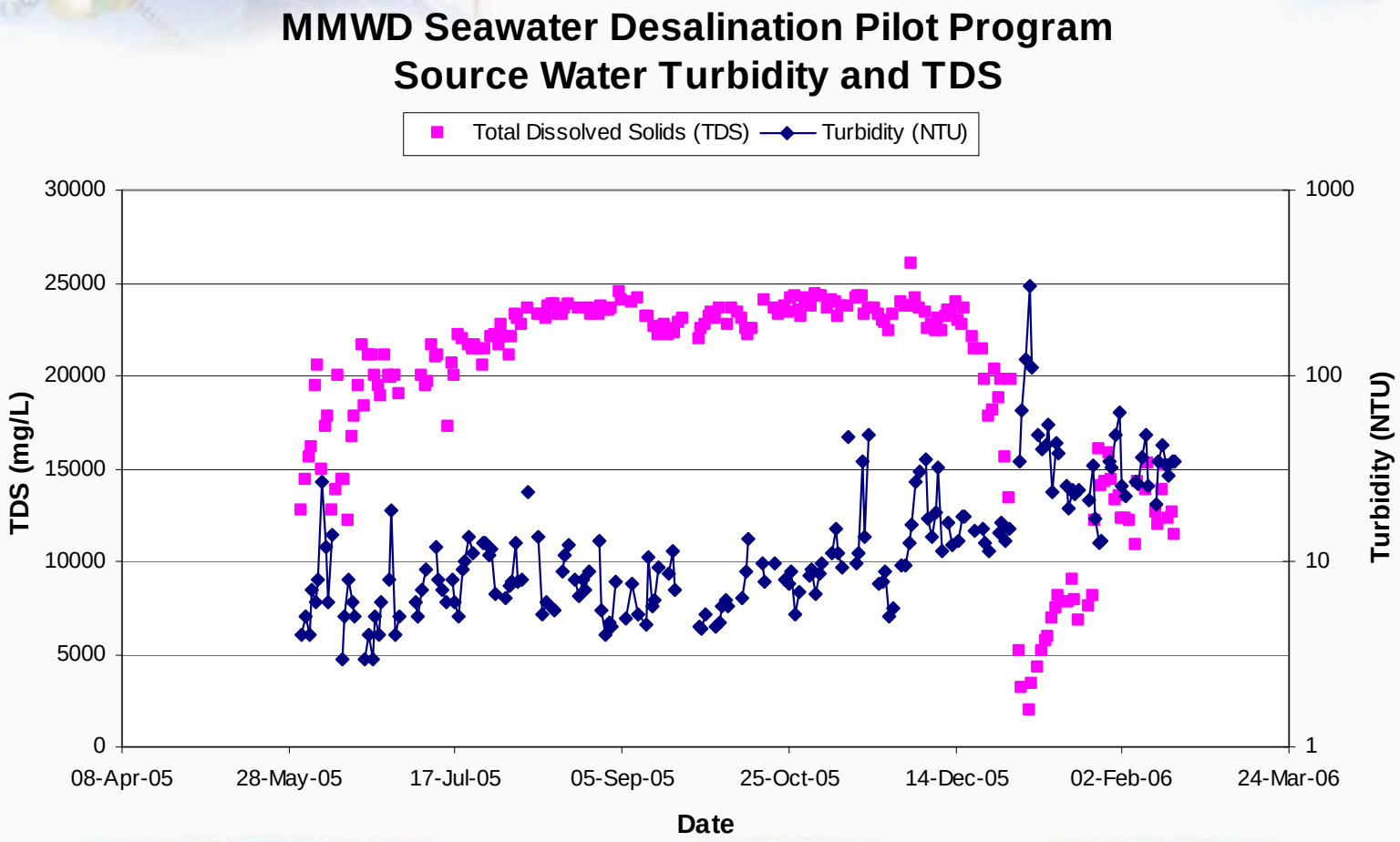
MMWD Desalination Pilot Plant



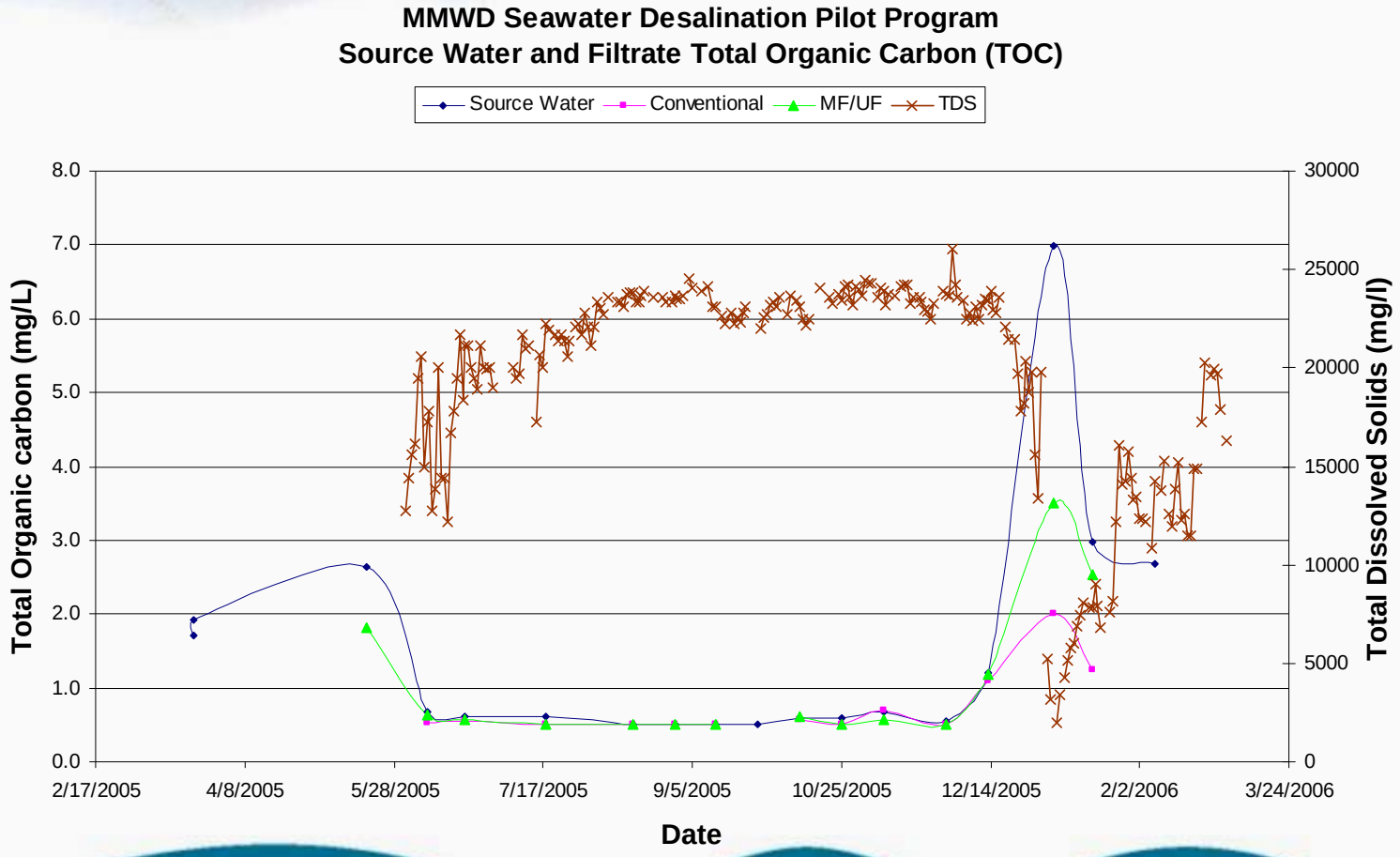
Dynamic and Complex Source Water

- San Francisco Bay is the largest estuary on the West Coast
- Bay Water is a mix of:
  - Ocean Water
  - Delta Water
  - Storm Water Runoff
  - Municipal and Industrial Discharges
- Water quality varies seasonally and diurnally

