Case study of a successful in-plant water reuse project that solved the water shortage problem while providing a good payback for a major petrochemical plant

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Presentation Outline

- Introduction of CAPCO Kaohsiung PTA Plant
- Plant Water Problems
- Water Resources Management Study
- Water Reclamation Project
- Pilot Testing Program
- Project Cost Analysis
- Full-Scale Implementation
- Summary of 14 Years of Operation
- Present Status and Conclusions

CAPCO PTA Plant – 1 Million Tons Per Year Production (1993)

New PTA Production Units – 600,000 Tons Per Year (1995)

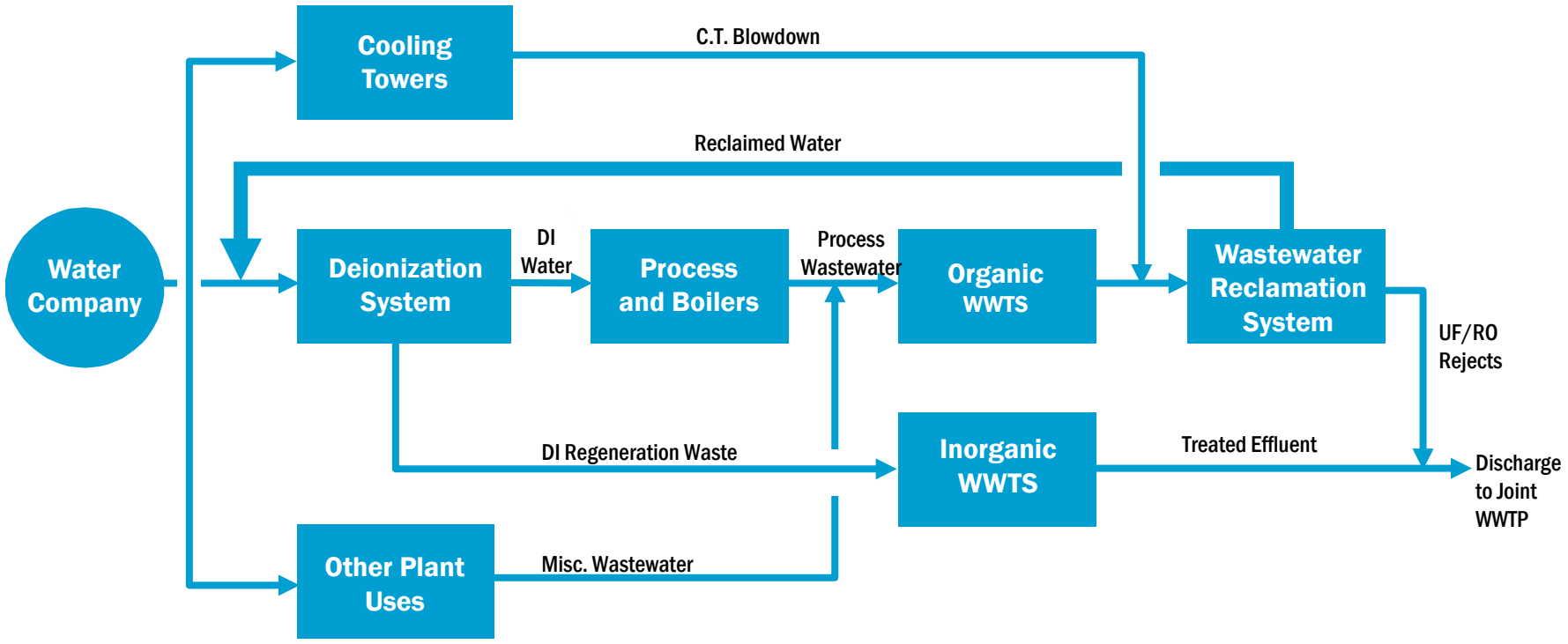
Petrochemical Plant Water Problems

- Large Water User
- Water Rationing Due to Drought
- Raw Water TDS Increase
- Deionization (DI) System Constraint
- Wastewater Discharge Sewer Overloading
- Future Plant Expansion Constraint

