



**O-Day: Storming the  
Beaches of  
Ocean Shores-  
An Assault on Waves of  
Organics in the Water  
Supply**



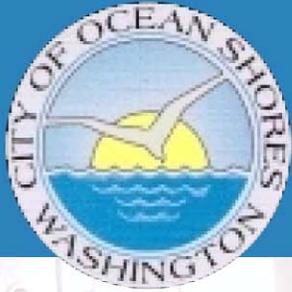
**Bill Persich, P.E.  
Brown and Caldwell  
PNWS-AWWA Annual Conference  
Salem, Oregon  
May 6-9, 2009**



# Couldn't Resist the D-Day Theme

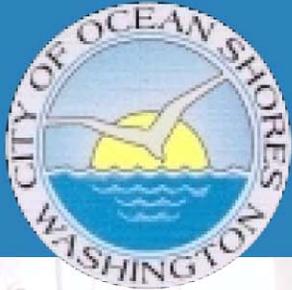
- **65<sup>th</sup> Anniversary Year**
- **Ocean Shores-a Beachfront Community**
- **Water Must be “Liberated” from Excessive Organics**
- **Waterworks Utilities Superintendent**  
*Miles Beach ---- his real name!*





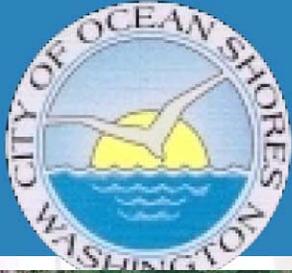
# Presentation Summary

- **Introduction and Background**
- **Two Pilot Plant Studies**
- **Full Scale Water Treatment System Preliminary Design**
- **Comparison of Alternatives**
- **Summary**



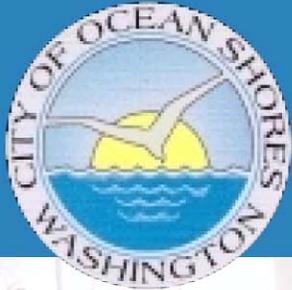
# Presentation Summary

- **Introduction and Background**
  - Overview of City's Current Water Supply System
  - Water Quality Concerns and Goals
- **Two Pilot Plant Studies**
  - Past Study for Greensand Filtration and MIEX
    - Description of Pilot Plant Facilities
    - Test Results
  - New Pilot Plant Investigation (Membranes)
    - Description of Pilot Plant Facilities
    - Test Results
- **Full Scale Water Treatment System Preliminary Design**
  - General Criteria
  - Greensand Filtration MIEX System
    - Design Criteria
    - Plant Features
    - Plant Layout
  - Membrane Based System
    - Design Criteria
    - Plant Features
    - Plant Layout
- **Comparison of Alternatives**
  - Cost Development Assumptions
  - Wastewater Handling Issues
  - Economic Comparisons
  - Non-economic Comparisons
- **Summary**



# Aerial View of Ocean Shores and Neighboring Communities



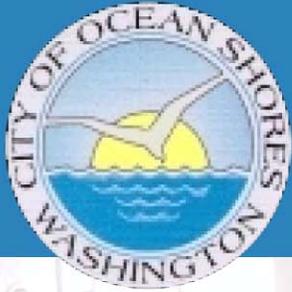


# Key Water Quality Issues for Shallow Aquifer Supply

- Iron and Manganese
  - Fixture and Laundry Staining
  - Unaesthetic Particulates
  - Chemically Complexed with Organics
- Disinfection Residual – hard to maintain
- Sulfides, Organic Nitrogen, etc.
- Organics – TOC 6-8 mg/L
  - Taste and Odor - **Yes!**
  - Disinfection Byproducts - TTHM-FP 270  $\mu\text{g/L}$
  - Color – 41 cu

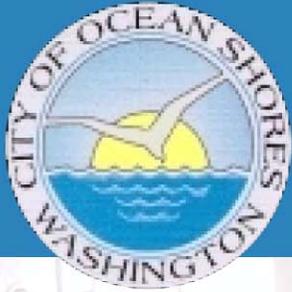


***Must Defeat Organics!***



# Shallow Aquifer Raw Water Quality and Finished Water Goals

Water Quality Parameter	Units	Measured Raw Water Values	Finished Water Quality Goal
Temperature	°C	12.5-14.4	-----
pH	-	7.86-8.16	Unchanged from raw water
True Color	color units	41	<1
Apparent Color	color units	36-43	-----
Taste/odor	-	presence	Non-detectable
Total Organic Carbon (TOC)	mg/L	6-8	1.4
Dissolved Organic Carbon (DOC)	mg/L	3.84-4.65	1.0
UVA (254 nm)	cm <sup>-1</sup>	0.198-217	0.030
SUVA (DOC/UVA)	L/mg-m	4.60-6.03	3.0
THM-FP	mg/L	0.214-0.276	≤0.080
HAA5-FP	mg/L	0.179-0.273	≤0.060
Chlorine residual	mg/L	<0.5	0.5
Iron	mg/L	0.6	≤0.3
Manganese	mg/L	0.05	≤0.05
Arsenic	mg/L	0.013	0.010
H <sub>2</sub> S	mg/L	presence	Non-detectable
TKN-N	mg/L	presence	1.0
NO <sub>3</sub> -N	mg/L	<0.2	10.0
NO <sub>2</sub> -N	mg/L	<0.2	1.0
Turbidity	NTU	1.06-4.43	0.1
Alkalinity	mg/L as CaCO <sub>3</sub>	280	-----
Conductivity	μS/cm	508-540	-----
Calcium Hardness	mg/L as CaCO <sub>3</sub>	20	-----
Total Hardness	mg/L as CaCO <sub>3</sub>	40	-----
Sulfate	mg/L	0.892	-----
Chloride	mg/L	65	-----

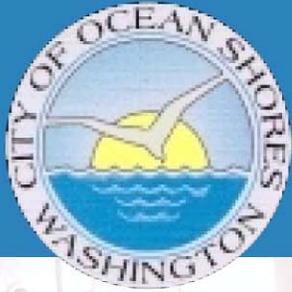


# Two Water Treatment Process Pilot Plant Studies

- Greensand Filtration/MIEX System
- Membrane Based System
  - Greensand Filtration/Nanofiltration Membrane
  - Ultrafiltration/Nanofiltration Membranes







# Greensand Filtration/MIEX Pilot Plant Test

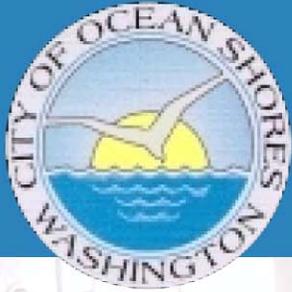
Testing Started:

September 27, 2005

Testing Completed:

December 12, 2005

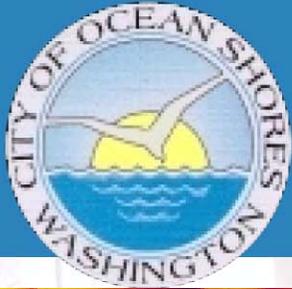




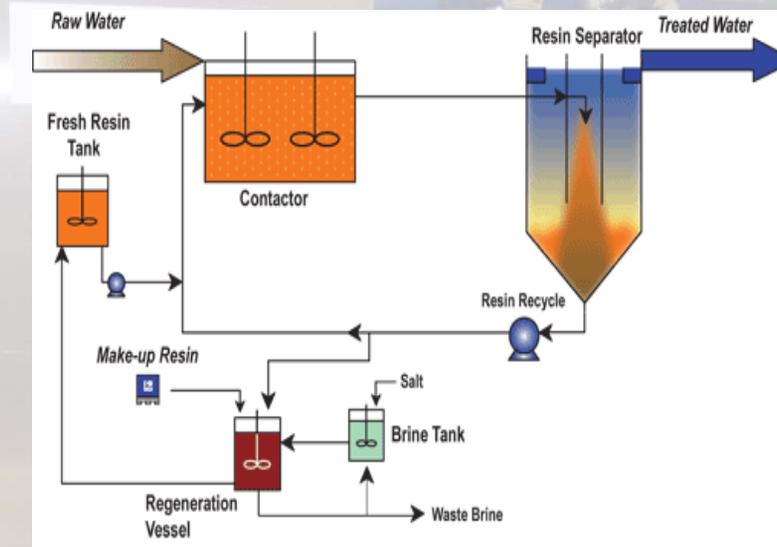
# Past Greensand/MIEX Pilot Plant Test

- **Pilot Plant Test Duration**
  - Testing Started: September 27, 2005
  - Testing Completed: December 12, 2005



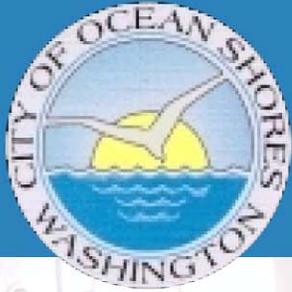


# MIEX® Dual Stage Treatment System

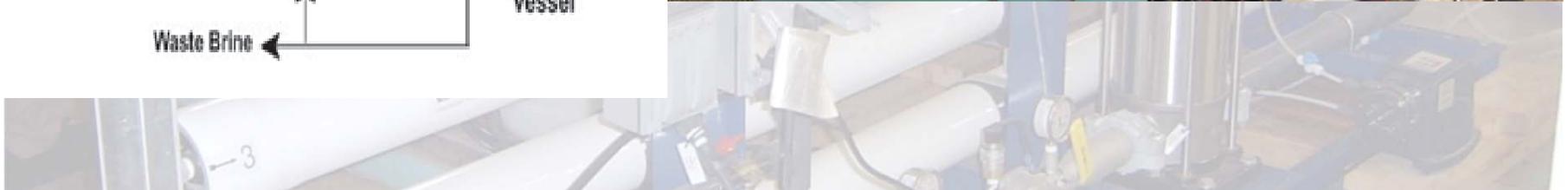
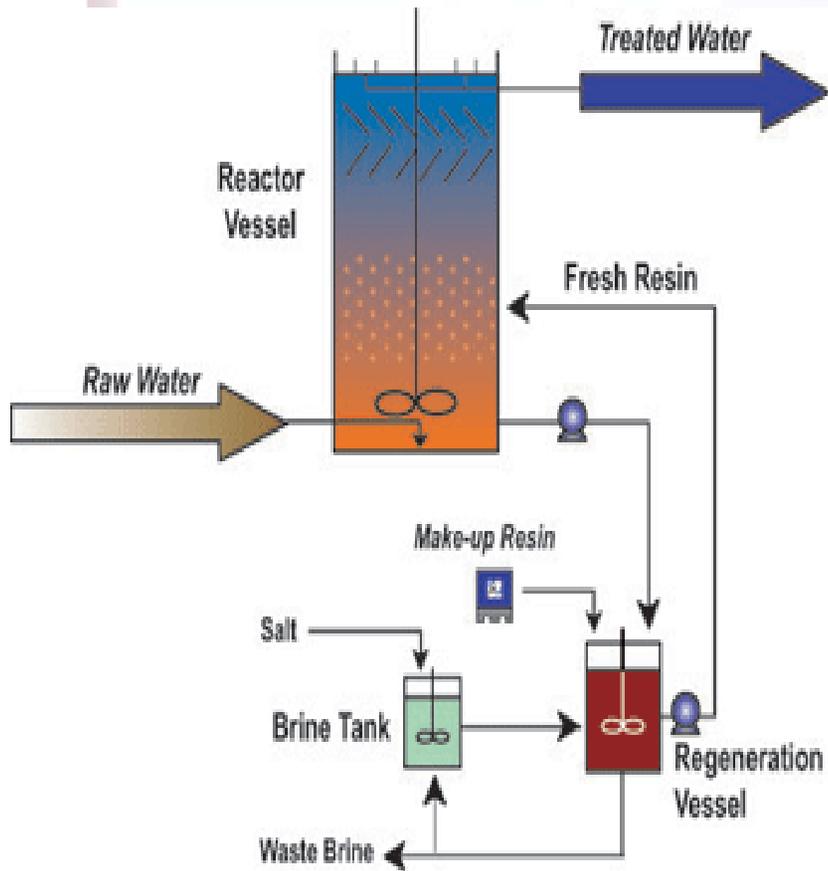


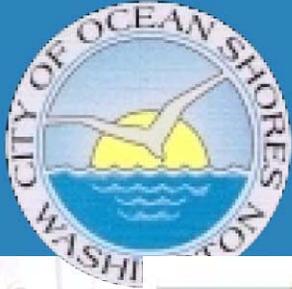
- MIEX Resin
  - Magnetic Ion Exchange
  - Anionic
  - Removes DOC
  - Proprietary