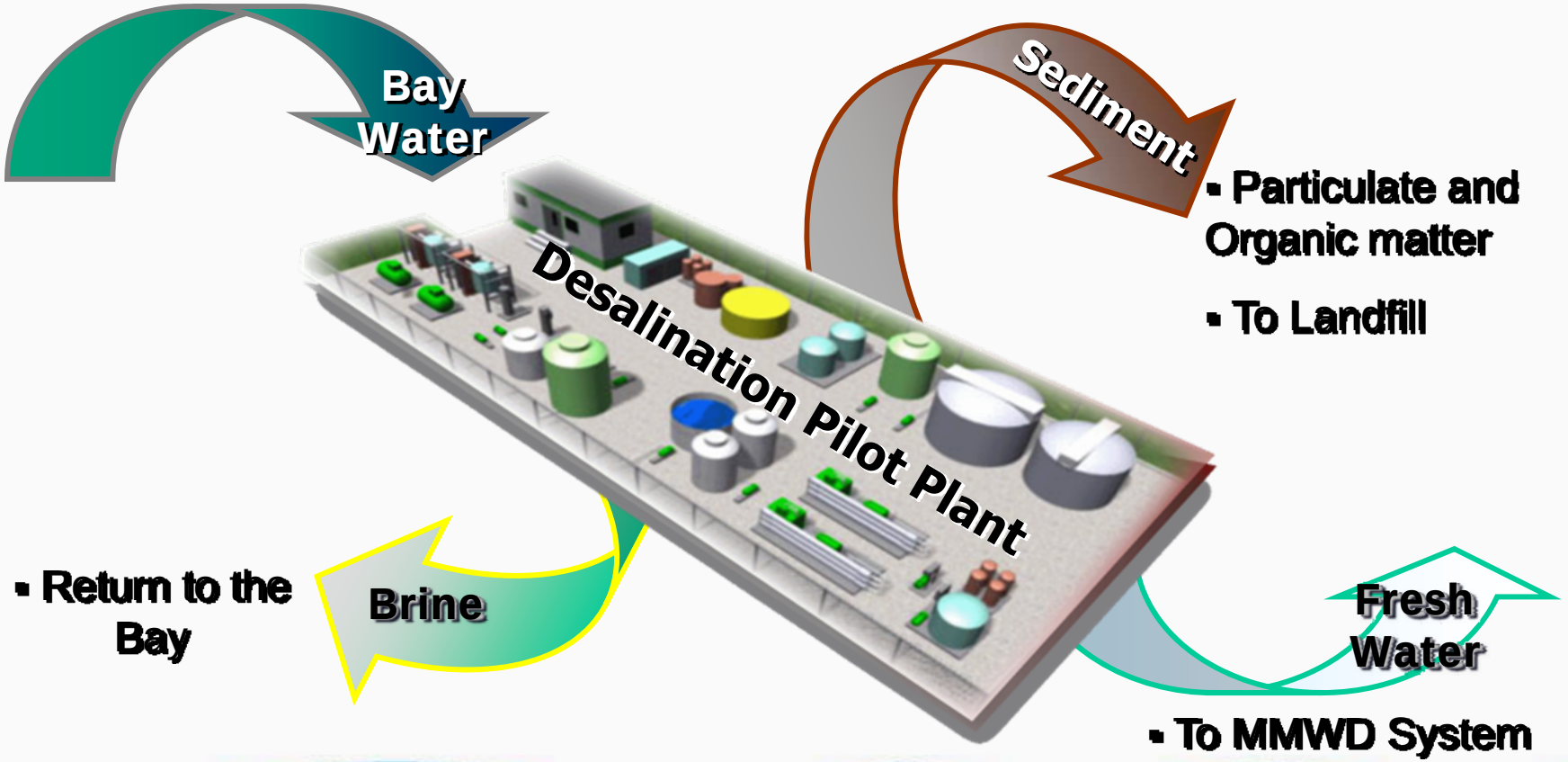
Salinity and Turbidity Vary Diurnally and Seasonally



Source Water Organics Vary with Freshwater Runoff in Bay



MMWD Desalination: From Bay Water to Drinking Water



Step 1 - Intake Screening

- Designed to meet Federal and State criteria (316b) for fish protection
  - 3/32-inch openings
  - <0.3 fps velocity
  - airburst cleaning
- Removes large particles and debris