Water Resources Management Study

- More than 90 Percent Usage in Two Systems – Cooling Towers & DI System Makeup (~3.2 mgd each)
- Cooling Tower Improvements
- DI Systems Improvements
- Major In-plant Water Reuse Project Identified

Relation of Wastewater Reclamation System with Plant Water Systems



Two Stage Anaerobic-Aerobic Organic Wastewater Treatment System

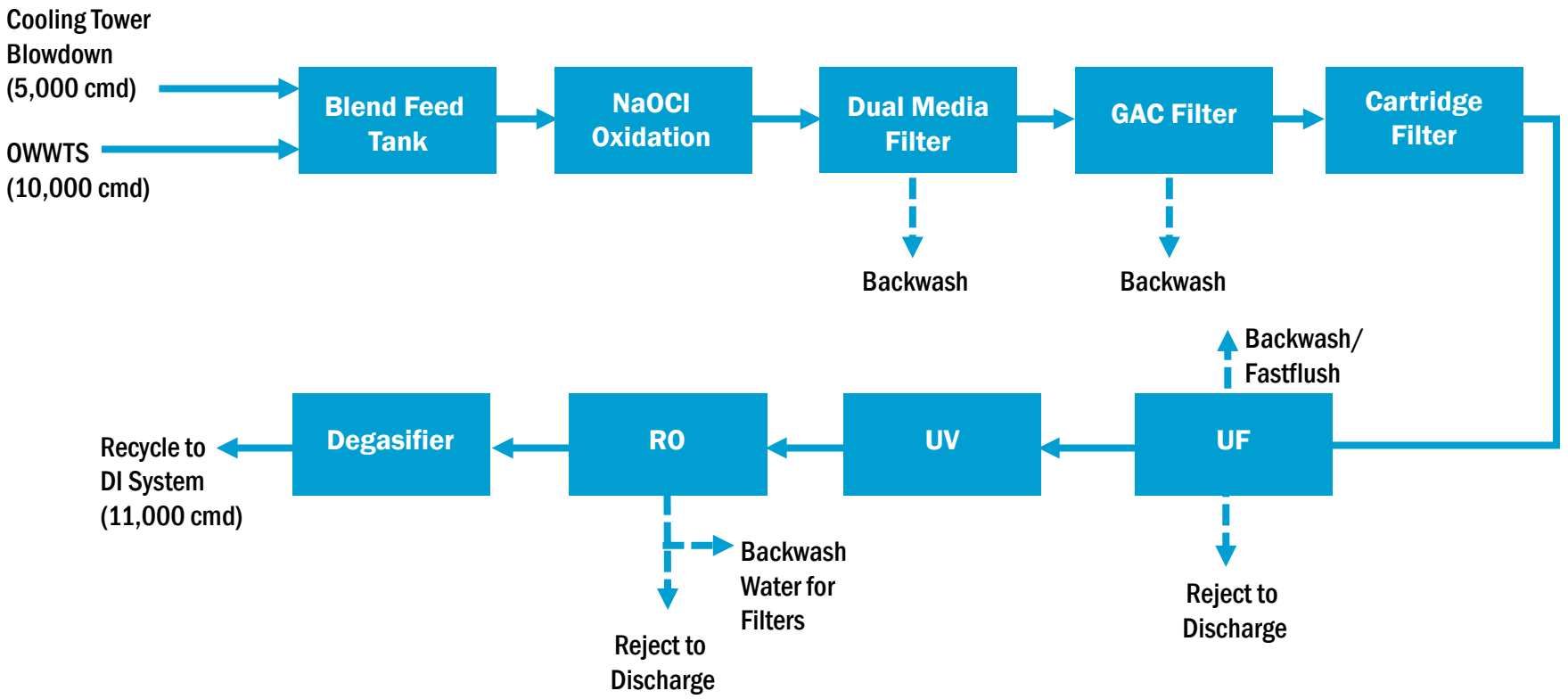
Organic Wastewater Treatment System Clarifiers