# MIEX® High Rate Fluidized Bed Treatment System



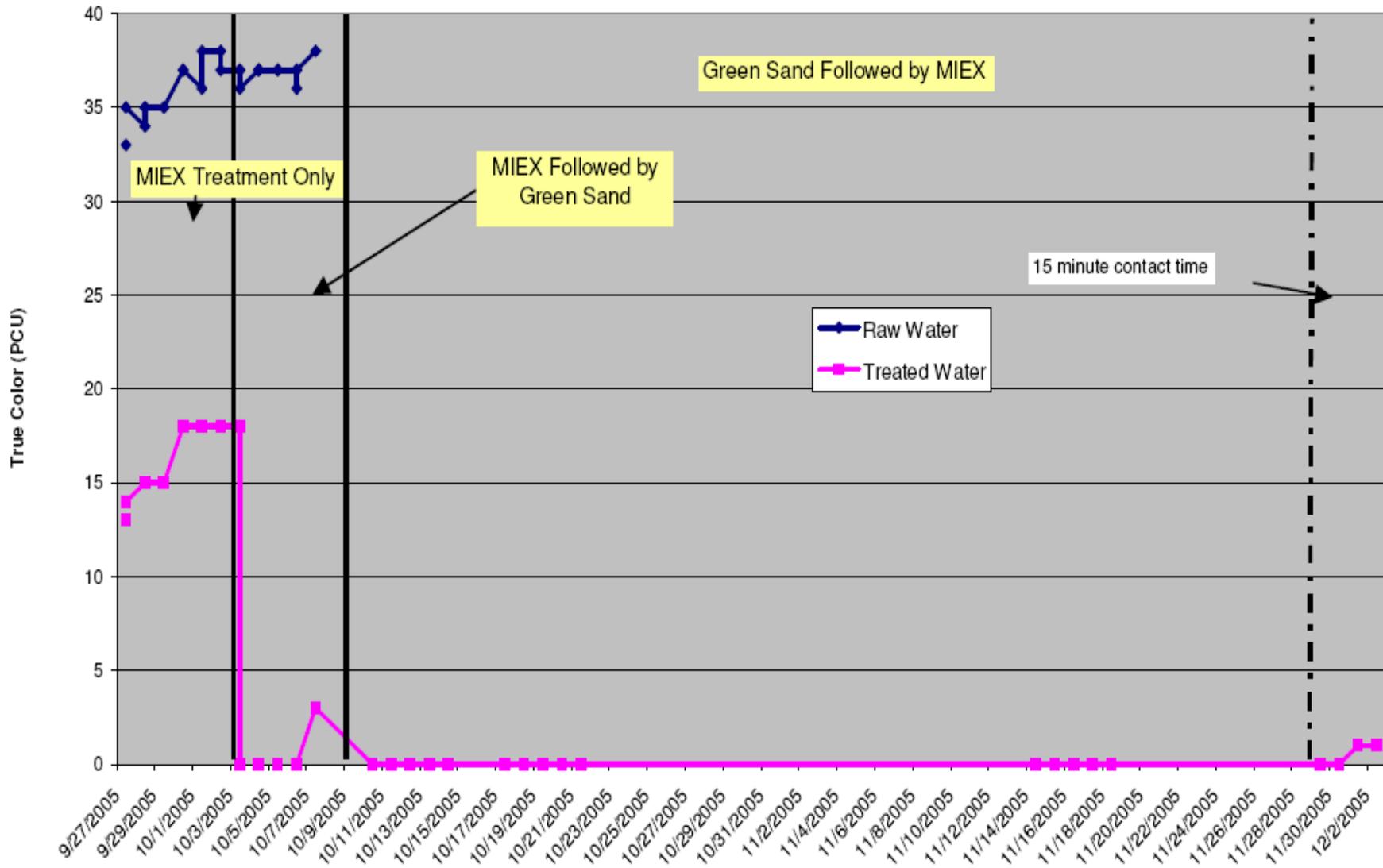


# MIEX Pilot Plant Test Facilities



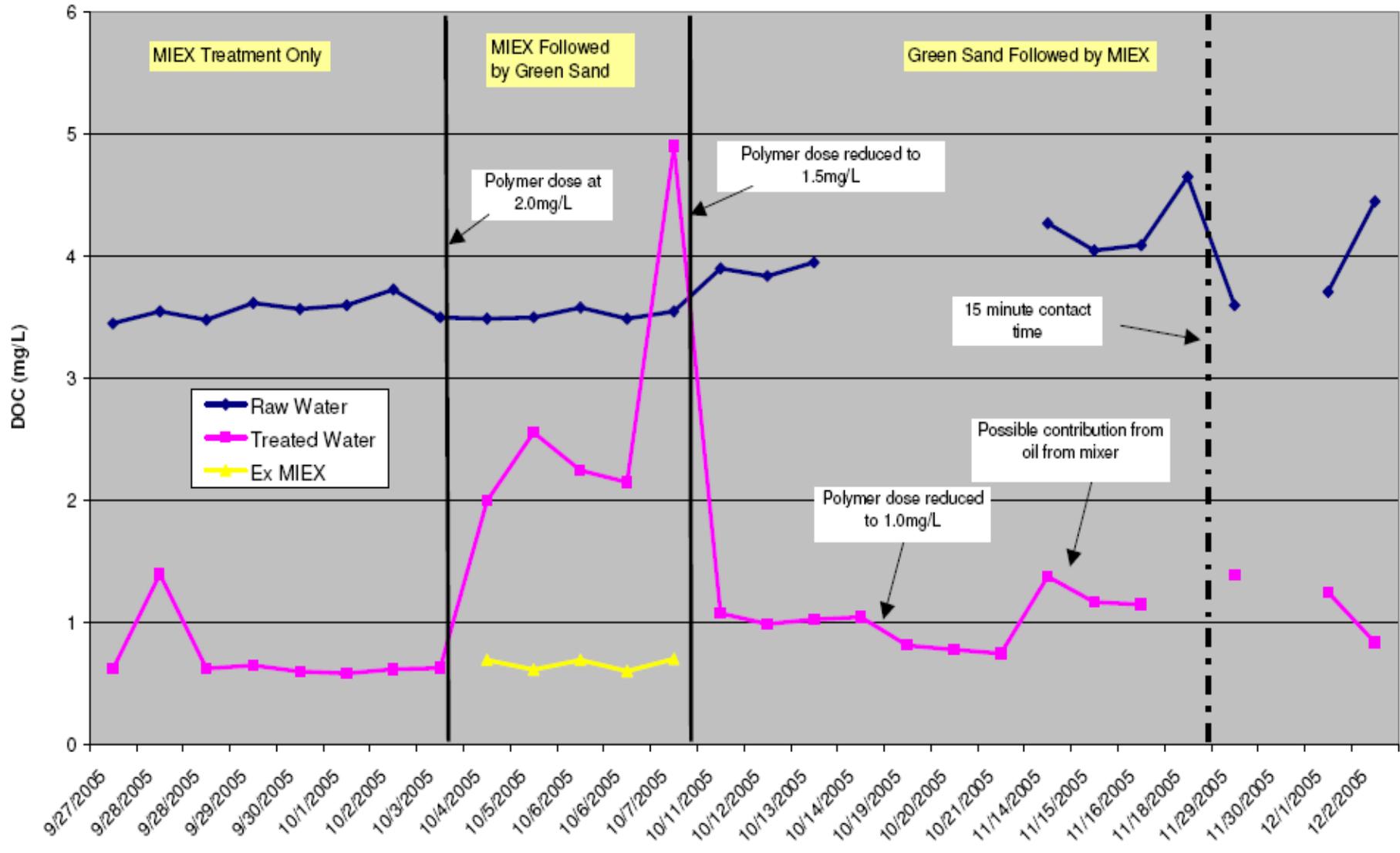


# Greensand/MIEX Process — Color Removal Results



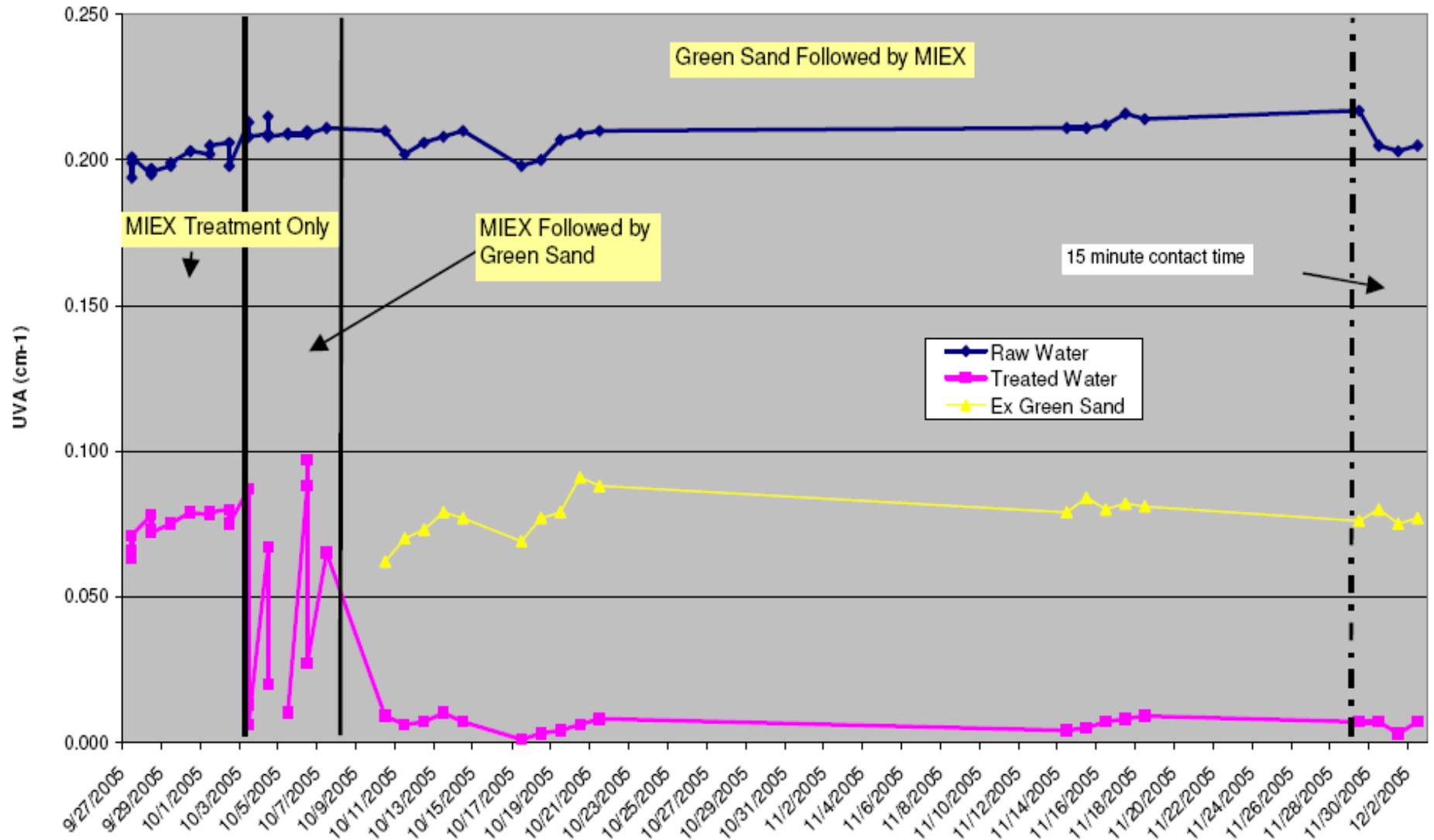


# Greensand/MIEX Process — DOC Removal Results





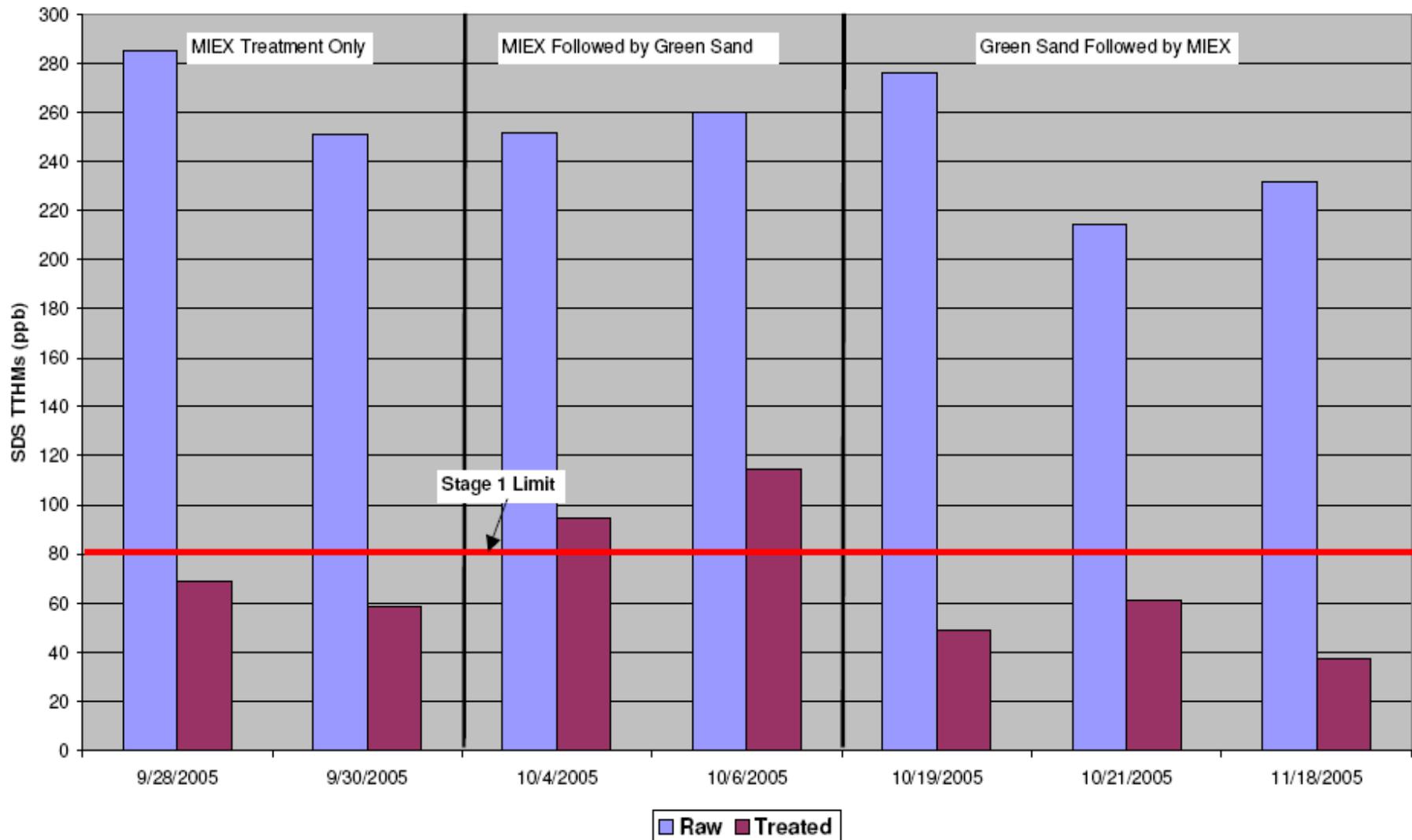
# Greensand/MIEX Process — $UVA_{254}$ Removal Results





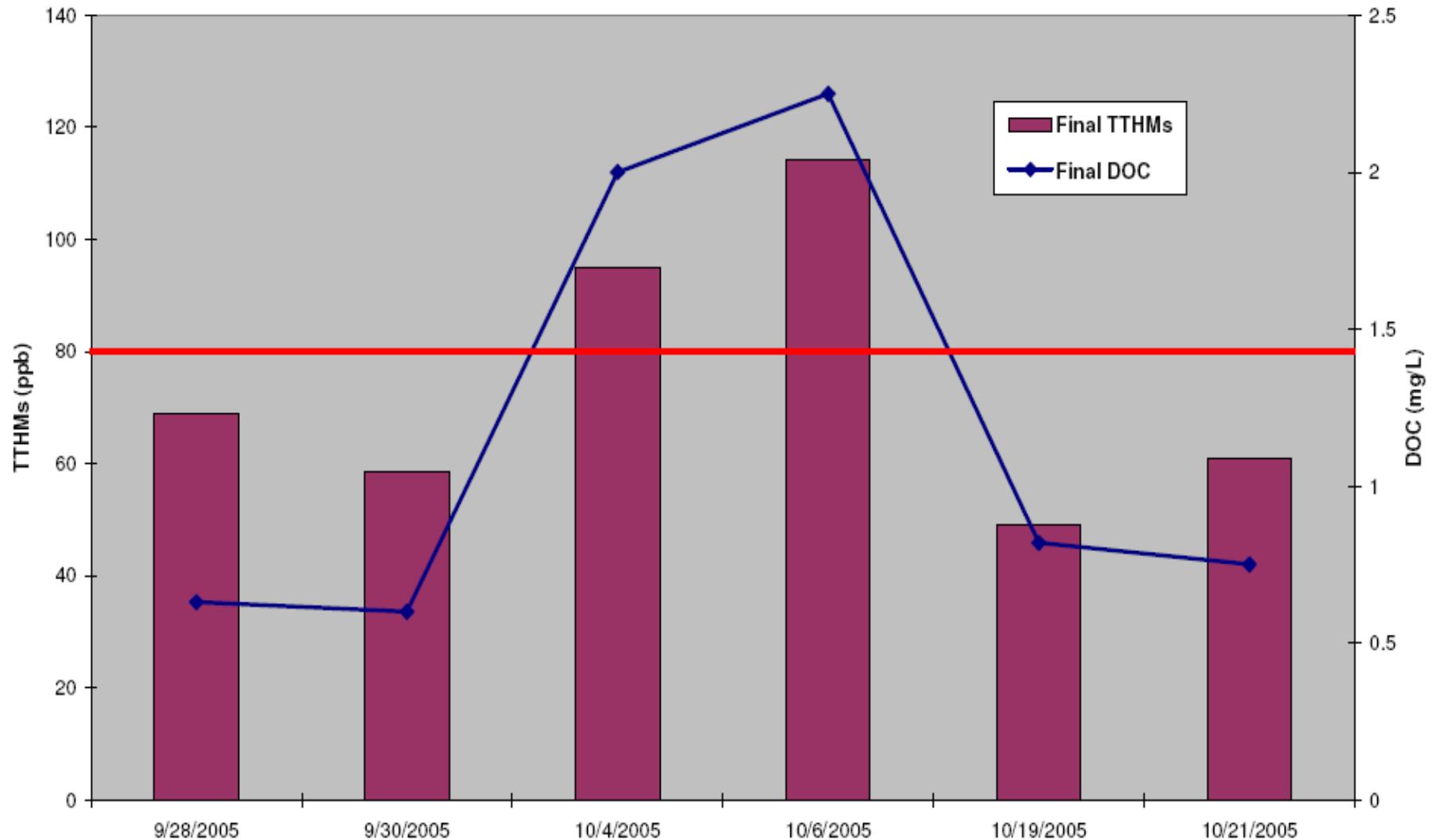


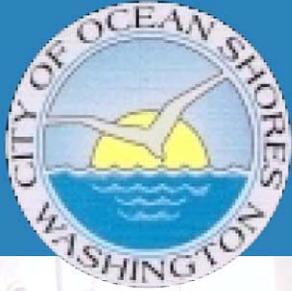
# Greensand/MIEX Process — SDS THM Results



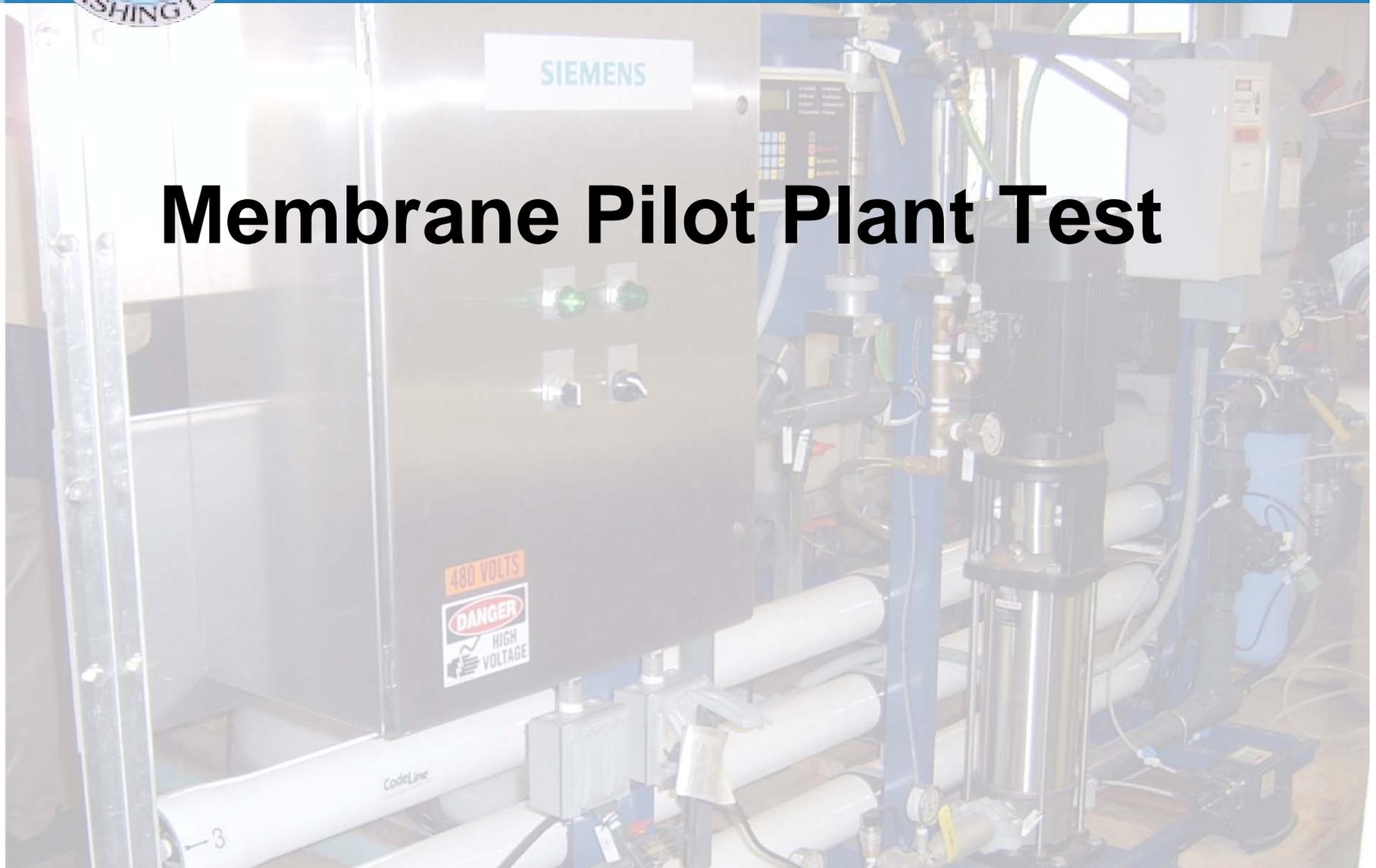


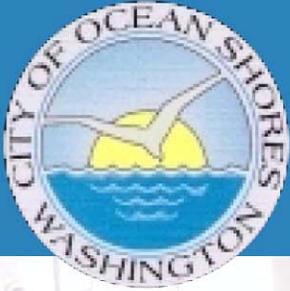
# Greensand/MIEX Process — THM versus DOC Results