Feed Strainers Reduce Solids Loading and Protect MF/UF Systems

- Bollfilter - 100 micron Wedgewire Strainer
  - Stainless steel
  - Water backwash
- Arkal - 100 micron Disk Strainer
  - Plastic disks and body
  - Air or water backwash

Disk strainer provides better water quality with easier maintenance

100 micron Wedgewire Strainer

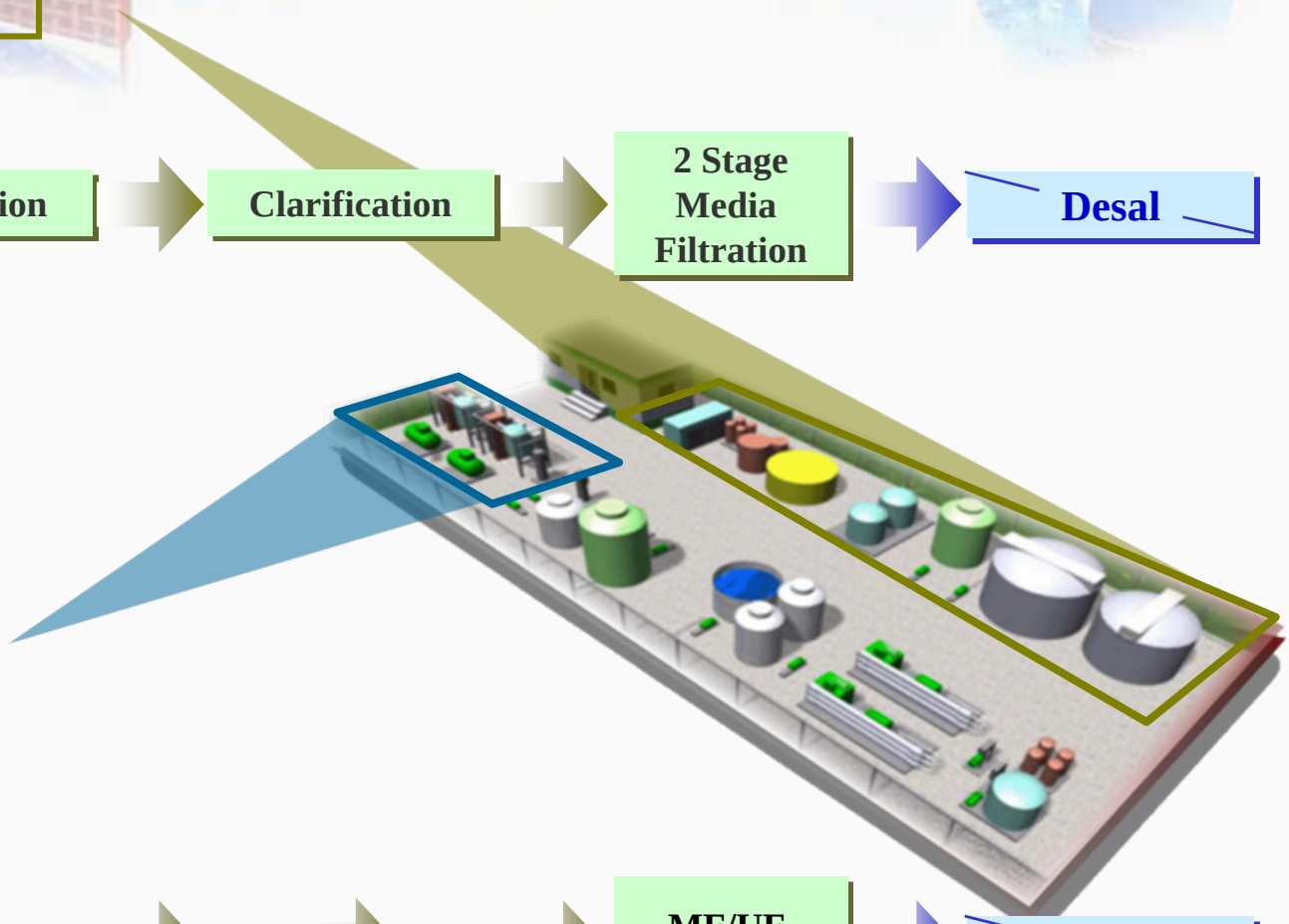
100 micron Disk Strainer

- Parallel 2-hr clogging capacity test of strainer effluent
- Disk Strainer effluent contained fewer solids
- Disk strainer permitted easy access to strainer elements
- Plastic materials for corrosion resistance

Step -2 Pretreatment Processes

Conventional Pretreatment

Seawater → Coagulation → Flocculation → Clarification → 2 Stage Media Filtration → Desal



MF/UF Pretreatment

Seawater → Strainer → MF/UF Filtration → Desal

Conventional System Parameters

Process	Pilot Plant Characteristics	Loading Rate (gpm/ft2)	HDT (min)/ Dose (mg/l)
Flocculator	Center flocculation paddle mixer, 5-ft water depth.	N/A	14.8
Clarifier	Cone bottom clarifier with tube settlers 2-ft deep	0.45 to 0.6	60.0
Filter #1	36-inches of anthracite with an effective size of 1.0-1.1 mm	3 to 4	N/A
Filter #2	24-inches of silica sand with an effective size of 0.45-0.65 mm 12-inches of garnet having an effective size of 0.18-0.28 mm	3 to 4	N/A
Filter BW	Backwash frequency from 18 to 48 hours. Backwash is set for 5 minutes with filter to waste for 5 minutes.	17.7	N/A
Coagulant	Ferric Chloride	N/A	12 - 30
Polymer	PolyFloc – Coagulant Aid	N/A	0.5