Cooling Towers

Wastewater Effluent Characteristics & Discharge Requirements

	Cooling Water B/D	OWWTS Effluent	Effluent Discharge Standards
pH	7.32	8.45	6 –9
TSS (mg/L)	10	24	30
T-H (mg/L) as Ca CO_3	980	39	--
TDS (mg/L)	3,000	3,544	--
Cond (µS/cm)	3,690	4,260	--
SiO_2 (mg/L)	71.6	3.5	--
COD (mg/L)	51	74	100
Co (mg/L)	--	2.2	--
Mn (mg/L)	--	1.3	10

Wastewater Recovery Treatment System Block Flow Diagram



Wastewater Reclamation Project Benefits

- Economically Advantageous
- Save Fresh Water for Community
- Improve and Expand DI System
- Minimize Drought Effects on Plant Production
- Minimize Discharge Sewer Overloading Situation
- Minimize Effects of W/WW Fee Increases
- Enhance Community Relations
- Future Plant Expansion Opportunity

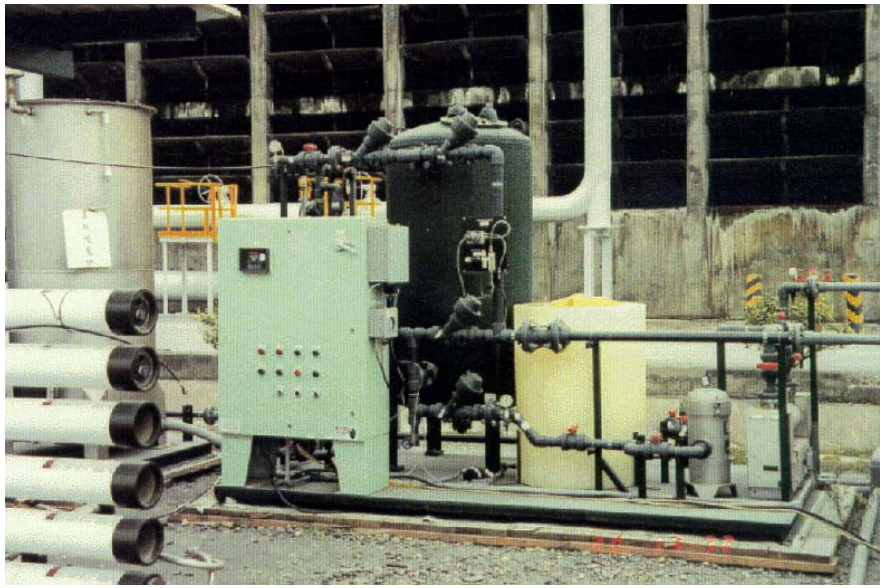
Pilot Test Program

- Bench-Scale Testing
- Semi-Automatic 110 cmd (20 gpm) Pilot System
- Basic Performance Testing
- Optimization Testing
- Accelerated Biofouling Testing