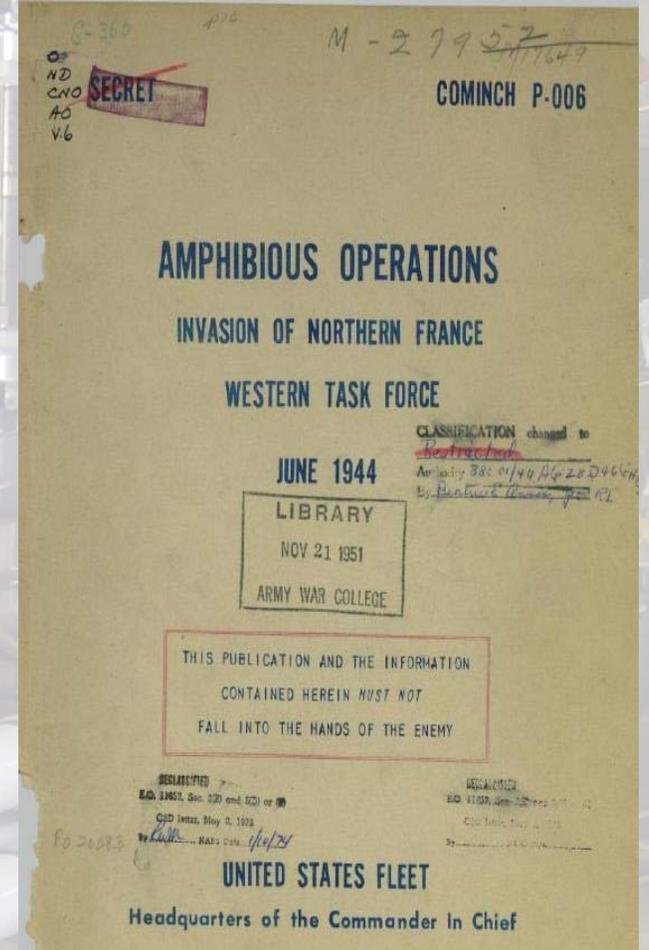
# Membrane Pilot Plant Test

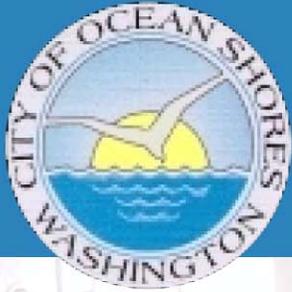




# Plan and Strategize

- WAC 246-290-250
- Work Plan Formally Approved by DOH





# Siemens Membrane Pilot Plant Test Program Officially Launched

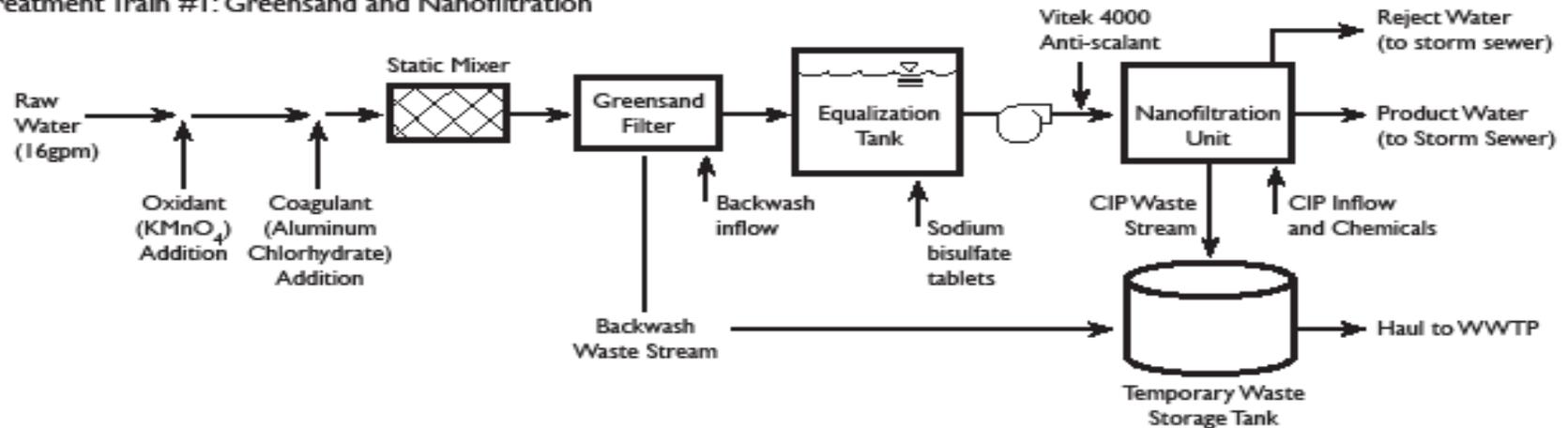
- Pilot Plant Test Duration
  - Testing Launched: October 1, 2007
  - Testing Completed: March 14, 2008



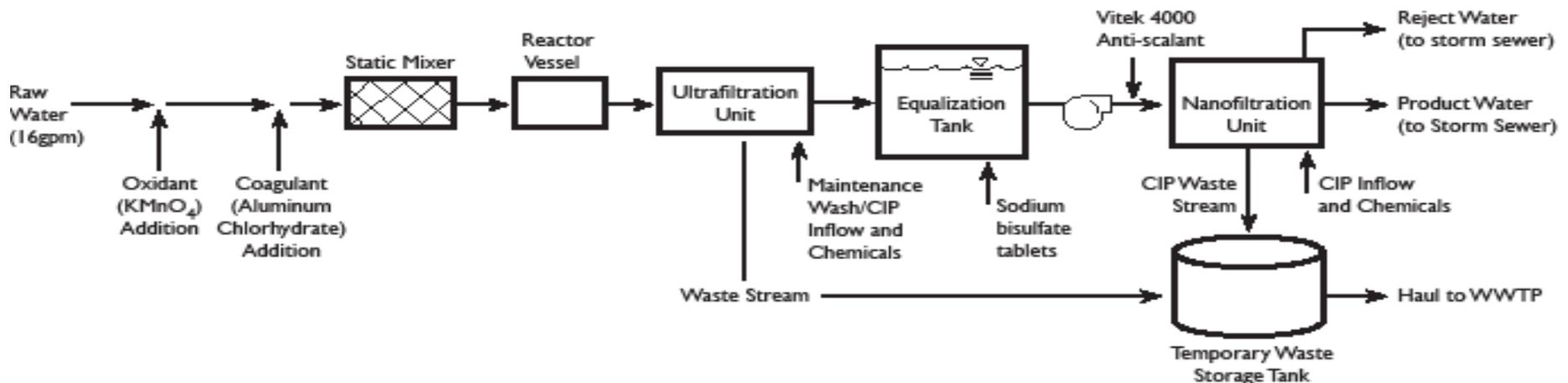


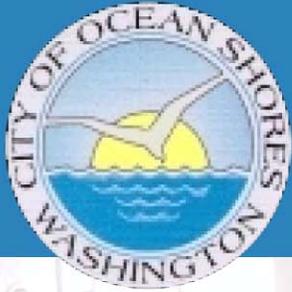
# Membrane Pilot Plant Configurations

Treatment Train #1: Greensand and Nanofiltration



Treatment Train #2: Ultrafiltration and Nanofiltration

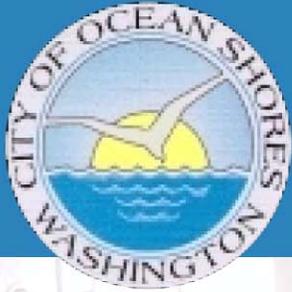




# Greensand Filter Pilot Plant Design Summary

Parameter	Characteristic
Number of Filters	2
Approx. Diameter (each), in	24
Filtration Rate, gpm/sf	5
Oxidant	$\text{KMnO}_4$
Oxidant Dose, mg/L	1.5





# Siemens Membrane Pilot Plant Design Summary

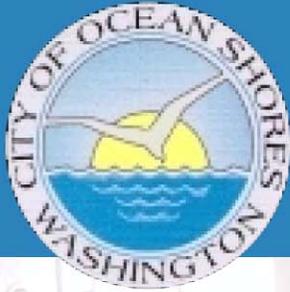
**Siemens Memcor CMF L20 V  
UF Membrane Module-56 gfd**

Parameter	Characteristic
Membrane Type	Hollow Fiber
Membrane Material	PVDF
Maximum Pore size, $\mu$	0.1
Coagulant	ACH
Coagulant Dose, mg/L	4

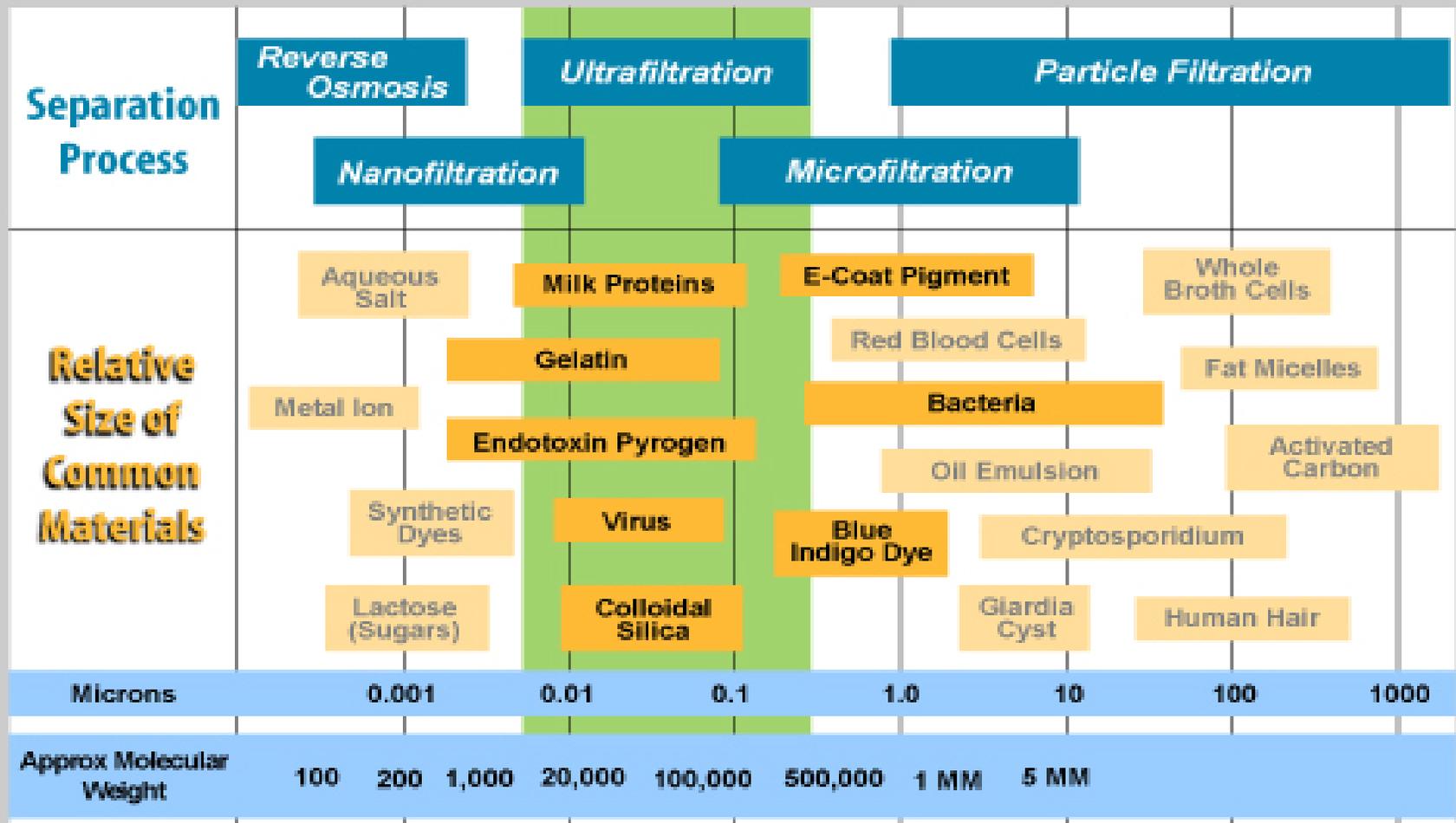
**Dow Filmtec NF90 NF  
Membranes-15 gfd**

Parameter	Characteristic
Membrane Type	Spiral Wound
Membrane Material	Polyamide Thin-film Composite
Maximum Pore size, $\mu$	0.001
Anti-scalant	Vitec 4000
Anti-scalant Dose, mg/L	2



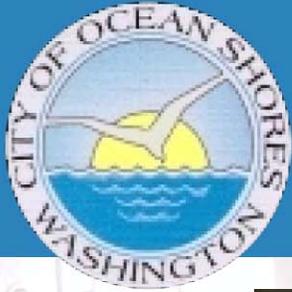


# Typical Membrane Pore Size Spectrum



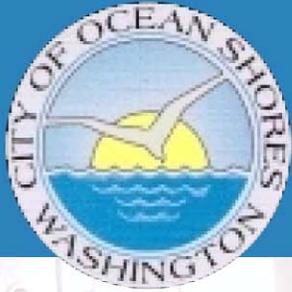
Note: 1 micron (micrometer) = 4 x 10<sup>-5</sup> inches = 1 x 10<sup>4</sup> Angstrom units

© 2004 - Koch Membrane Systems



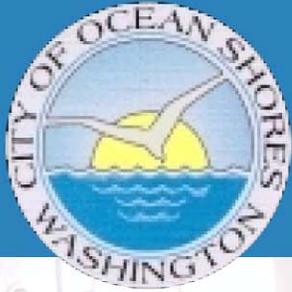
# Siemens Pilot Plant Ultrafiltration Module





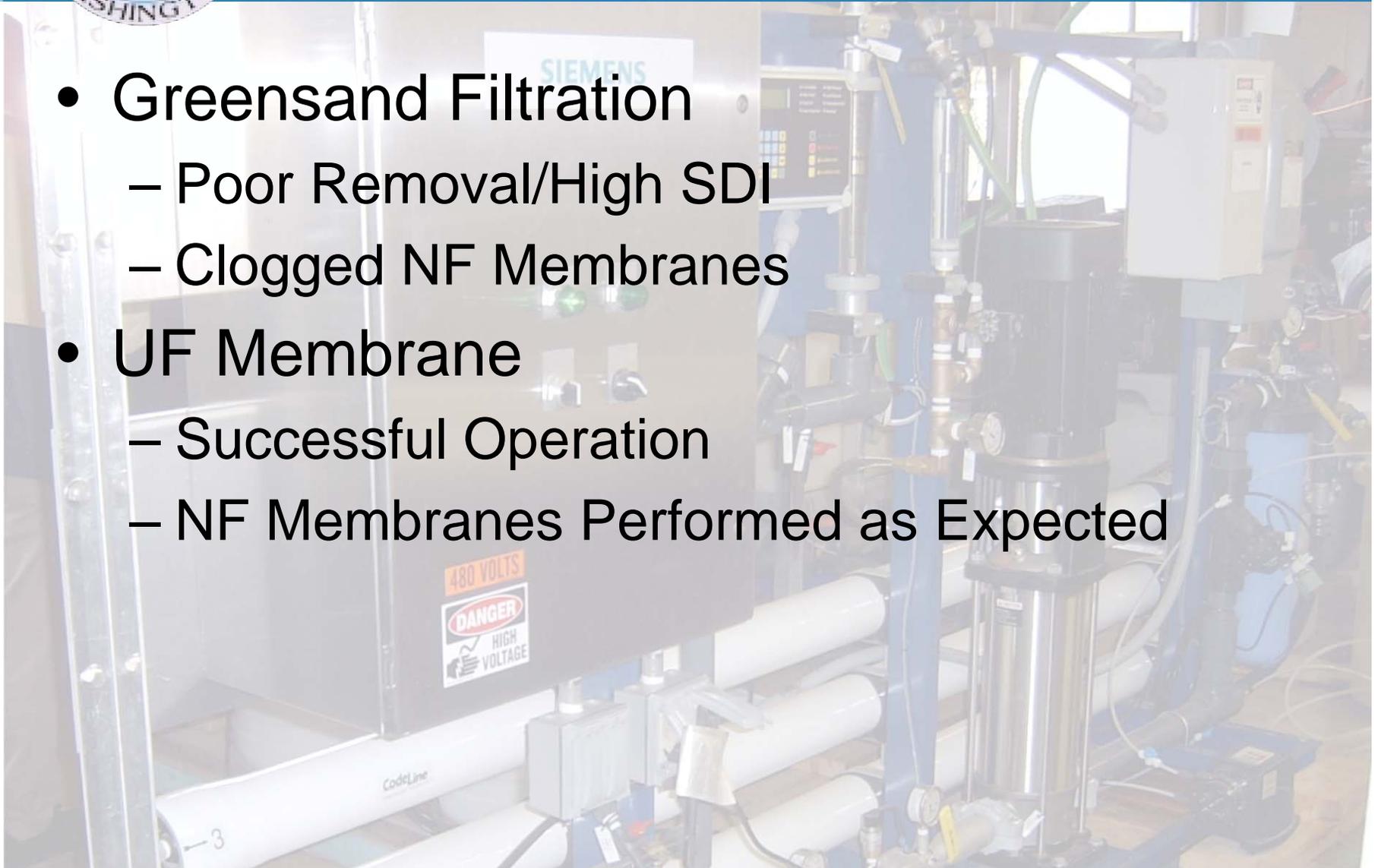
# Siemens Pilot Plant Nanofiltration Modules