Conventional Treatment

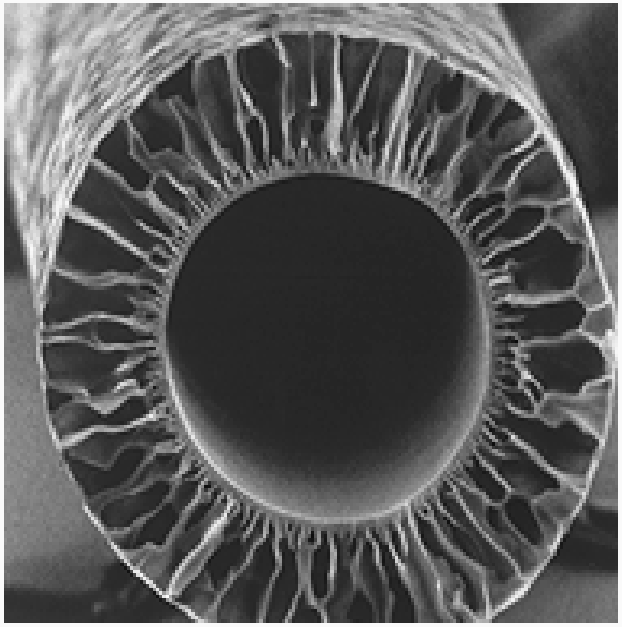
- Requires proper coagulation and clarification conditioning of source water
- Particles removed by sedimentation/clarification and depth filtration
- Sensitive to changes in source water quality (change in coagulant dose)
- Provides TOC reduction in RO feedwater
- Does not require feed strainer (although strainer may be beneficial for biological control)

MF/UF System Parameters

Parameter	Units	MF System	UF System
Membrane Configuration	--	Submerged	Submerged
Membrane Flow Path	--	Outside-In	Outside-In
Membrane Nominal Pore Size	microns	0.2	0.04
Membrane Material	--	PVDF	PVDF
Membrane Area	ft^2/element	272	450/600
Instantaneous Flux	GFD	25 to 40	25 to 36
Recovery Average	%	95	95
FOULING MANAGEMENT			
Backwash	Frequency	22- 30 minutes	25-30 minutes
Chemical Wash (CW)	Frequency	Daily	Daily
CW Duration	minutes	30	15
CW Chemical	Chemical / Dose (mg/l)	NaOCl/ 200	NaOCl/ 50
Cleaning-In-Place (CIP) Objective	Frequency	> 45 days	> 45 days

MF/UF Membrane Treatment

- Particles removed by physical straining (no coagulant required)
- Filtered water solids independent of source water variation
- Requires feed strainers
- Provides minimal TOC reduction to RO feedwater (no coagulation)
- Requires bisulfite to ensure no chlorine in RO feedwater from daily maintenance washes



Step 3 - Reverse Osmosis Desalination

- Two parallel RO units
  - MF/UF Feed
  - Conventional Feed
- 8 to 10 gfd
- 40 to 50% recovery
- 3 parallel SWRO elements
  - Dow-Filmtec
  - Hydranautics
  - Toray/Koch
- Second Pass RO for stringent boron and sodium objectives

Step 4 - Post Treatment

- Calcium and bicarbonate added to match stability and taste of current MMWD water
- Disinfection similar to current MMWD practices
- MMWD customers find taste of Desal water as good as water from local reservoirs

Marin Independent Journal

MONDAY

H_2O taste test

MMWD's desalinated bay water beats Marin competition

Tastings dispel desal's bad reputation

Which water tastes best?