Pilot Plant Pictures

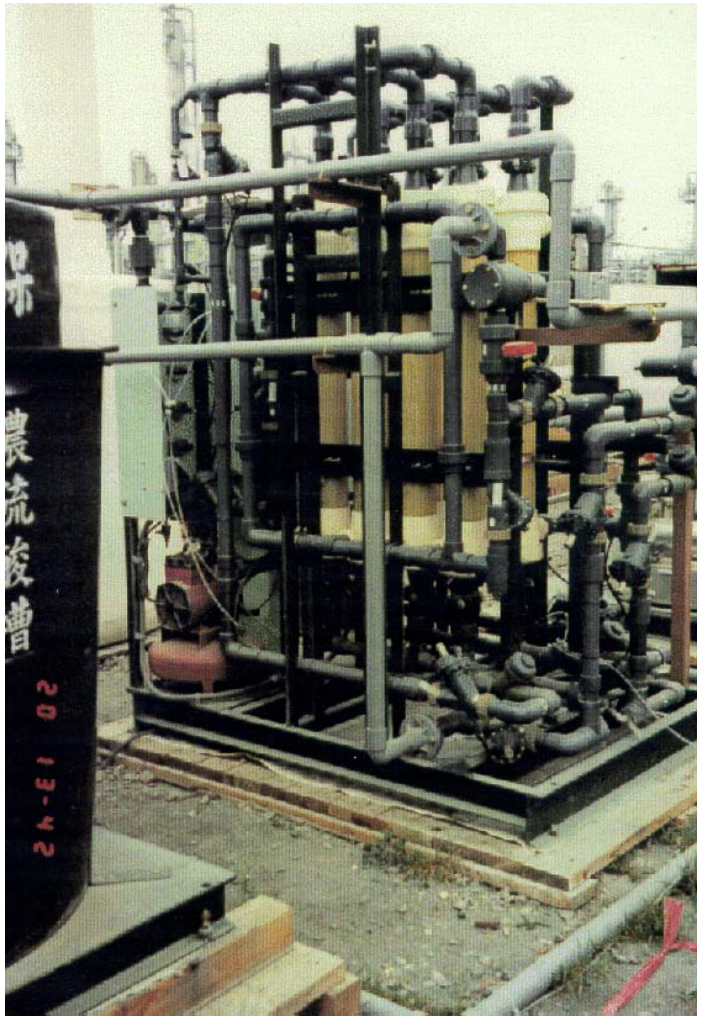
Pilot Plant #1

Pilot Plant #2



Pilot Plant Pictures

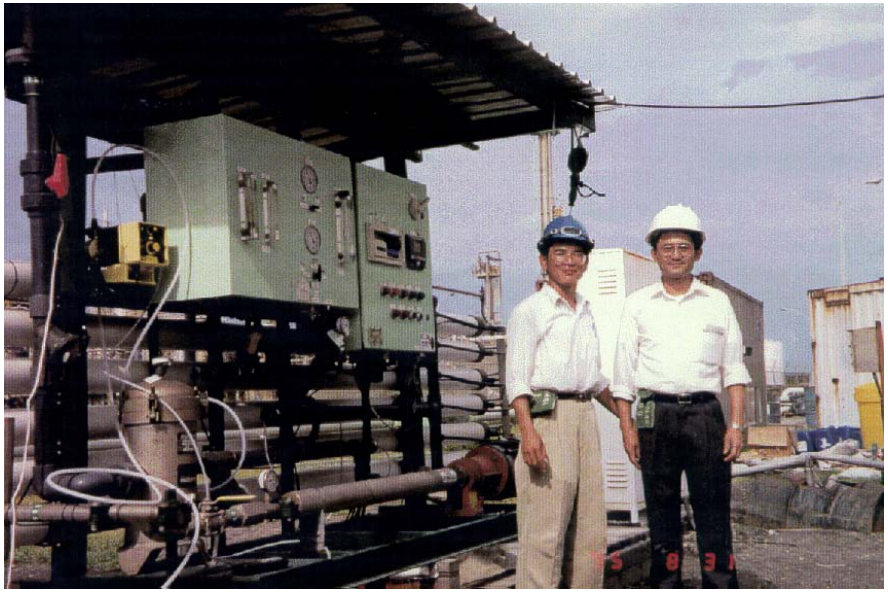
Pilot Plant #4



Pilot Plant #3

Pilot Plant Pictures

Pilot Plant #5



Pilot Plant #6

Continuous Pilot Test Results

Average Product Water Quality	
Conductivity, μ S/cm (>94.8 percent removal)	<240
Hardness, mg/L as $CaCO_3$	<5
SiO_2, mg/L	<2
pH, su	6.9
CO_2, mg/L	5
Mn, mg/L	Trace
Co, mg/l	Trace
COD, mg/L	Trace
Average Recovery Rates	
UF	92 percent
RO	80 percent
UF/RO	73.6 percent