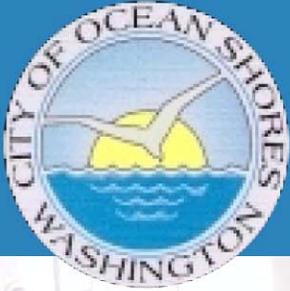




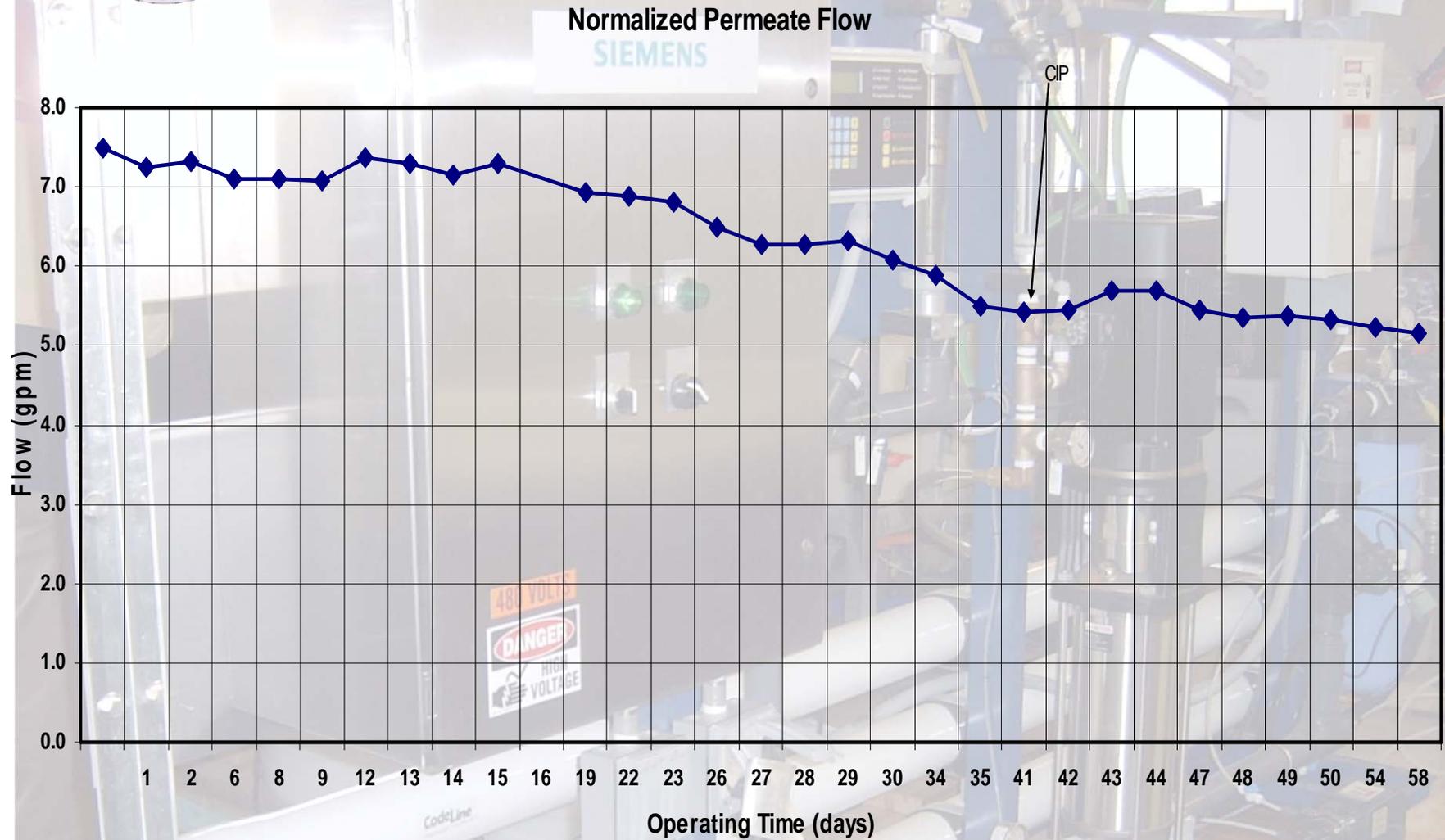
# Greensand Filtration Versus UF Pretreatment

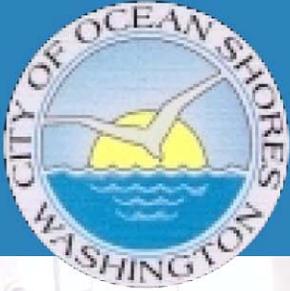
- Greensand Filtration
  - Poor Removal/High SDI
  - Clogged NF Membranes
- UF Membrane
  - Successful Operation
  - NF Membranes Performed as Expected





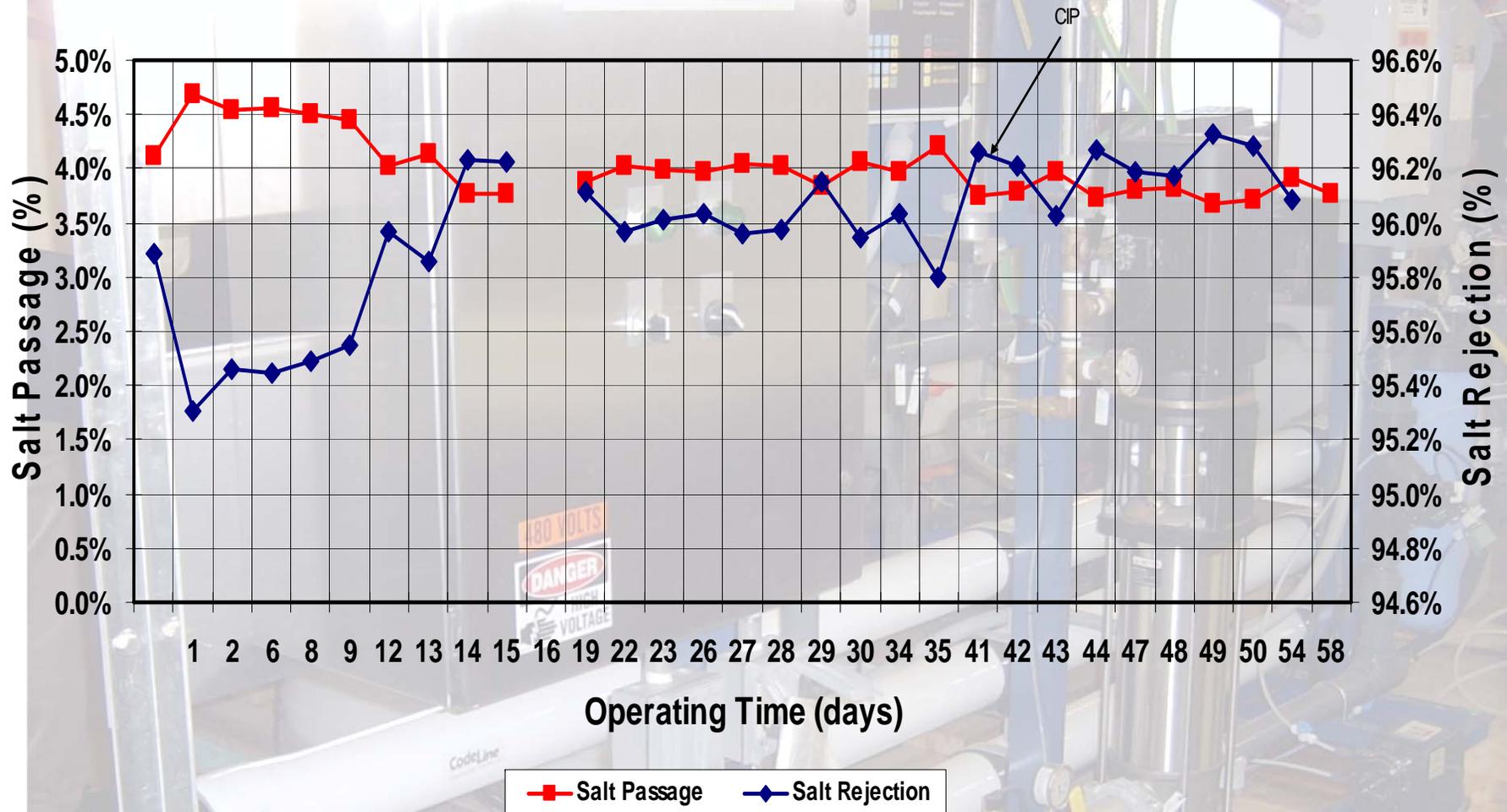
# Normalized NF Permeate Flow with UF Pretreatment

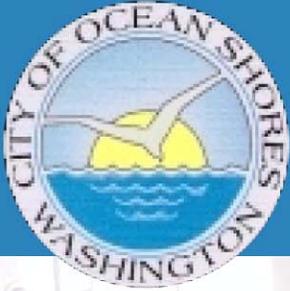




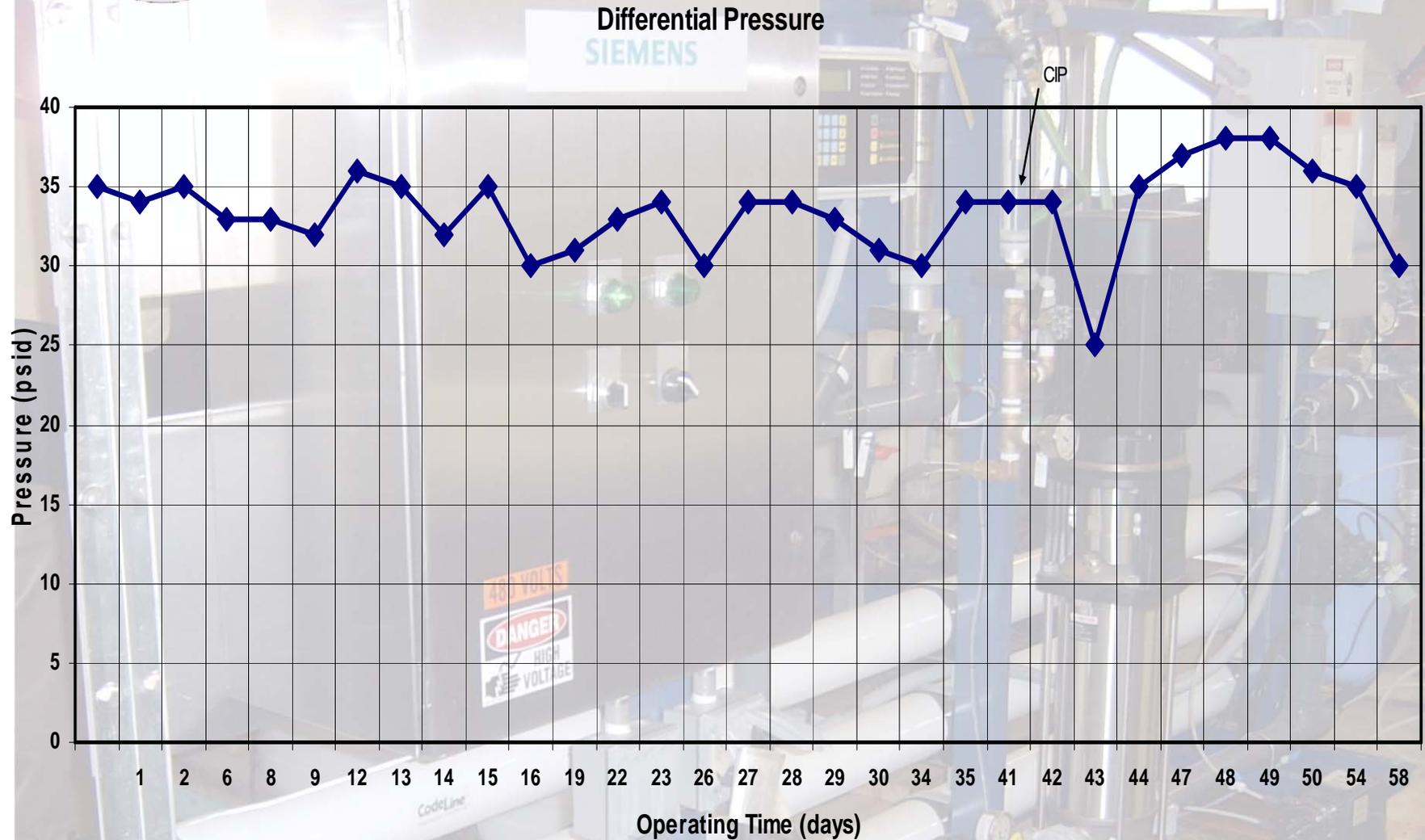
# Normalized NF Salt Passage and Rejection with UF Pretreatment

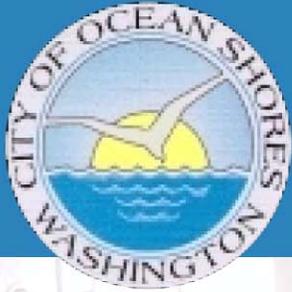
## Normalized Salt Passage and Salt Rejection





# NF System Differential Pressure with UF Pretreatment

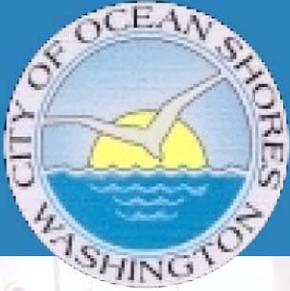




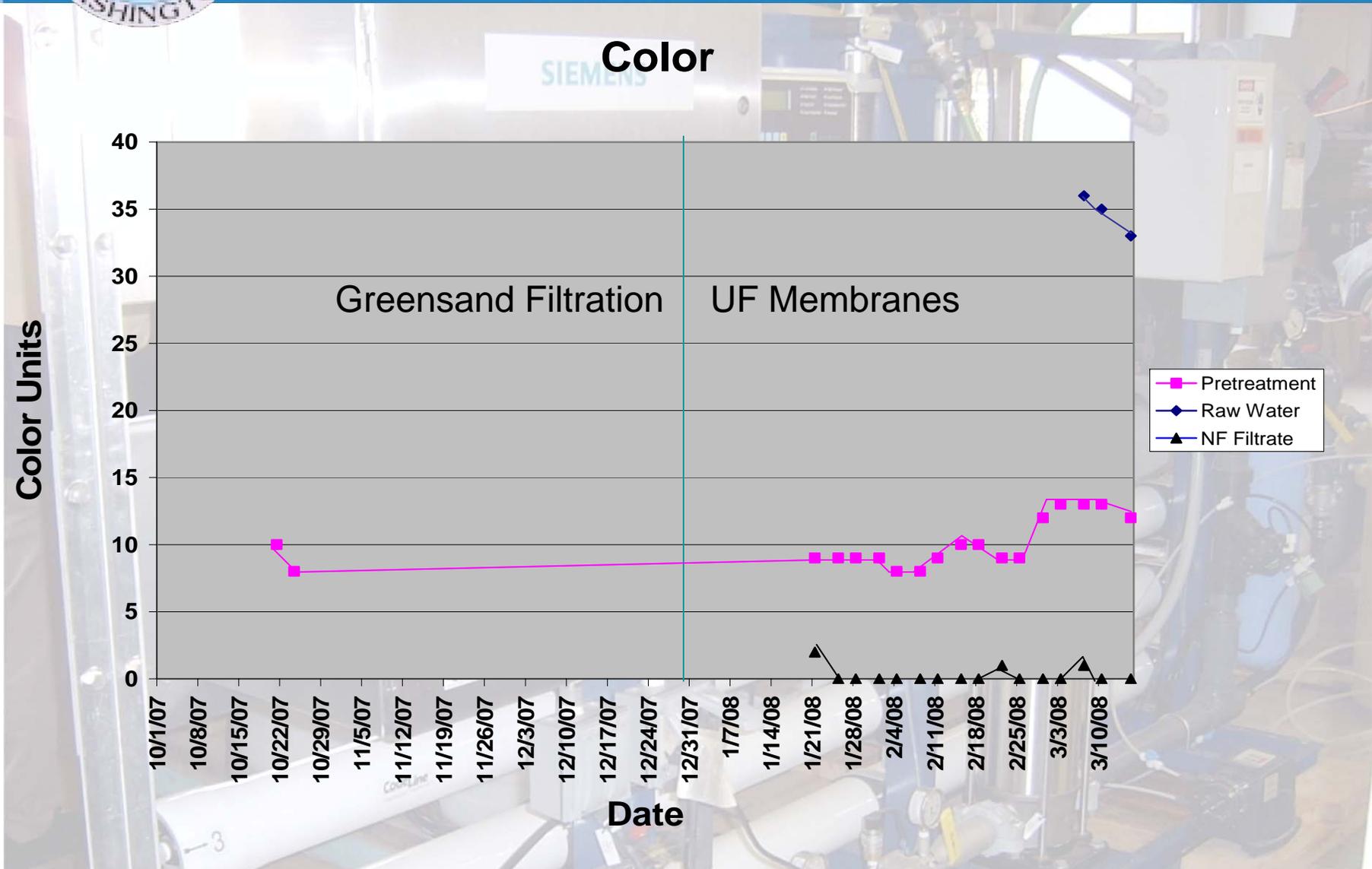
# UF/NF Water Quality Constituent Removals

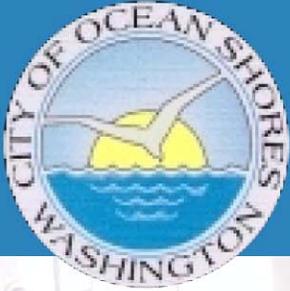
<b>Parameter</b>	<b>Percent Removal UF Only</b>	<b>Percent Removal NF Only</b>	<b>Percent Removal Overall</b>
Color	71%	98%	99%
TOC	20%	91%	93%
DOC	20%	87%	89%
UVA <sub>254</sub>	56%	>99%	>99%
THM-FP	19%	89%	91%
HAA5-FP	26%	83%	88%
Cl <sub>2</sub> Demand	8%	96%	96%
Iron	98%	21%	99%
Manganese	36%	98%	99%