Pipeiine project could soon die

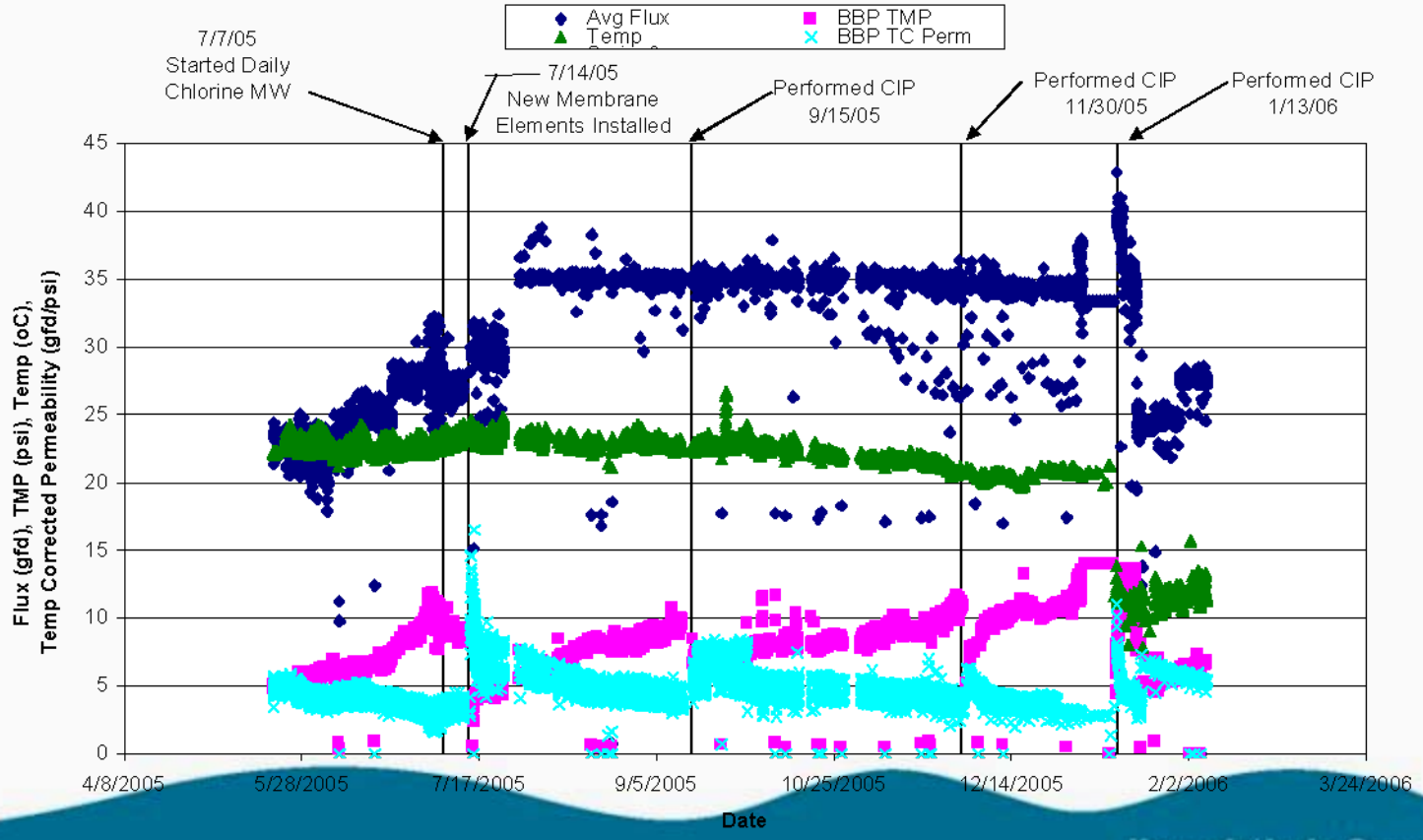
PIPE: Extension is sought

TASTE: Desalinated water wins

Comparison of Conventional and MF/UF Pretreatment Performance

Stable MF/UF operation - reduced flux during high turbidity winter storms

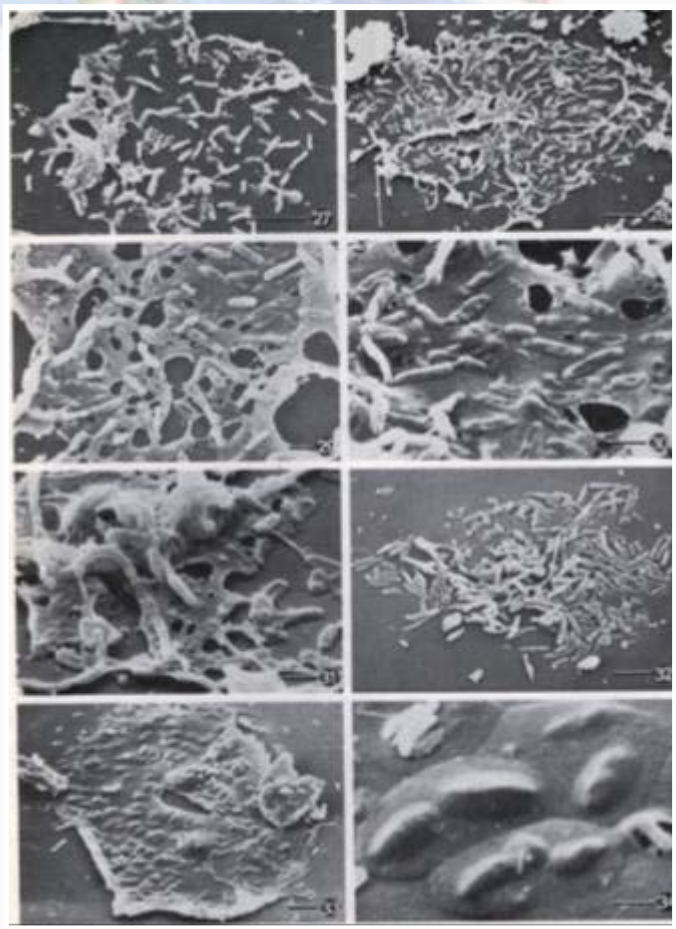
Figure 2.2
MMWD Seawater Desalination Pilot Program
UF System Flux, TMP, Temp and Temp Corrected Permeability



MF/UF Provides Better Solids Removal and lower SDI

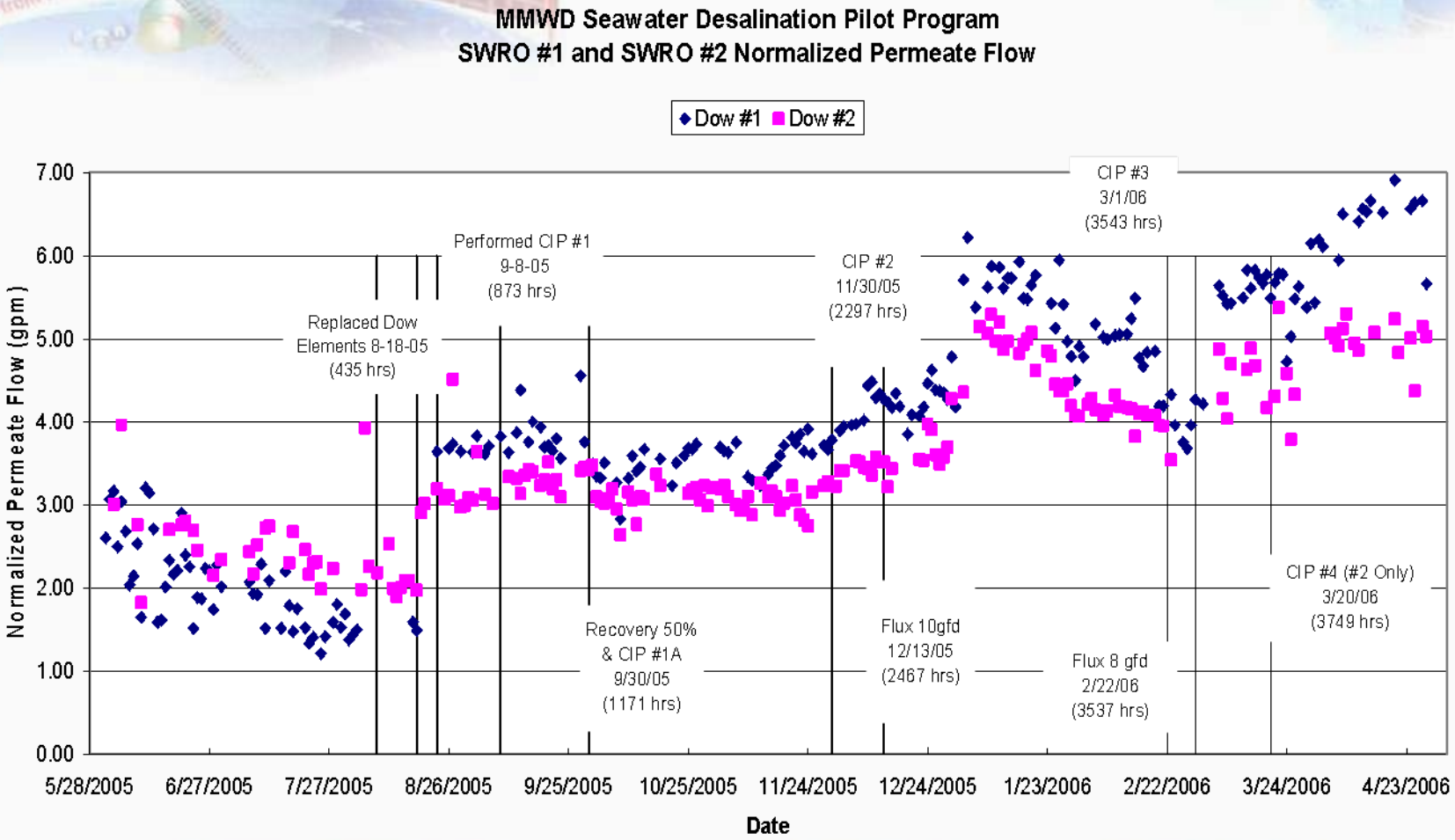
	Conventional Filtered Water	MF Filtrate	UF Filtrate
Average Turbidity	0.09	0.06	0.05
Average SDI	3.88	2.64	2.57
SDI Standard Deviation	0.55	0.51	0.49