UF System Performance

- UF Flux: 38 to 55 gfd
- Chemical Cleaning Frequency: 3 to 4 Weeks
- Accelerated Biofouling Test
- No Permanent Fouling Found

RO System Performance

- More than 2000 Hours Without Cleaning
- No Significant Performance Deterioration
- No Signs of Physical, Chemical, or Biological Fouling

Conclusions of Pilot Testing

- Demonstrated Technical Feasibility
- Identified Potential Problems and Solutions
- Provided Operating Parameters
- Provided O&M Cost Estimation Data

Estimated Capital Cost of 15,000 CMD (4 mgd) WW Reclamation System

Water Reclamation System	Cost, dollars
Equipment	
Horizontal dual-media filters	400,000
GAC filters	500,000
Cartridge filters	100,000
Hollow-fiber UF system	2,500,000
UV system	150,000
RO system	2,000,000
Degasifier	100,000
Pumps	500,000
Tanks	500,000
Total major equipment cost	6,750,000
Equipment installation at 100 percent	6,750,000
Piping	1,000,000
Instrumentation and control	500,000
Building	1,000,000
Electrical	1,000,000
Total construction cost	17,000,000
Contingency at 10 percent	1,700,000
Legal, administrative, and engineering at 20 percent	3,400,000
Total capital cost	22,100,000
Tax credit at 10 percent	<2,210,000>
Net investment cost	20,000,000

Estimated Annual O&M Cost

Item	Cost, dollars
Electrical power	500,000
Chemicals	
H_2SO_4	480,000
NaOCl	100,000
Polymer	25,000
Antiscalant	60,000
UF/RO cleaning chemicals	40,000
RO membrane replacement at 4-year life	170,000
UF membrane replacement at 5-year life	270,000
UV lamp replacement at 1-year life	15,000
Cartridge filter replacement	60,000
GAC regeneration/makeup	600,000
Other maintenance and analytical materials	80,000
O&M labor	100,000
Total Annual O&M Cost	**2,500,000**

Project Cost Analysis

Net investment cost	$20,000,000
Total annual savings at present water/wastewater costs	$6,885,000
Annual O&M cost	2,500,000
Net annual savings (present cost)	$4,385,000
Simple Payback (Present Cost)	4.56 years
Total annual savings at future water/wastewater cost	$7,968,000
Annual O&M cost	2,500,000
Net annual savings (future cost)	$5,468,000
Simple Payback (Future Cost)	3.66 years

Full Scale Implementation

- First Phase: 9,000/6,600 cmd
- Design/Build: 2 Years
- Space Limitation: Four-Story Building
- Capital Cost: US$15 Million
- Commissioned: April 2000

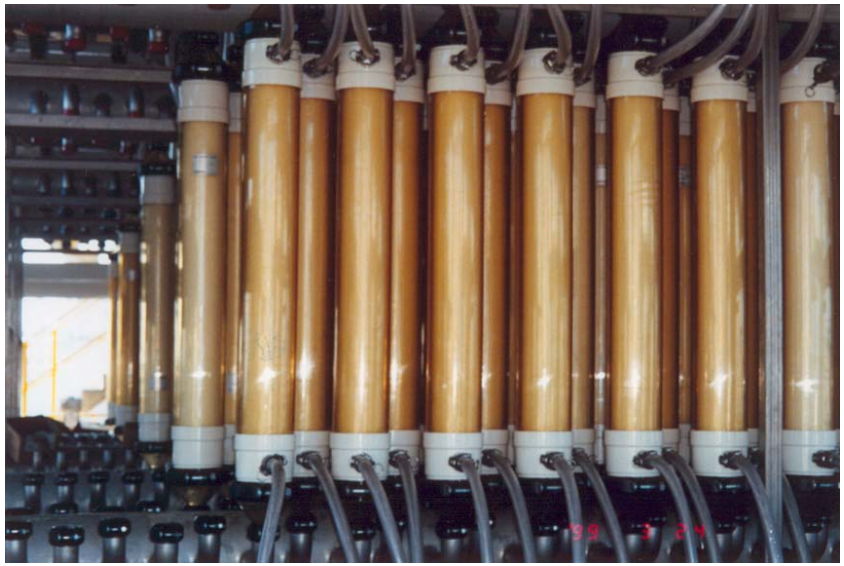
Full Scale Plant

Four-Story Building

Vertical GAC Filters

Horizontal Dual Media Filters

UF Cartridges (Koch PM100)