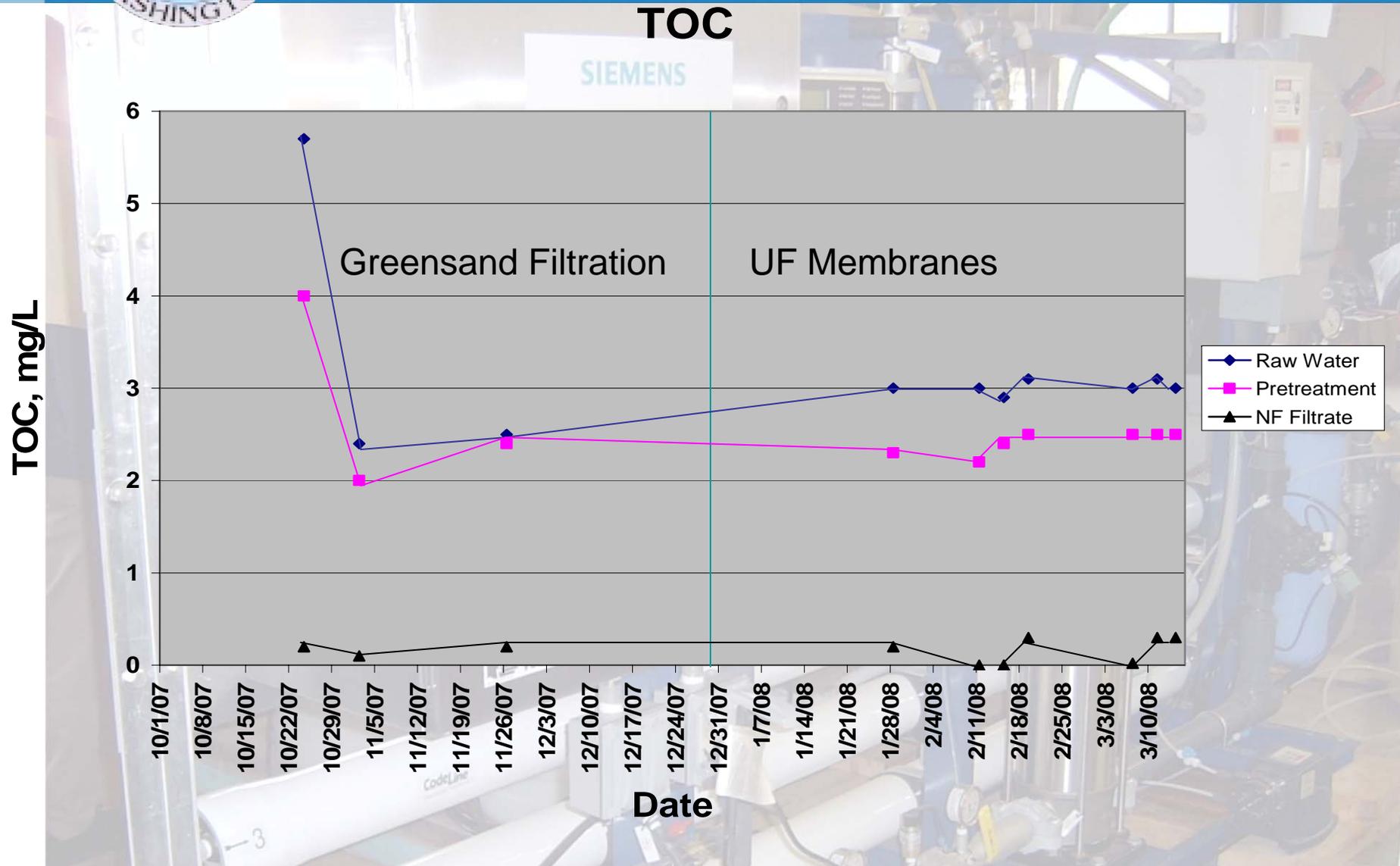


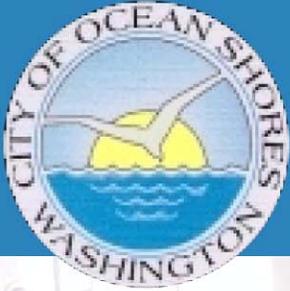
# Membrane Pilot Plant Water Quality Performance-Color



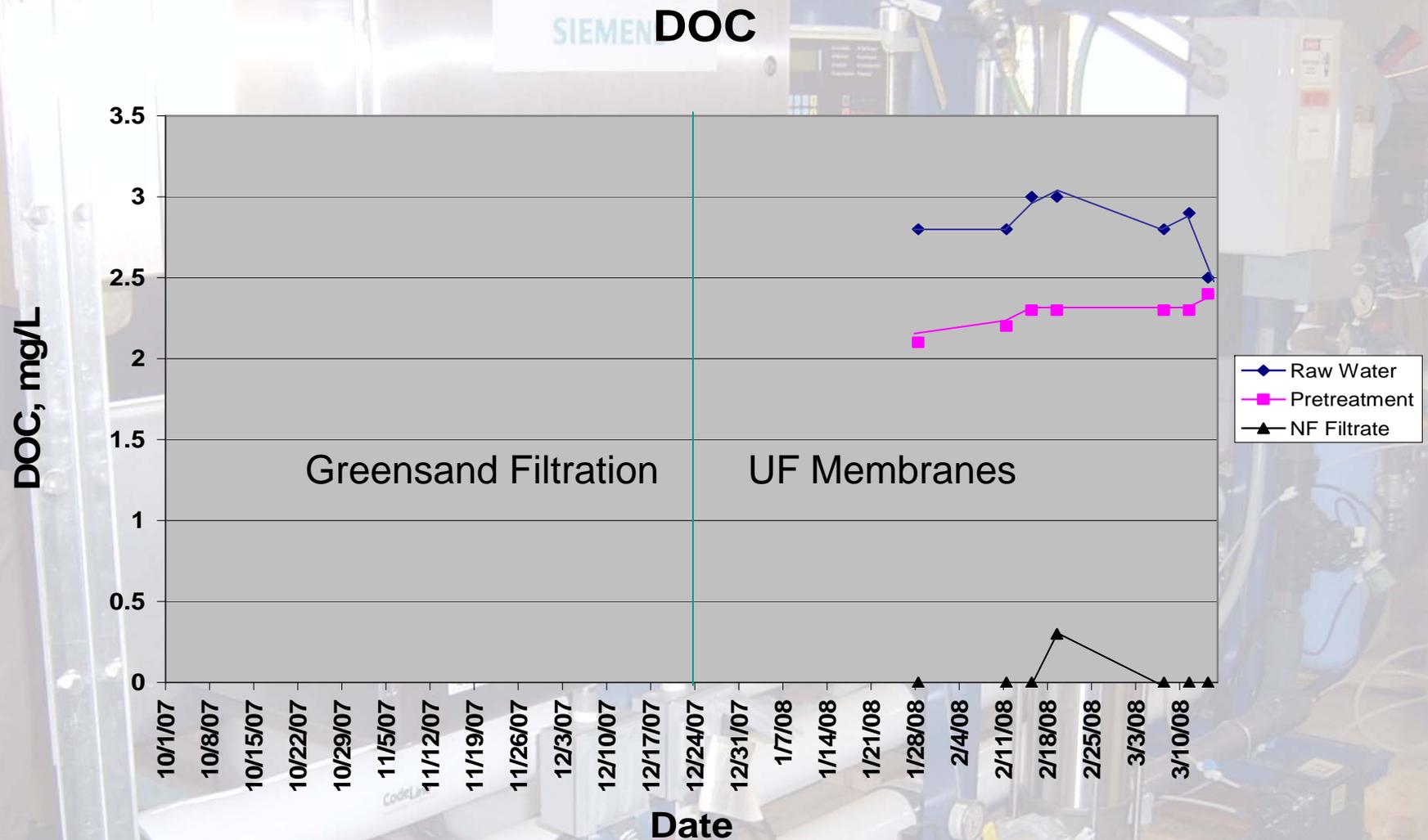


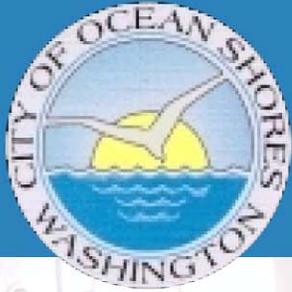
# Membrane Pilot Plant Water Quality Performance-TOC





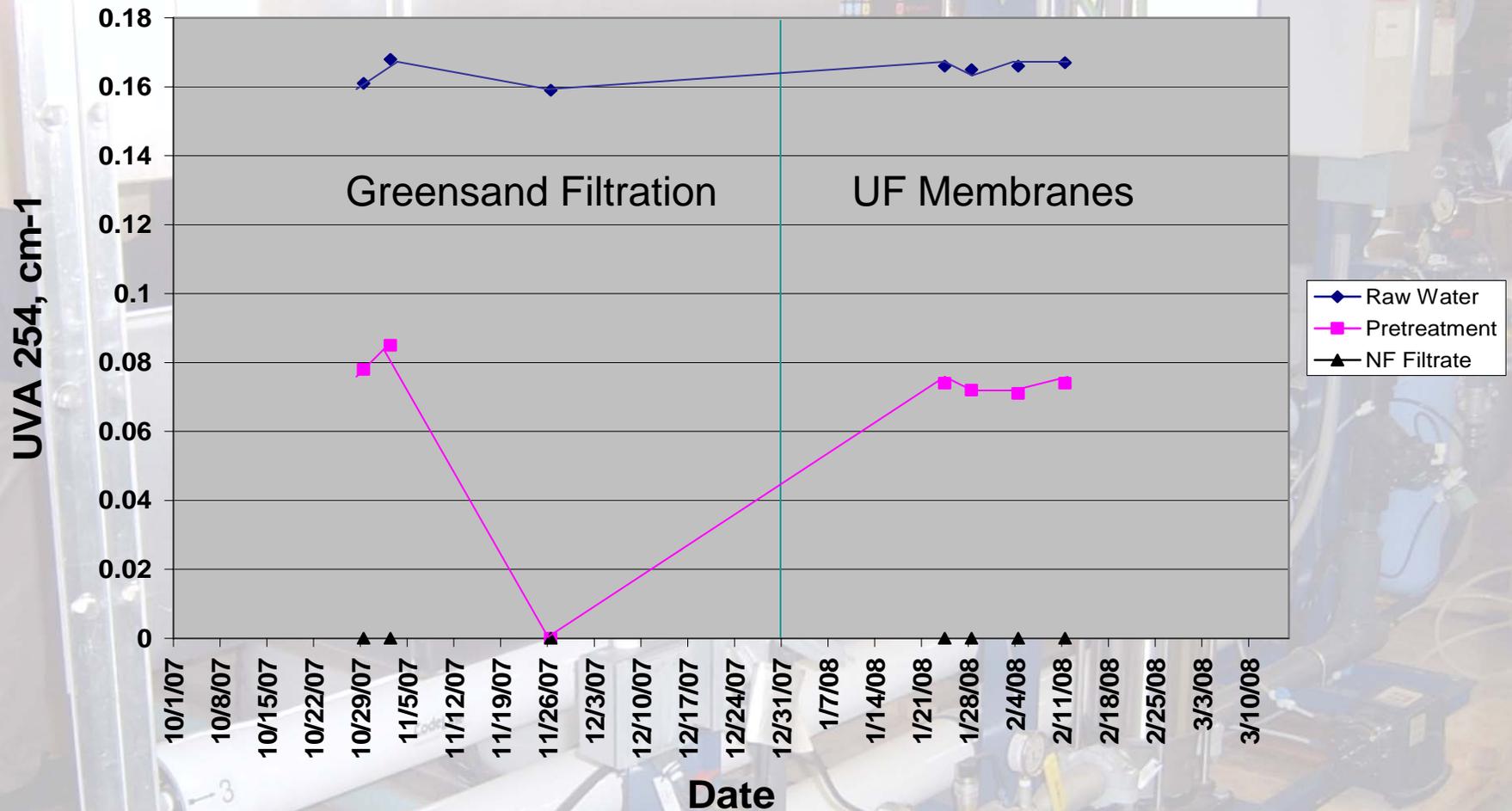
# Membrane Pilot Plant Water Quality Performance-DOC