Types of SWRO membrane fouling

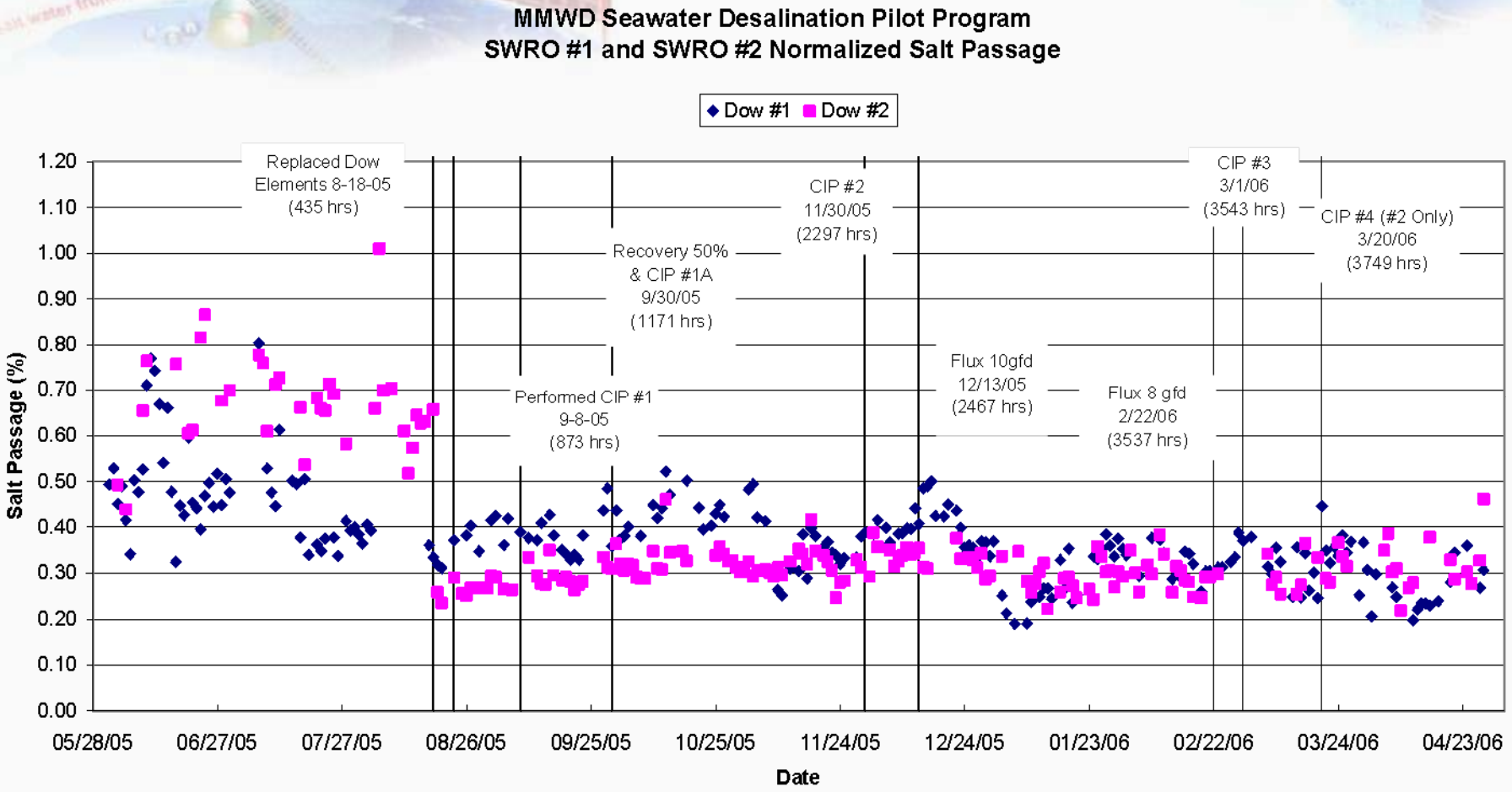


- Inorganic scale - control with antiscalant, system recovery
- Particulate fouling – minimize feed water turbidity and SDI
- Organic fouling – minimize feed water dissolved organics
- Biofouling – control with flux rate, shock Cl