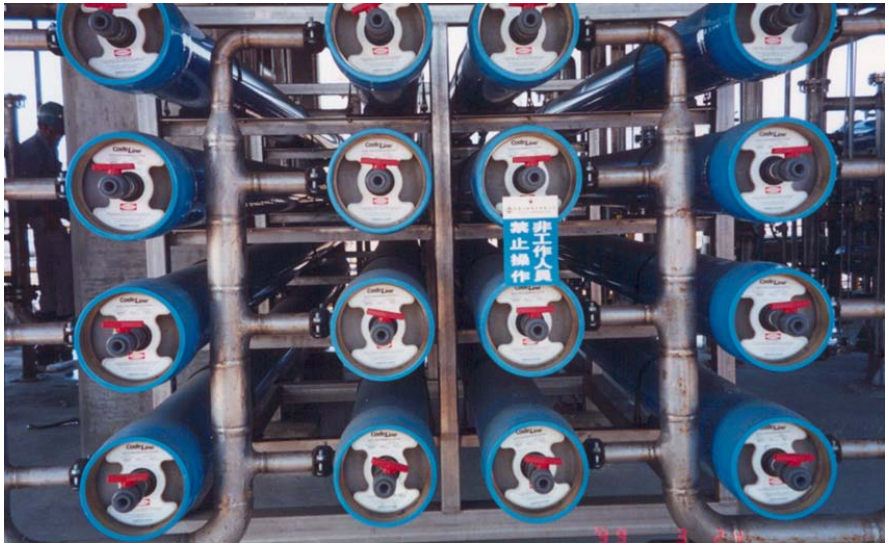


UF System (6-inch Cartridges)

RO Prefilters

RO Skids

RO Modules (FT BW30-400)