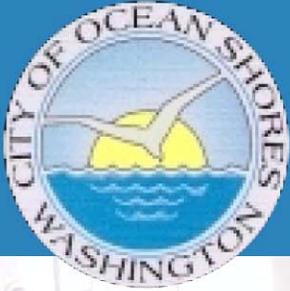




# Membrane Pilot Plant Water Quality Performance-UVA<sub>254</sub>

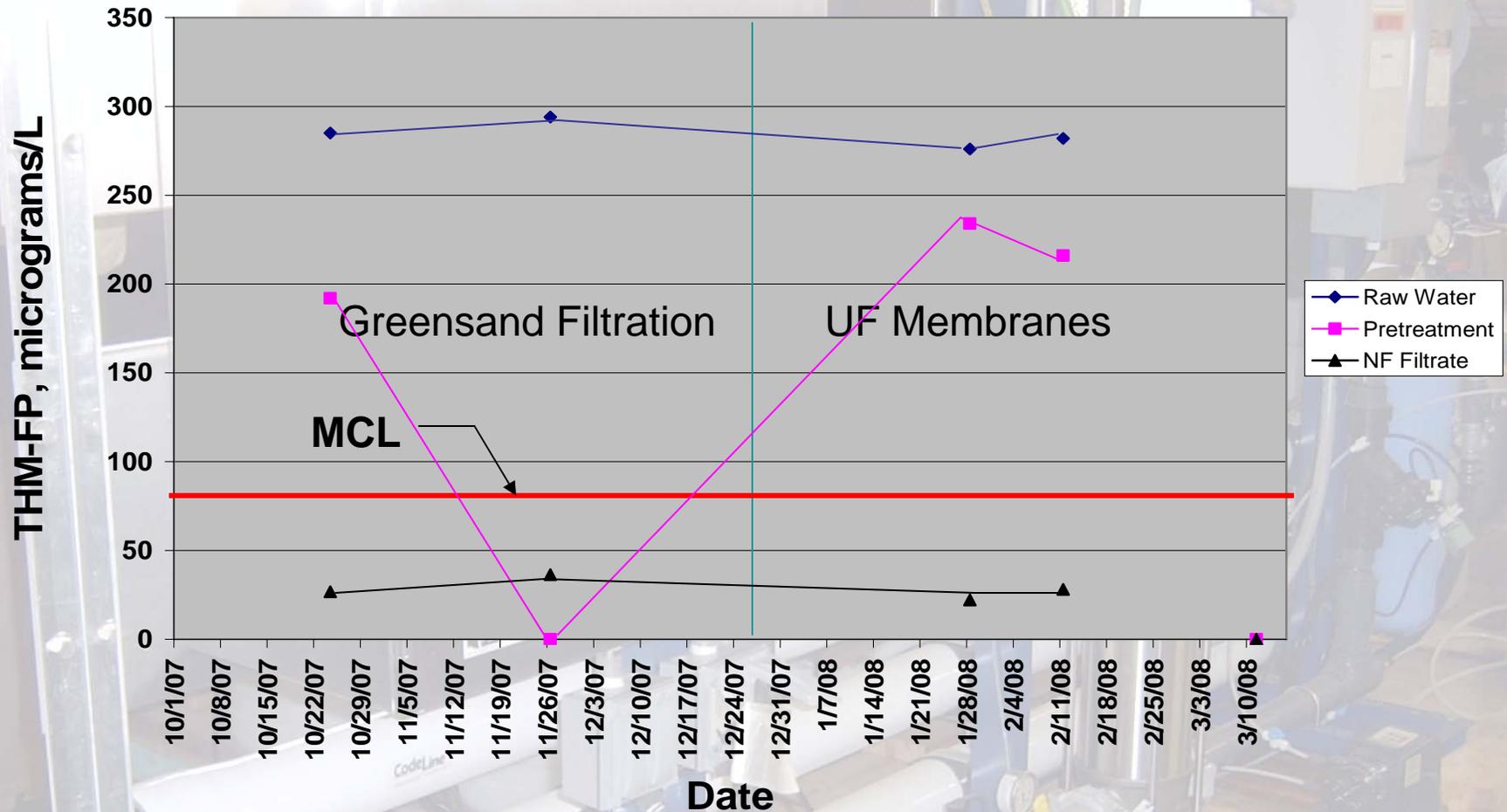
SIEMENS UVA 254

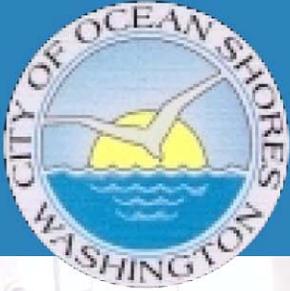




# Membrane Pilot Plant Water Quality Performance-THM

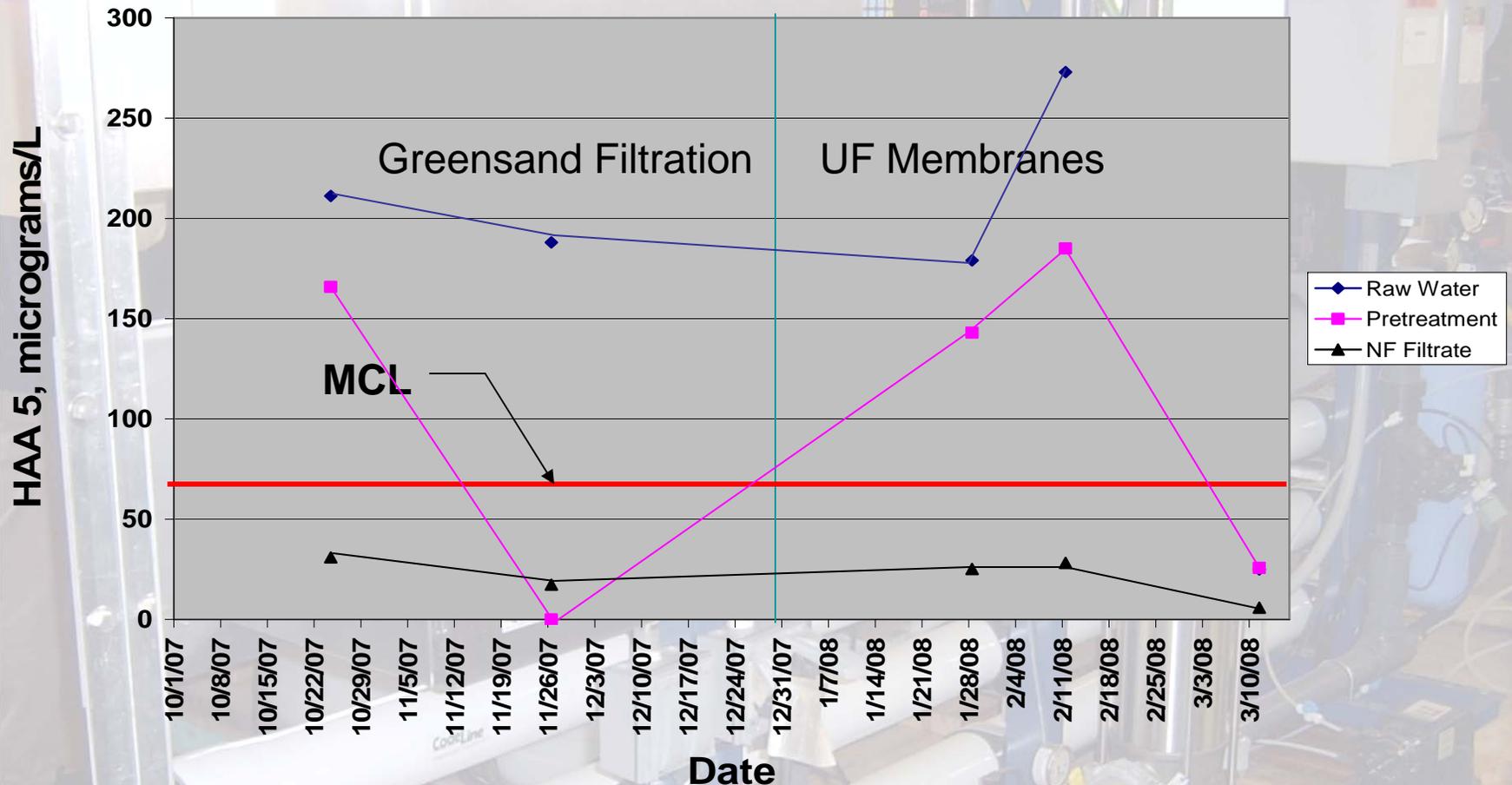
## THM Formation Potential

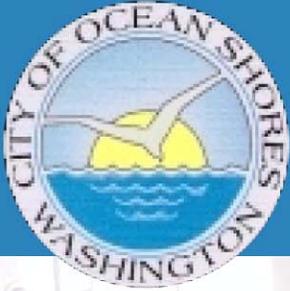




# Membrane Pilot Plant Water Quality Performance-HAA 5

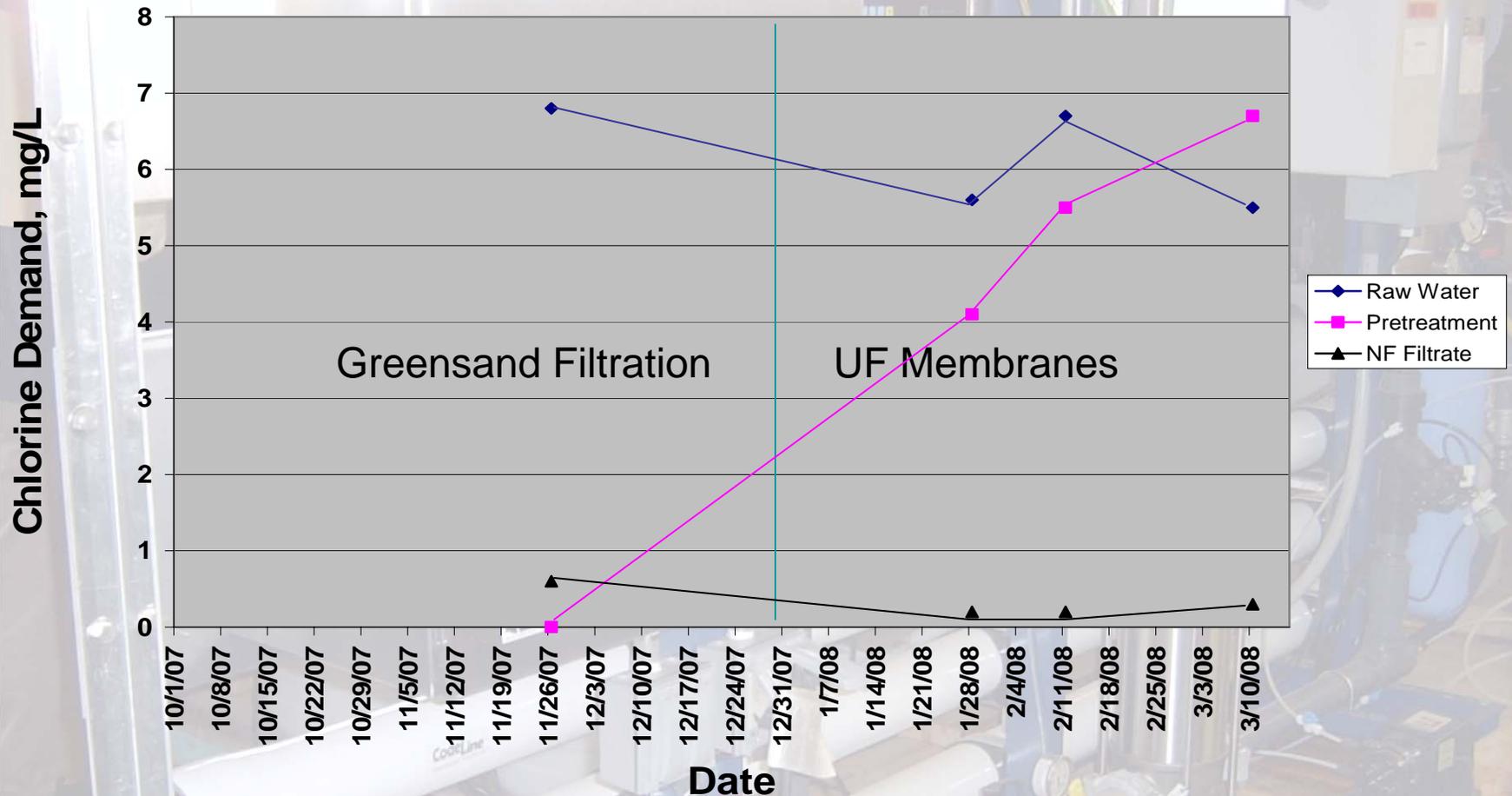
## HAA 5 Formation Potential

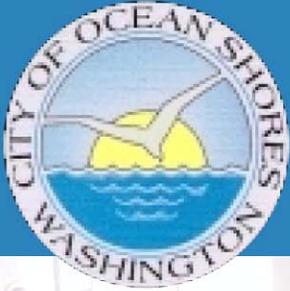




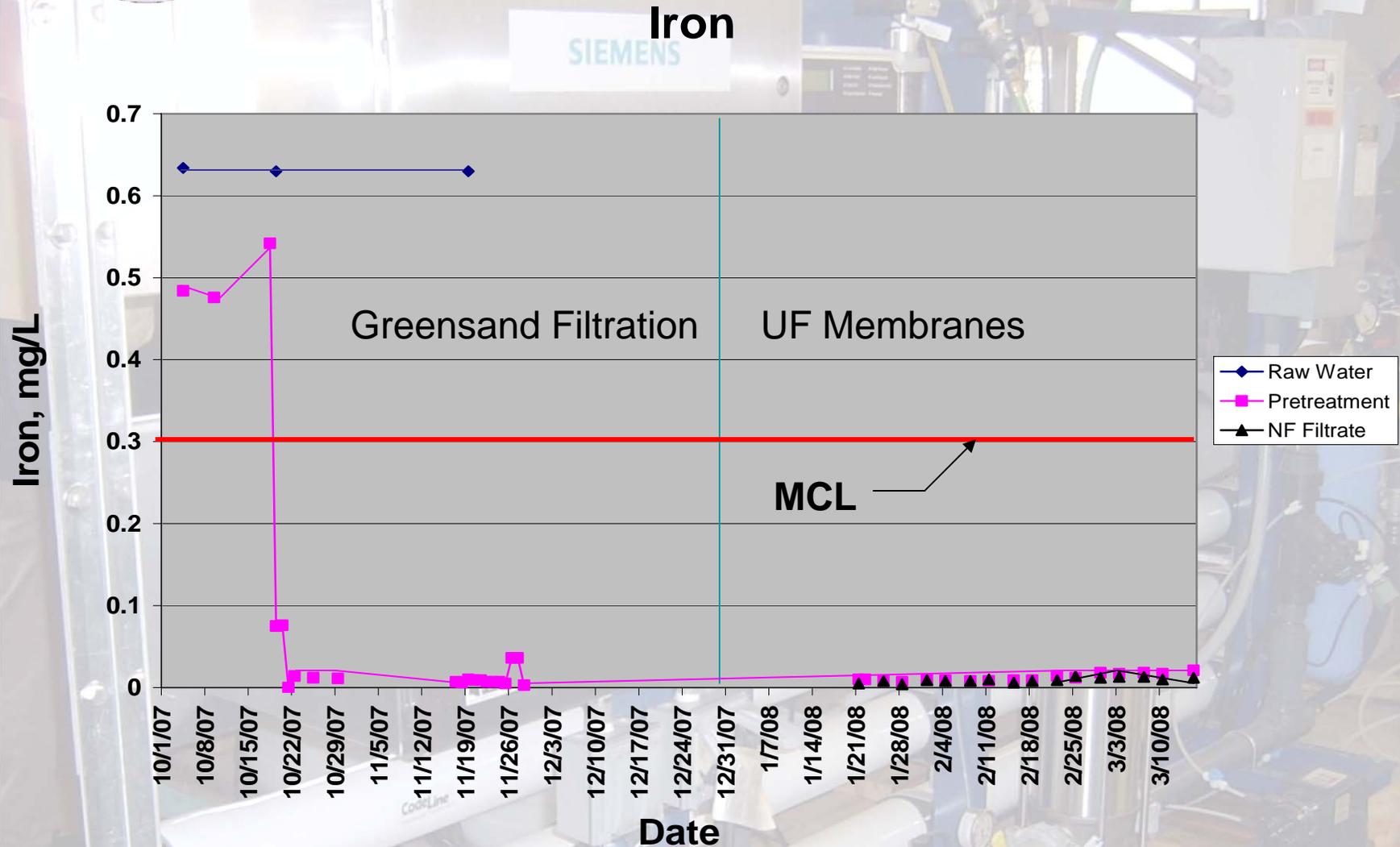
# Membrane Pilot Plant Water Quality Performance-Chlorine Demand

## Chlorine Demand

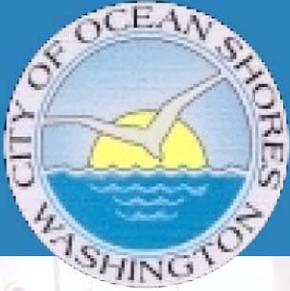




# Membrane Pilot Plant Water Quality Performance-Iron

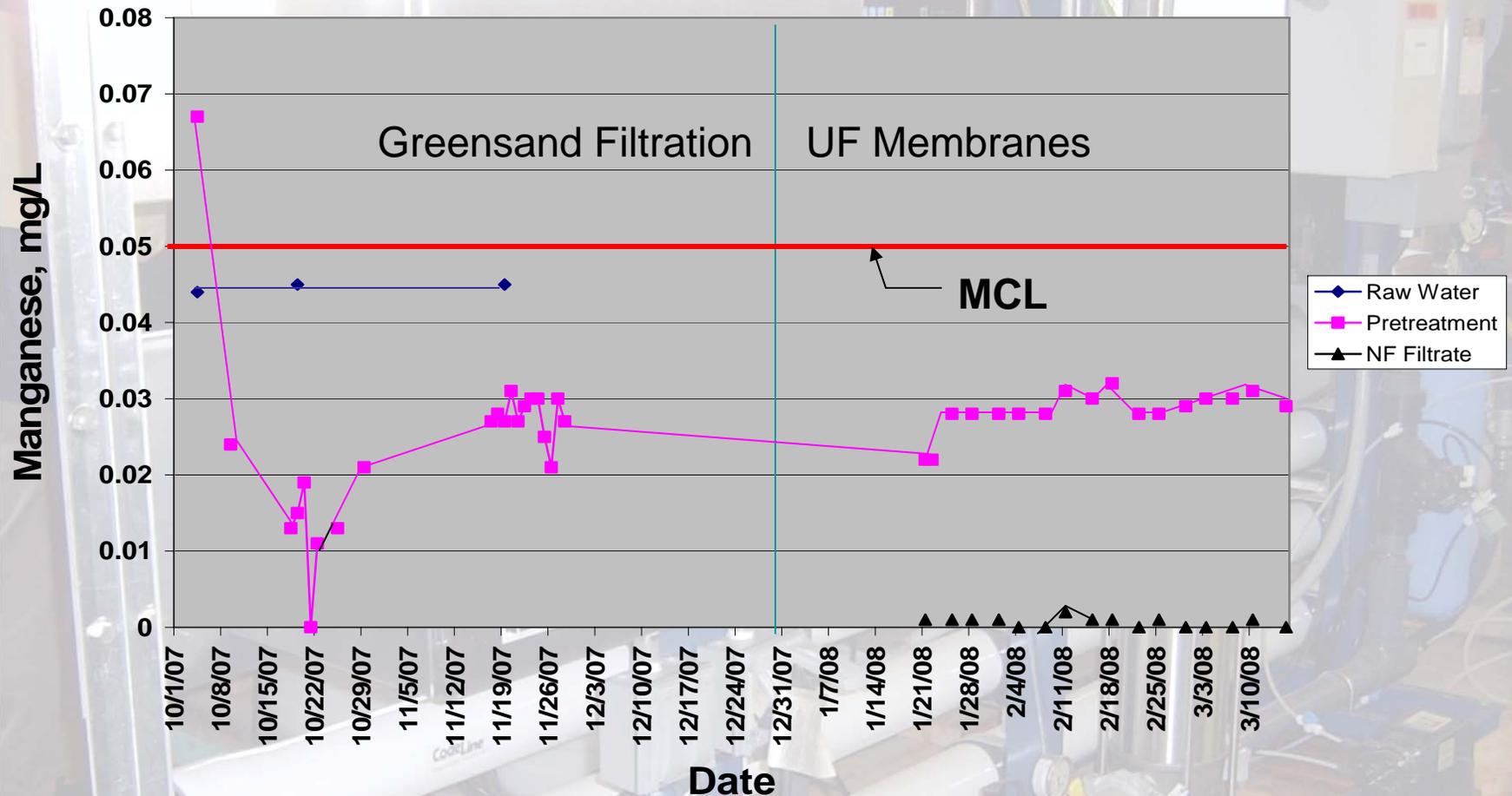


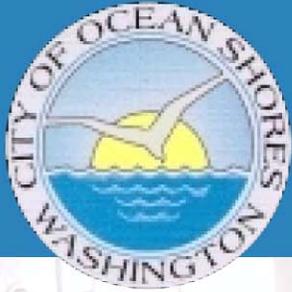




# Membrane Pilot Plant Water Quality Performance-Manganese

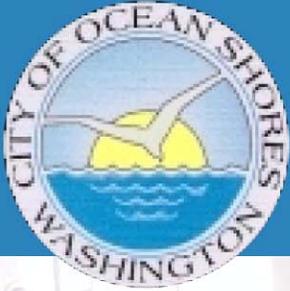
## Manganese





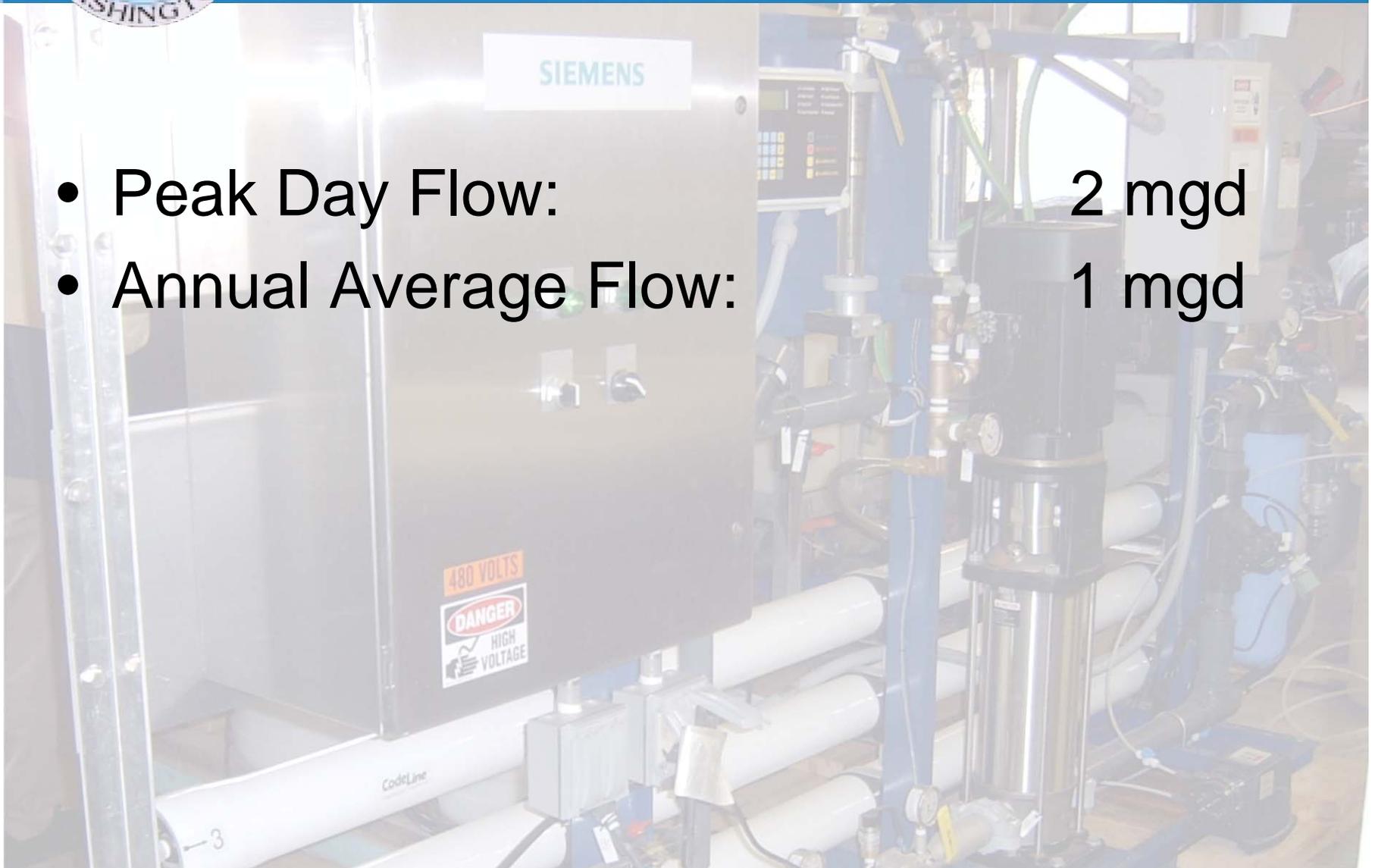
# Full Scale Water Treatment System Preliminary Design