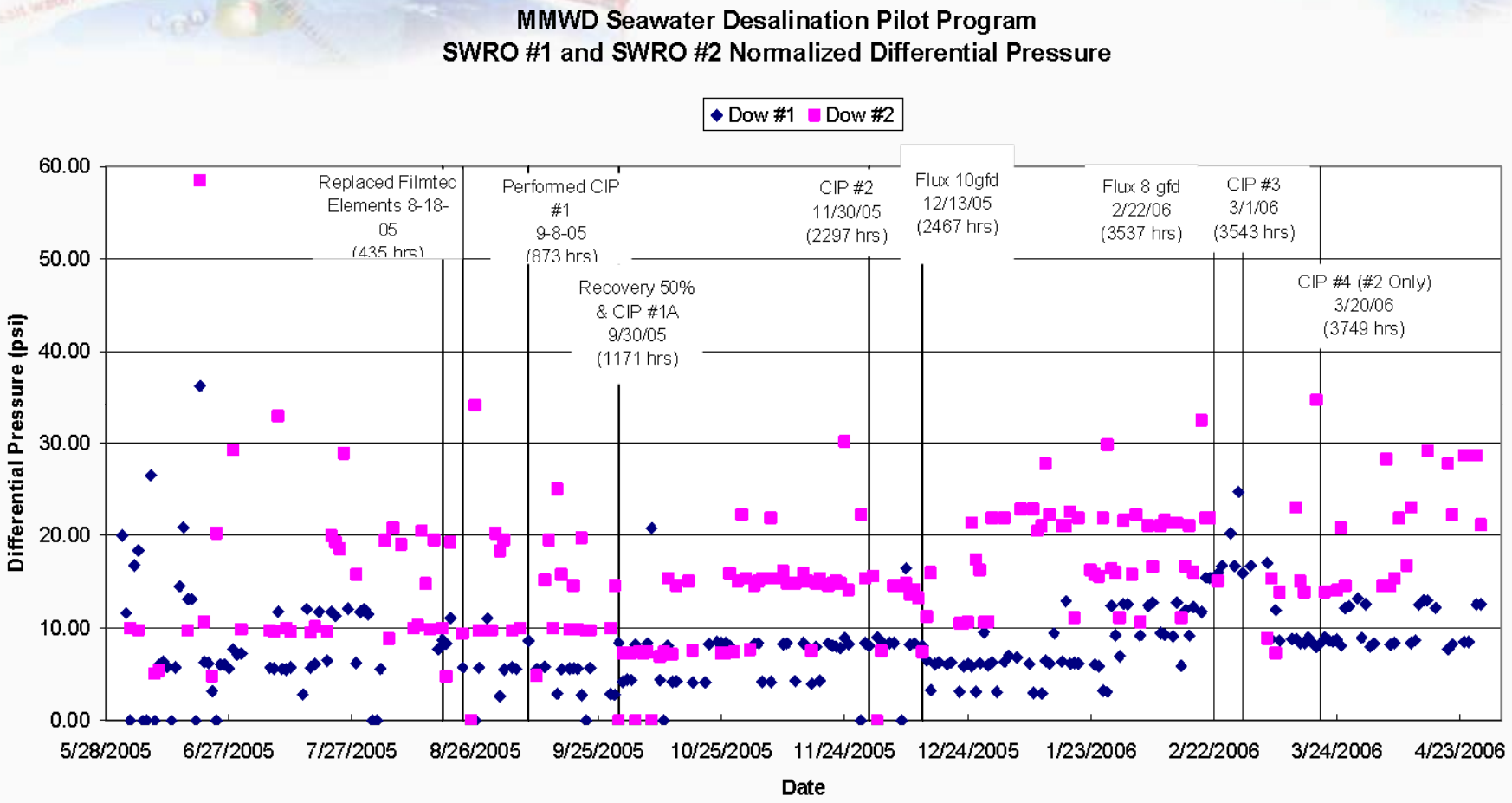
MF/UF SWRO has better permeate flow



Both systems show similar salt passage

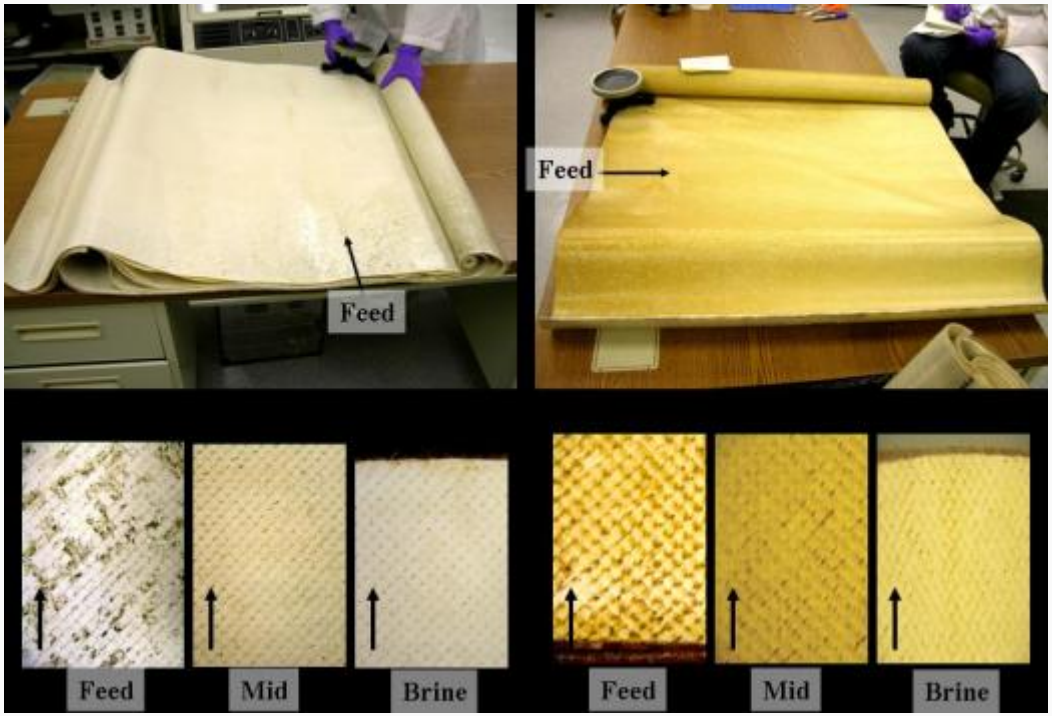


MF/UF SWRO has less fouling



Autopsy confirmed MF/UF SWRO has less fouling

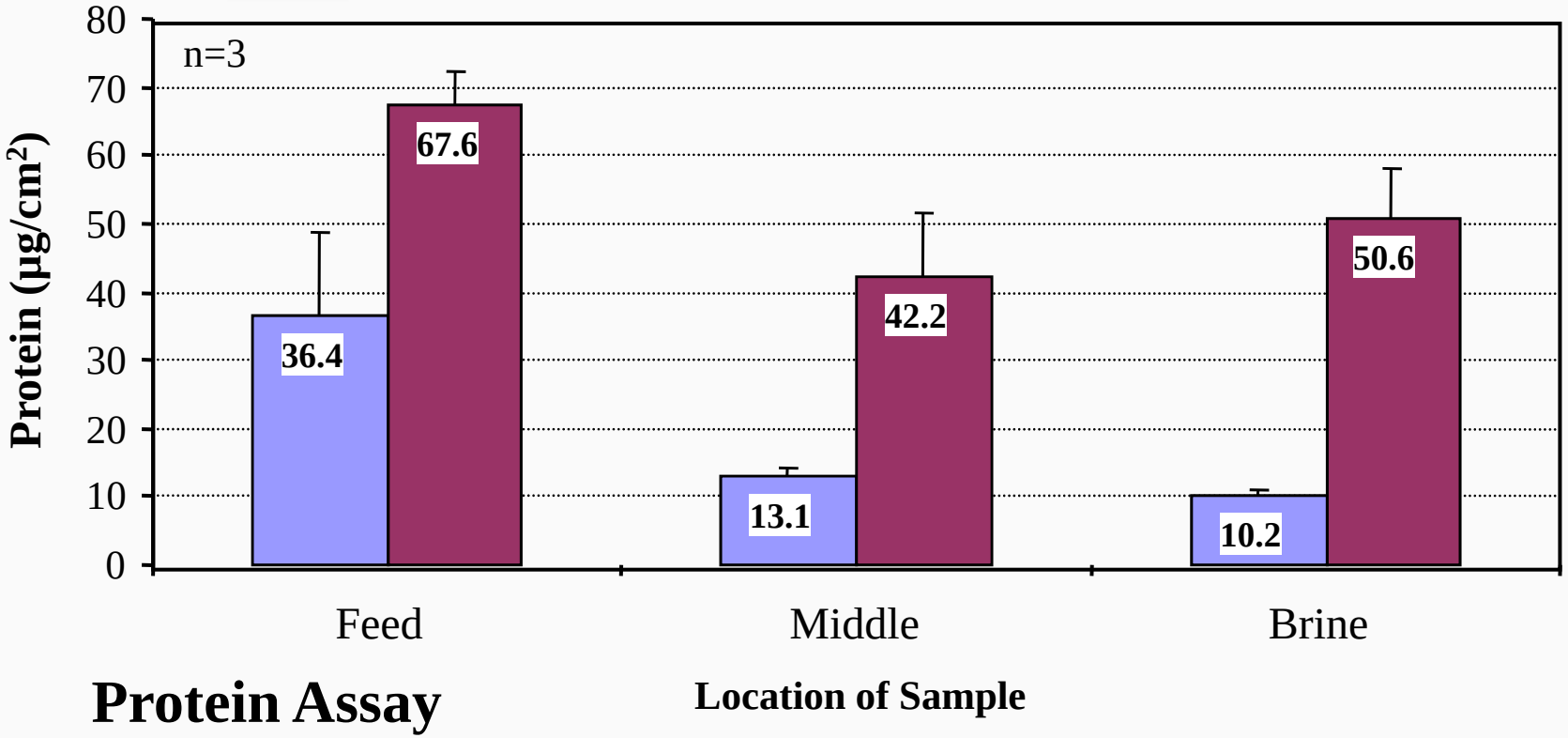
Photos of SWRO Membrane Visual Analysis



MF/UF Pretreatment

Conventional Pretreatment

MF/UF SWRO had lower particulate and organic fouling



MF/UF requires less area than conventional pretreatment

- For 10 MGD MMWD Desal Facility
- Conventional Pretreatment
  - Flocculation ~ 3,000 sf
  - Clarifiers ~7,000 sf
  - Filters ~14,000 sf
  - WW Recovery ~7,000 sf
  - **Total Area ~31,000 sf**
- MF/UF Pretreatment
  - Strainers ~2,000 sf
  - Flocculation ~2,000 sf
  - Membrane Bldg ~8,000 sf
  - WW Recovery ~2,000 sf
  - **Total Area ~14,000 sf**

MF/UF uses fewer process chemicals

- Conventional Pretreatment
  - ~2,200 to 4,500 lbs/day of ferric coagulant
  - ~100 lbs/day of polymer
- MF/UF Pretreatment
  - no coagulant required for suspended solids removal
  - ~2,000 lbs/day of ferric for periodic TOC reduction
  - ~200 lbs/day of ferric for spent MF/UF washwater coagulation and treatment
- MF/UF produces less solids for disposal
- Fewer chemical deliveries and solids off hauls

Advantages/Disadvantages with Conventional Pretreatment

- Advantages
  - Proven and familiar technology
  - Reduces organics along with suspended solids
  - Do not need feed strainer
- Disadvantages
  - More sensitive to source water challenges
  - Higher filtrate turbidity and SDI
  - Requires more space and process chemicals
  - More cartridge filter changes - every 2 to 3 months

Advantages/Disadvantages with MF/UF Pretreatment

- Advantages
  - Lower filtrate turbidity and SDI
  - Less particulate fouling of SWRO
  - Fewer cartridge filter changes – 4 to 5 months
  - Smaller footprint
  - Fewer process chemicals

- Disadvantages
  - Requires feed strainer
  - Requires bisulfite feed to protect SWRO
  - May require coagulation to address bio-fouling

MF/UF pretreatment system has lower capital and operating costs

- MF/UF capital costs are approximately 15 to 20-percent lower than conventional system
- MF/UF operating costs are approximately 5 to 10-percent lower than conventional system

MF/UF is recommended pretreatment for MMWD

- Better filtered water quality
- Increased reliability
- Less fouling of SWRO membranes
- Fewer process chemicals
- Smaller footprint
- Lower capital cost
- Lower operating cost

Questions and Answers