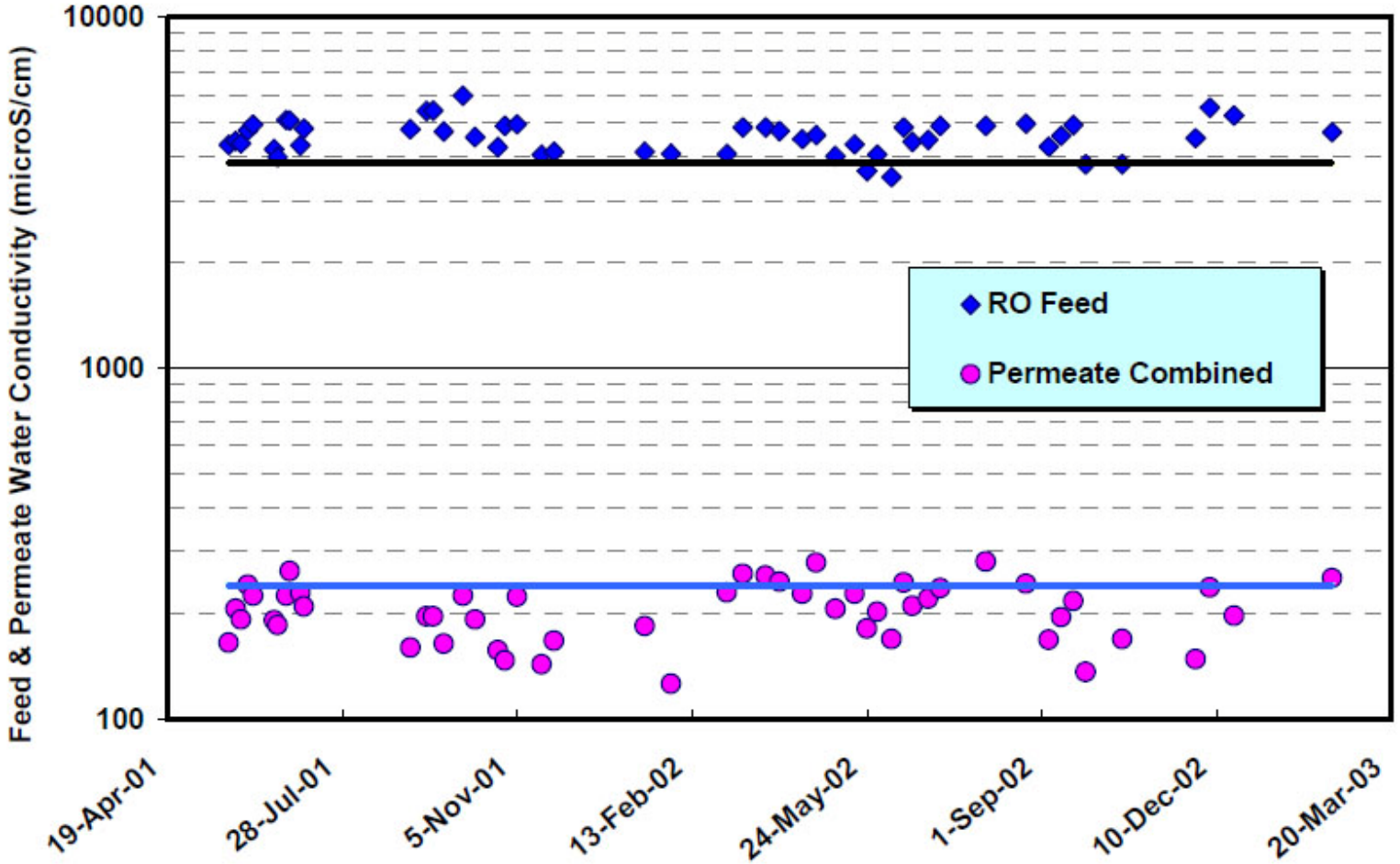
RO Tanks with Degasifier

UV Disinfection System

14 Years of Performance - RO

- 8 Trains of 2-Stage RO w/ 5:3 Array
- Membrane: Filmtech BW30-400
- Flux: 22 L/m2/h (13 gfd)
- Recovery: 80%
- Initial Chlorine Oxidation Caused Replacement of Membranes in 5 Trains
- Subsequent CIP Frequency: 1 years
- Average Membrane Life: >4 Years

Conductivity of RO Feed and Combined Permeate - Typical



14 Years of Performance - UF

- Flux: 85.9 L/m2/h (50.6 gfd)
- Recovery: 92%
- Effluent Turbidity: <0.1 NTU
- 5 Koch UF Skids – Each w/ 109 6-inch PM100 Cartridges
- CIP Frequency: 4 Weeks
- Average Membrane Life: >6 Years
- Converted to 10-in Cartridge System (Still in Use after 6 years)

Converted 10-inch UF System (1)

Converted 10-inch UF System (2)

10-inch Koch UF Cartridge

14-year Operations Recap and Status

- Operated at 82% of capacity for first 3 years due to cooling tower blowdown-caused scaling of piping and UF
- Suspended UF/RO operation in 2008 for 6 months due to very high acid cost
- Resumed operation since January 2009
- Presently operating well at 5,000 CMD (economical capacity)
- No CT blowdown in UF/RO feedwater
- UF membranes installed in 2006 still working

Conclusions

- Project is successful despite some initial startup and operational problems
- Recovered several billion gallons of low TDS water for DI system makeup in 14 years
- Long-term pilot testing pays off
- Good investment and good public relations for CAPCO
- First major water reuse project in Taiwan
- First of its kind in the worldwide petro industries
- This project has solved the water shortage problem while providing a good investment payback for the PTA plant

An Environment-Friendly Petrochemical Plant - CAPCO

Q & A

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