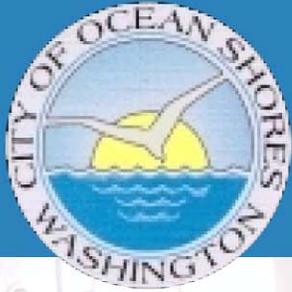
- Peak Day Flow: 2 mgd
- Annual Average Flow: 1 mgd



# Basic Full Scale Water Treatment Plant Design Criteria

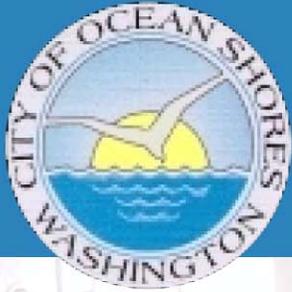
- Peak Day Flow: 2 mgd
- Annual Average Flow: 1 mgd





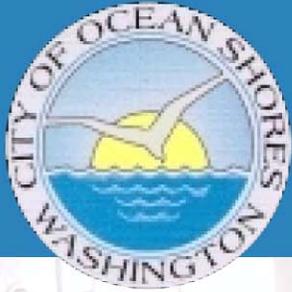
# Greensand Filtration/MIEX System





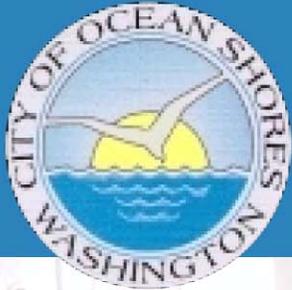
# Preliminary Greensand/MIEX Design Criteria

<b>Parameter</b>	<b>Units</b>	<b>Value (2 MGD)</b>
Greensand Filtration Rate	gpm/sf	5
Greensand Washwater	% of Throughput	3.4%
Greensand Filters	Number	8 (4 existing)
Greensand Filter Diameter	Feet	8
Greensand $\text{KMnO}_4$ Dosing	mg/L	1.5



# Preliminary Greensand/MIEX Design Criteria

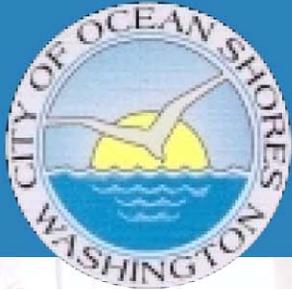
<b>Parameter</b>	<b>Units</b>	<b>Value (2 MGD)</b>
MIEX HR Contactors	Number	2
MIEX HR Contactor Volume, each	Gallons	4,000
MIEX HR Contactor Resin Concentration	ml/L	200
MIEX HR Contactor Resin Contact Time	Minutes	5
MIEX HR Contactor Upflow Rate	gpm/sf	9.6
Resin Volume Regenerated	gal resin/1,000 gal	1.67
Salt Consumption	lb/MG	500-600
Waste Brine Produced	gal/MG	400-450



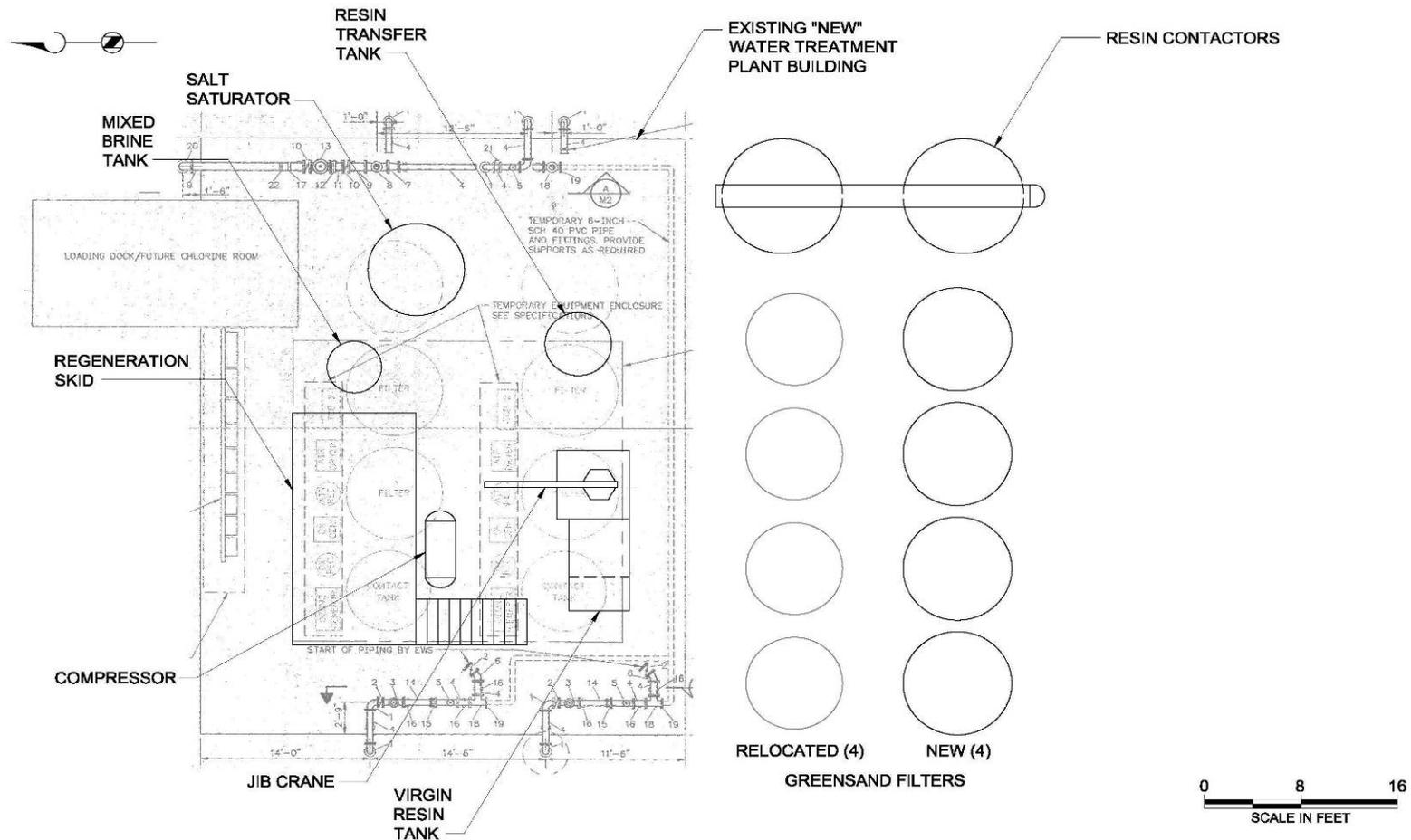
# Greensand/MIEX Plant Features

- Salvage 4 Existing Greensand Filters
- Add 4 New Greensand Filters
- Existing Building to House MIEX Regeneration, Brine Tank, and Virgin Resin Systems
- Items Located Outside
  - Greensand Filters
  - MIEX Contactors



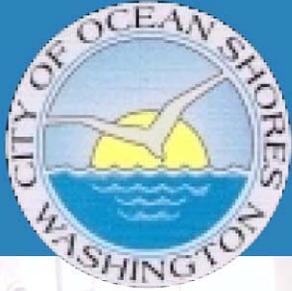


# Proposed Greensand/MIEX Layout



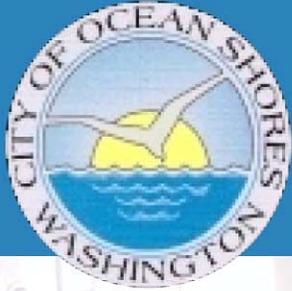
SHALLOW AQUIFER WATER TREATMENT FACILITIES  
 OCEAN SHORES, WASHINGTON  
 PROPOSED GREENSAND FILTER/MIEX LAYOUT





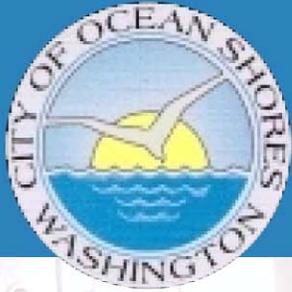
# Membrane Based System





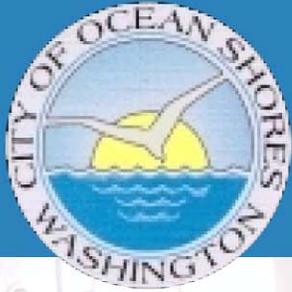
# Preliminary Membrane Plant Design Criteria

<b>Parameter</b>	<b>Units</b>	<b>Value (2 MGD)</b>
UF Flux Rate	gfd	56
UF Recovery (MW @ 30 Mins, CIP @ 30 days)	%	97.9%
UF TMP	psi	19
UF Coagulant Dosing (ACH)	mg/L	4



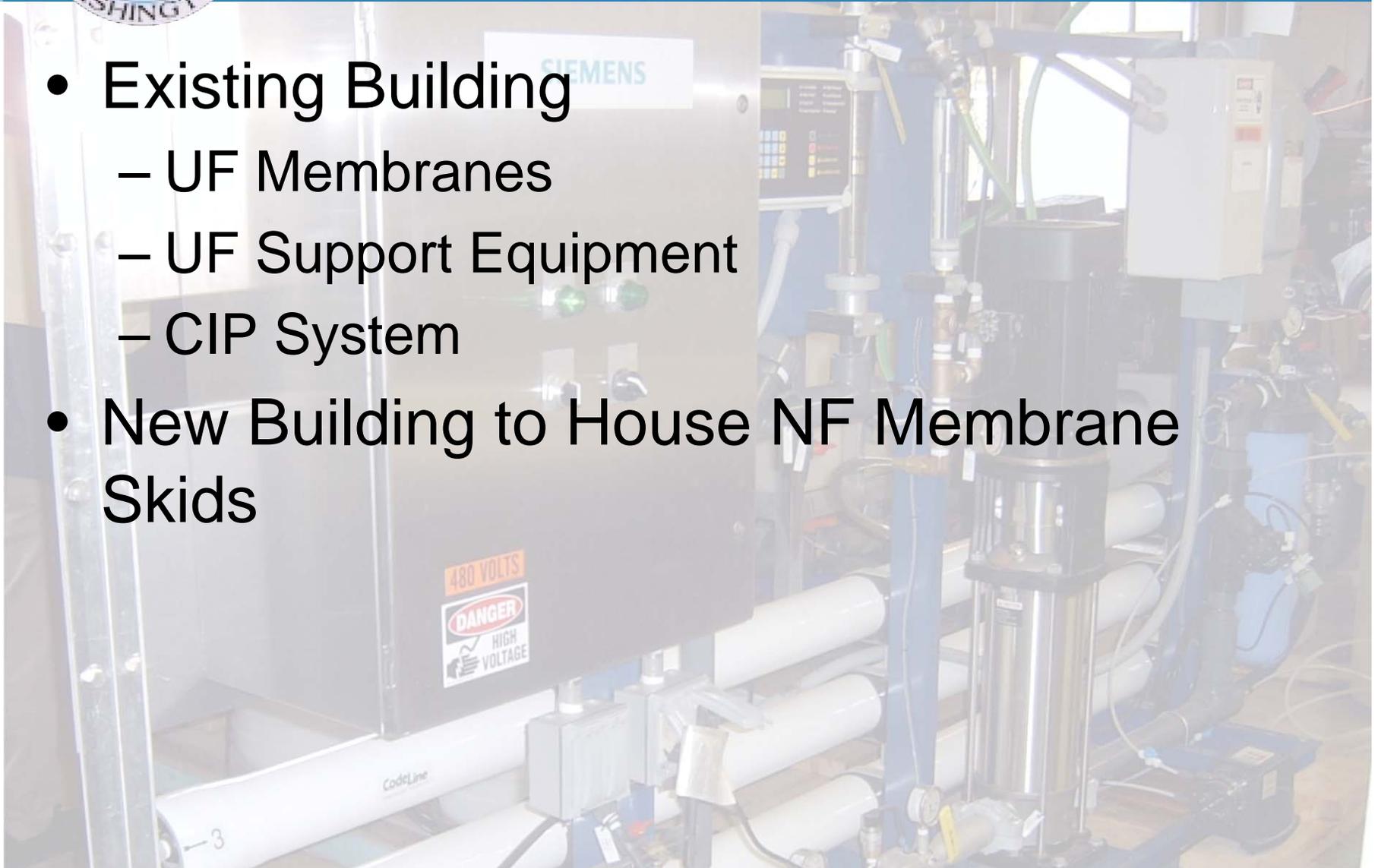
# Preliminary Membrane Plant Design Criteria

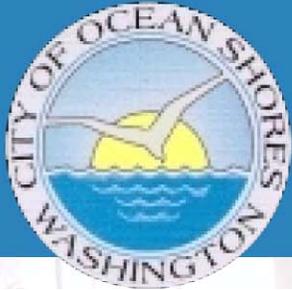
<b>Parameter</b>	<b>Units</b>	<b>Value (2 MGD)</b>
NF Flux Rate	gfd	15
NF Recovery	%	75%
NF TMP	psi	30-35
NF Salt Rejection	%	96%
NF Anti-scalant Dosing (Vitec 4000)	mg/L	2



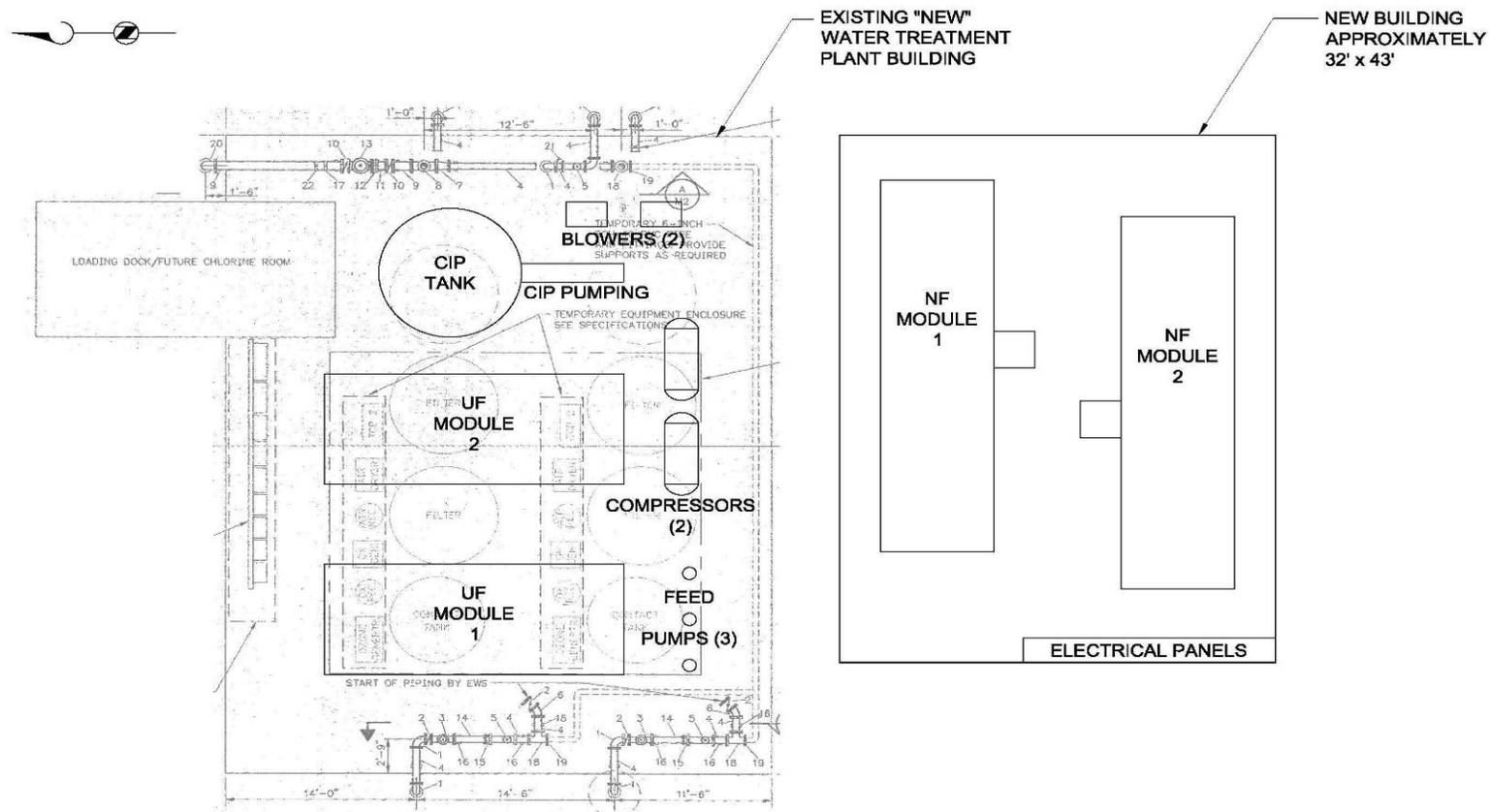
# Membrane Plant Features

- Existing Building
  - UF Membranes
  - UF Support Equipment
  - CIP System
- New Building to House NF Membrane Skids

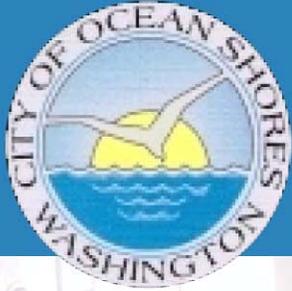




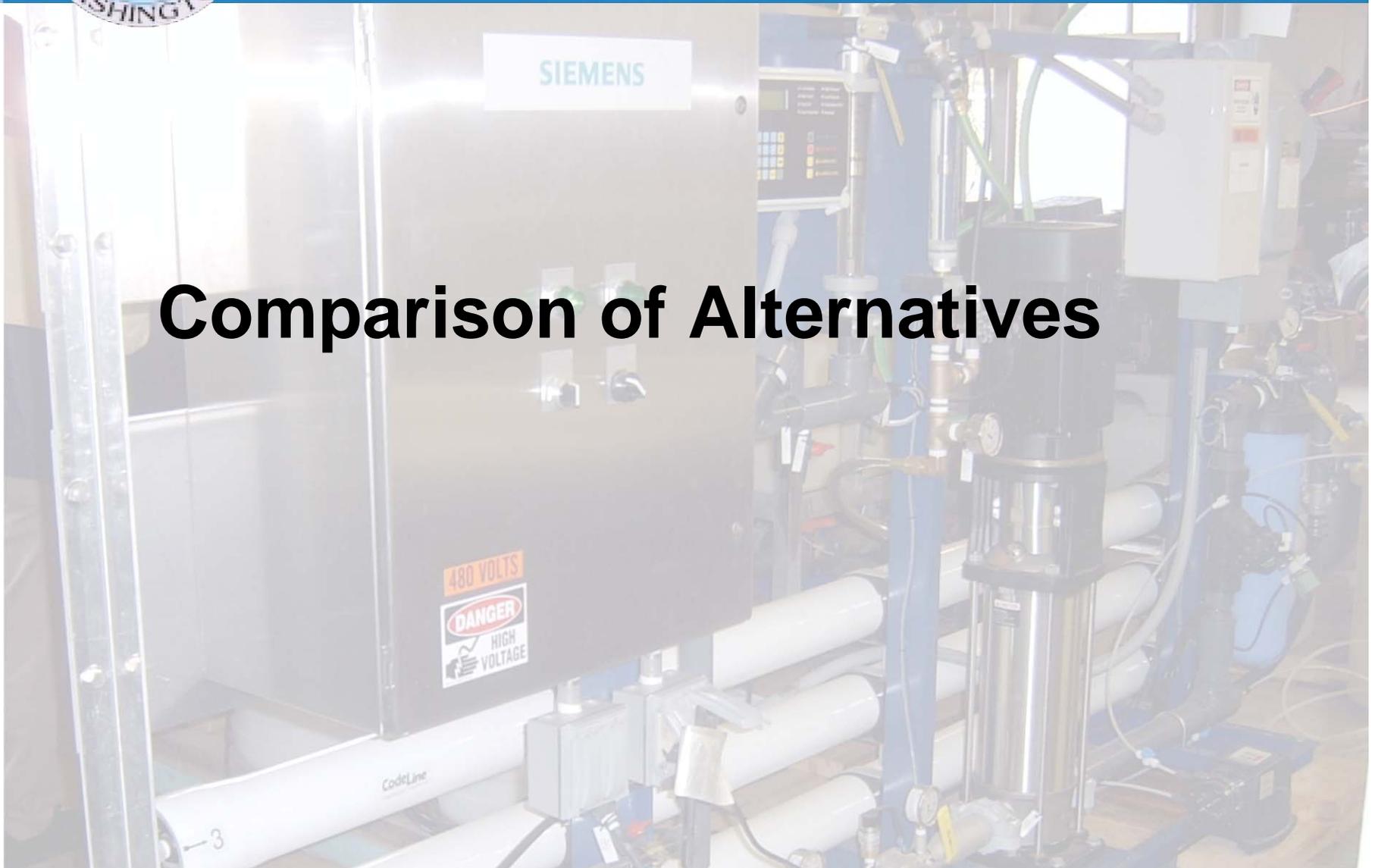
# Proposed UF/NF Membrane Layout

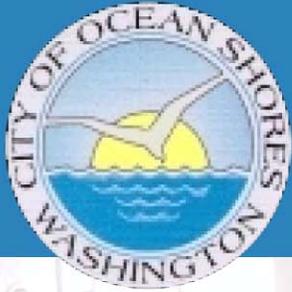


SHALLOW AQUIFER WATER TREATMENT FACILITIES  
OCEAN SHORES, WASHINGTON  
PROPOSED MEMBRANE LAYOUT



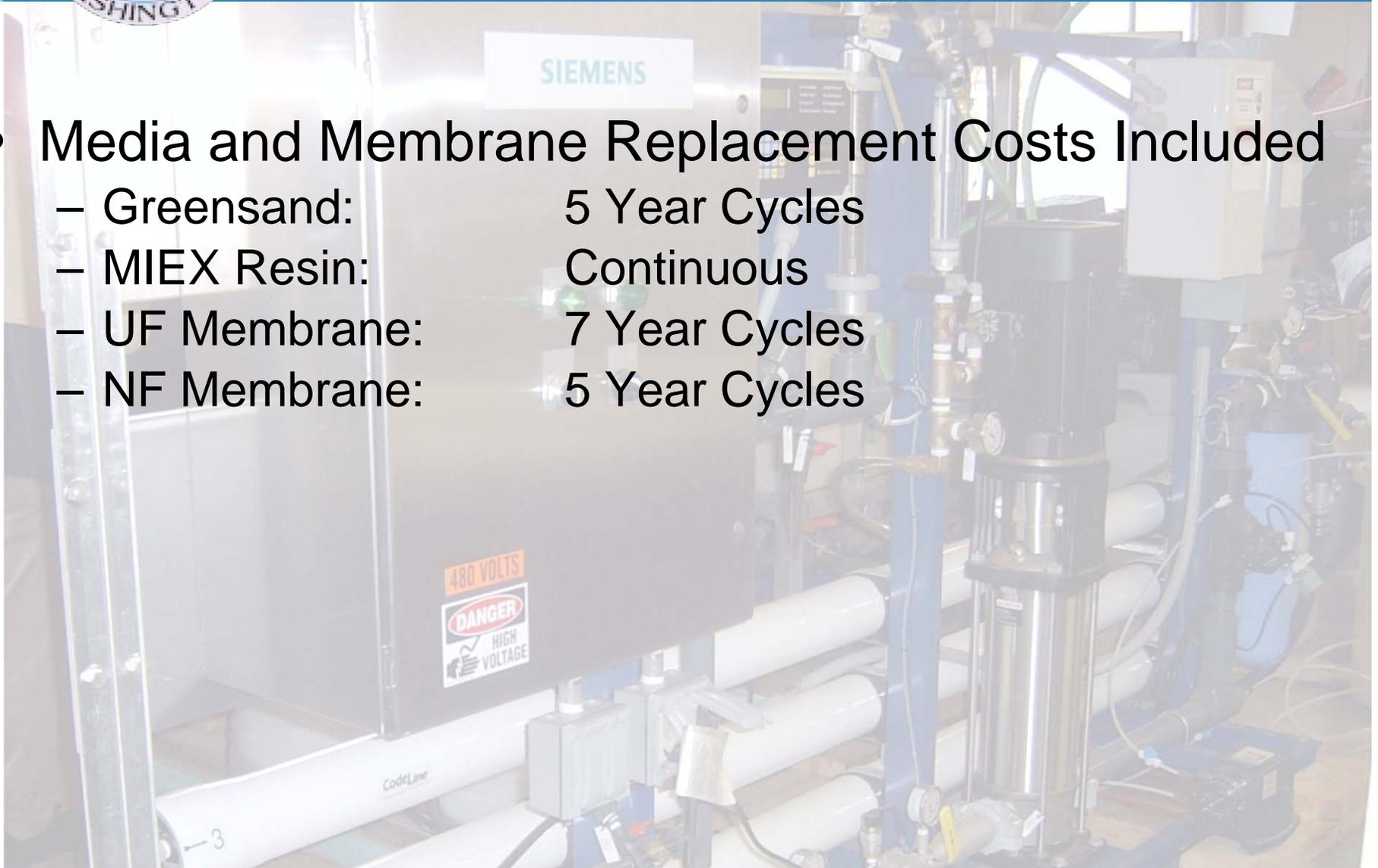
# Comparison of Alternatives

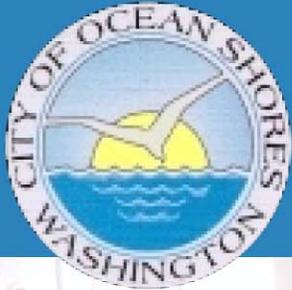




# Cost Development Assumptions

- Media and Membrane Replacement Costs Included
  - Greensand: 5 Year Cycles
  - MIEX Resin: Continuous
  - UF Membrane: 7 Year Cycles
  - NF Membrane: 5 Year Cycles

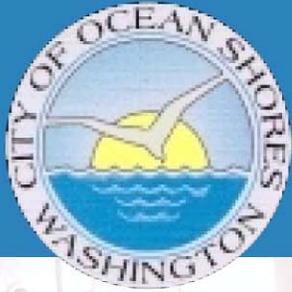




# Cost Development Assumptions

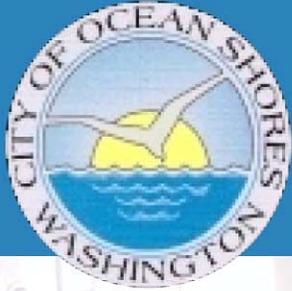
- All Costs in 2008 Dollars
- Discount Rate 6%
- Escalation Rate 4%
- Construction Contingency @ 30% (worth about \$1 million)
- Total Project Cost Includes Tax, Legal, Admin, and Engineering
- Existing Facilities Used to Maximum Extent
- New Standby Engine Generator Included
- Impacts to WWTP Included
- Media and Membrane Replacement Costs Included
  - Greensand: 5 Year Cycles
  - MIEX Resin: Continuous
  - UF Membrane: 7 Year Cycles
  - NF Membrane: 5 Year Cycles





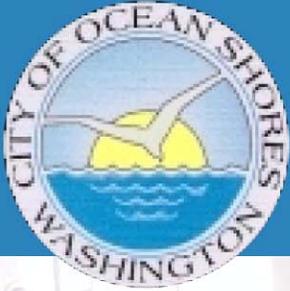
# Wastewater Handling Issues

- Greensand/MIEX
  - 35,000 gpd Greensand to Existing Ponds
  - 900 gpd MIEX Brine Waste to WWTP
  - Minimal Cost and Impact to WWTP
- UF/NF Membranes
  - 360,000 gpd Waste to WWTP
  - Wastewater Contains Salts
  - Large WWTP Impact
    - Significant Flow Contribution (1/3 more)
    - Low Strength/High Salinity Waste Impacts WWTP Biology
    - Flow Proportional Incremental WWTP Cost Assumed



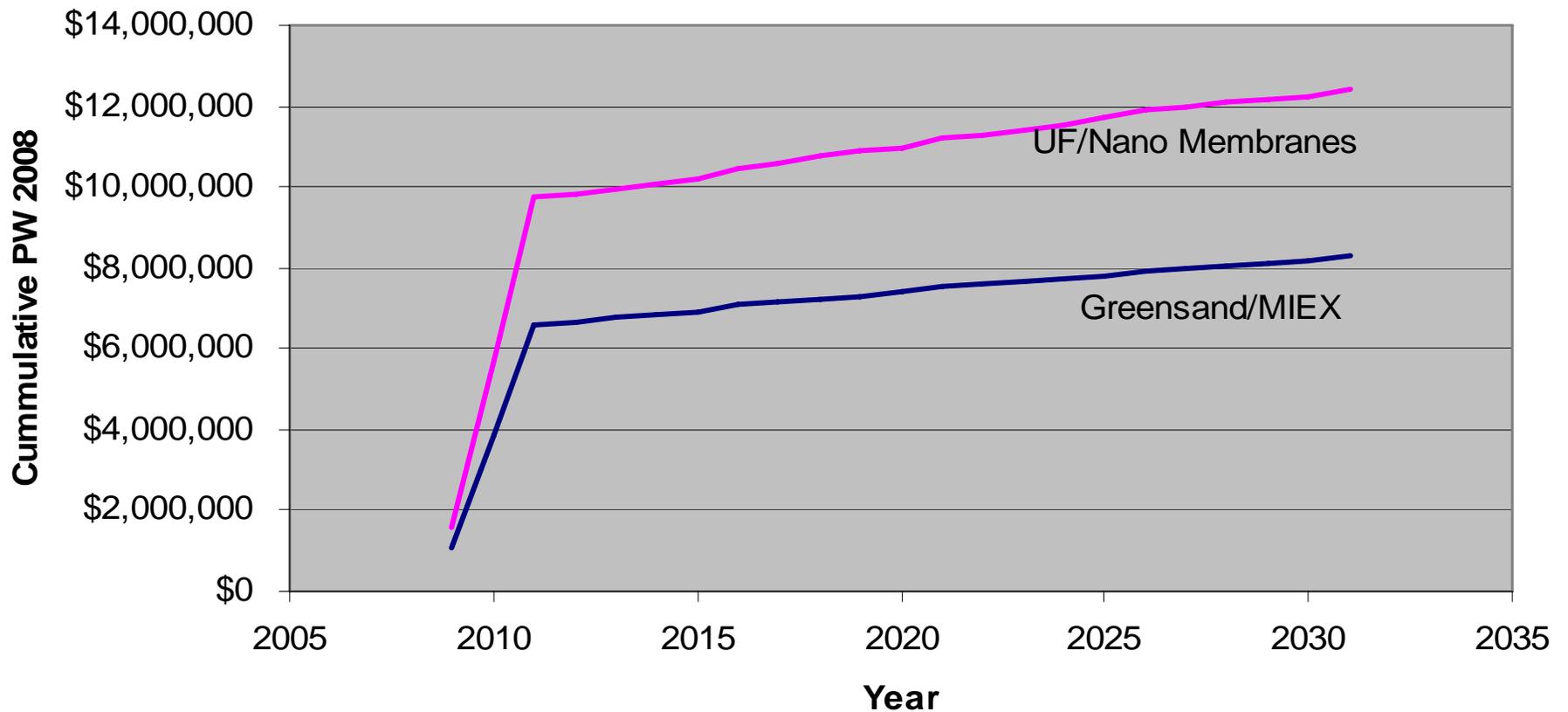
# Economic Comparison of Alternatives

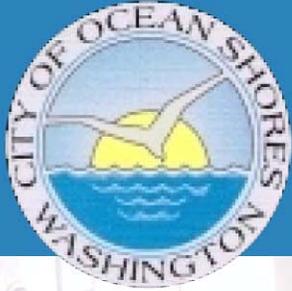
Parameter	Alternative 1- Greensand/MIEX	Alternative 2-UF/NF Membranes
Initial Total Project Cost	\$6.9 million	\$10.2 million
Annual Operating Cost	\$93,000/year	\$135,000/year
Net Present Worth	\$8.3 million	\$12.4 million
Cost of Water Treatment	\$1.41/CCF	\$2.11/CCF



# Cost Expenditures Over Time

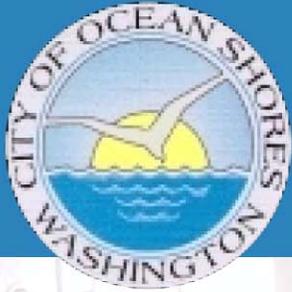
**Ocean Shores Cumulative Present Worth of Water Treatment Alternatives**





# Non-economic Comparison of Alternatives

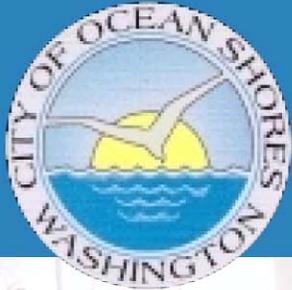
Parameter	Alternative 1- Greensand/MIEX	Alternative 2-UF/NF Membranes
Pumping Energy	21 KW	63 KW
Water Used for Washing/Wasting	3.4%	26%
Wastewater Generated	36,000 gpd	360,000 gpd
Finished Water Quality	Very Good	Excellent
Process Reliability	Very Good	Very Good
Process Flexibility	Very Good	Very Good



# Current Project Status

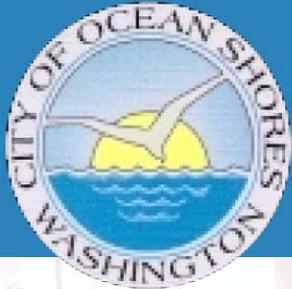
- DOH Approved All Pilot Plant Reports
- City Obtained Economic Stimulus Funds
  - Total \$6 Million
  - Half of that as a Forgiveness Grant
- Next Step is Design





# Summary

- Both Technologies Successful
  - Greensand Filtration/MIEX
  - UF/NF Membranes
- Greensand/MIEX Costs Less
  - Capital
  - Operating Costs
- Greensand/MIEX Uses Less Energy
- Greensand/MIEX Generates Less Waste
- MIEX: Proprietary and Not Particularly Common
- Membranes: Relatively Common



# Acknowledgements

- City of Ocean Shores
- Orica Watercare
- Siemens

*Most Importantly,*

*With Honor, Respect, and Gratitude*



Allies cemetery at Normandy