Pilot Scale Evaluation of High Rate Clarification, Ozone and Microfiltration Membranes for a New 41 MGD Water Treatment Plant

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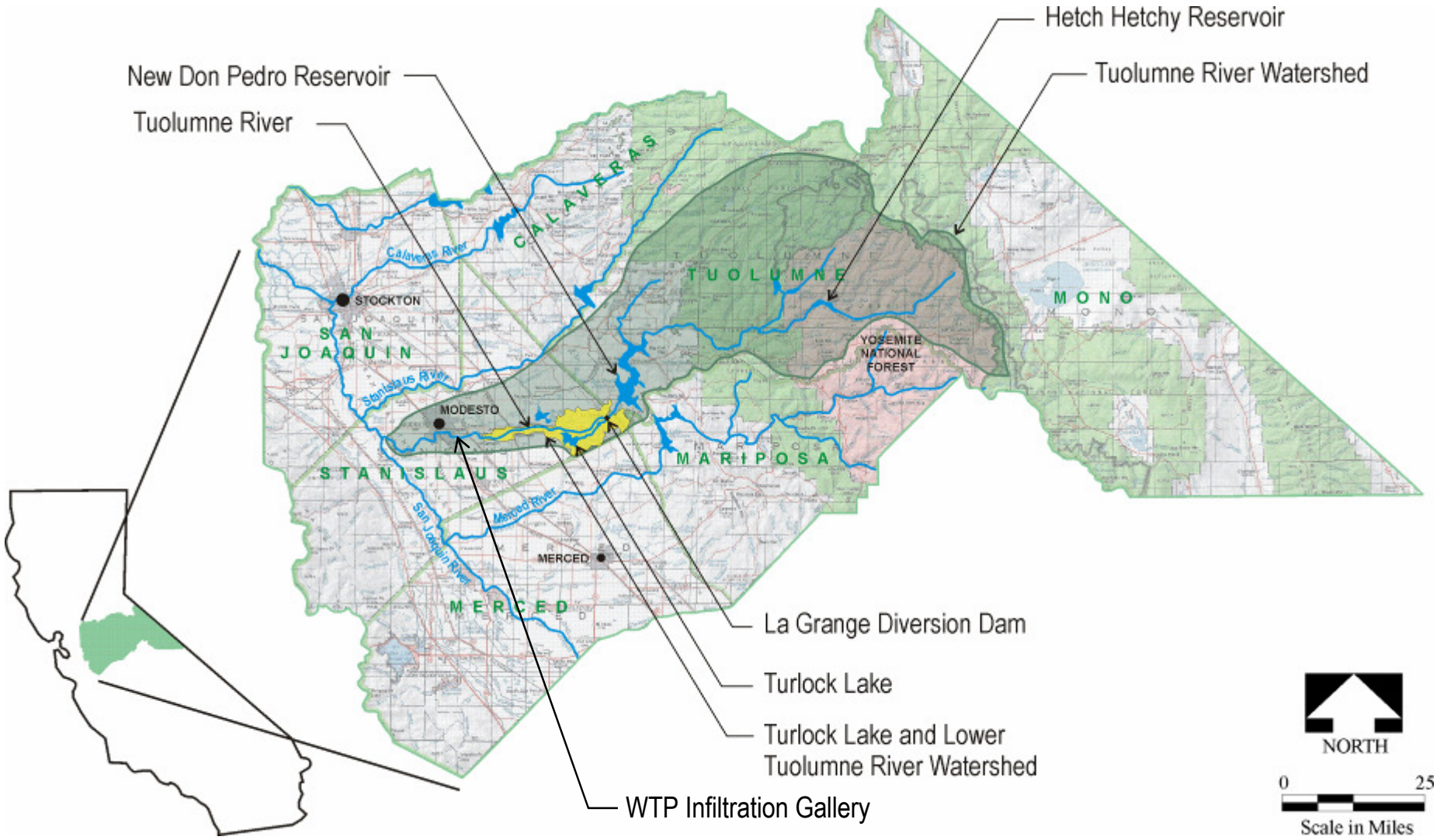
Presentation Outline

- Project Background
- Pilot Overview
- Results
  - High Rate Clarification Processes
  - Membrane Filtration Processes
  - Alternative Pilot Trains
- Conclusions

Project Location



Turlock Irrigation District

- Water and Power Company
- Water rights to the Tuolumne River
- Major part owner of New Don Pedro Reservoir located downstream of the Hetch Hetchy Reservoir
- Communities (4 cities – Ceres, Hughson, Modesto, and Turlock) identified need to use some water rights to provide a reliable surface water supply to customers in service area

TID Regional Surface Water Supply Program

- Infiltration Gallery (Existing)
- Raw Water Pumping Station and Pipeline
- 40.5 MGD Water Treatment Plant
- Treated Water Storage Facility
- Treated Water Pumping Station
- Treated Water Transmission Pipelines
- Interconnections with Communities' Existing Water Systems

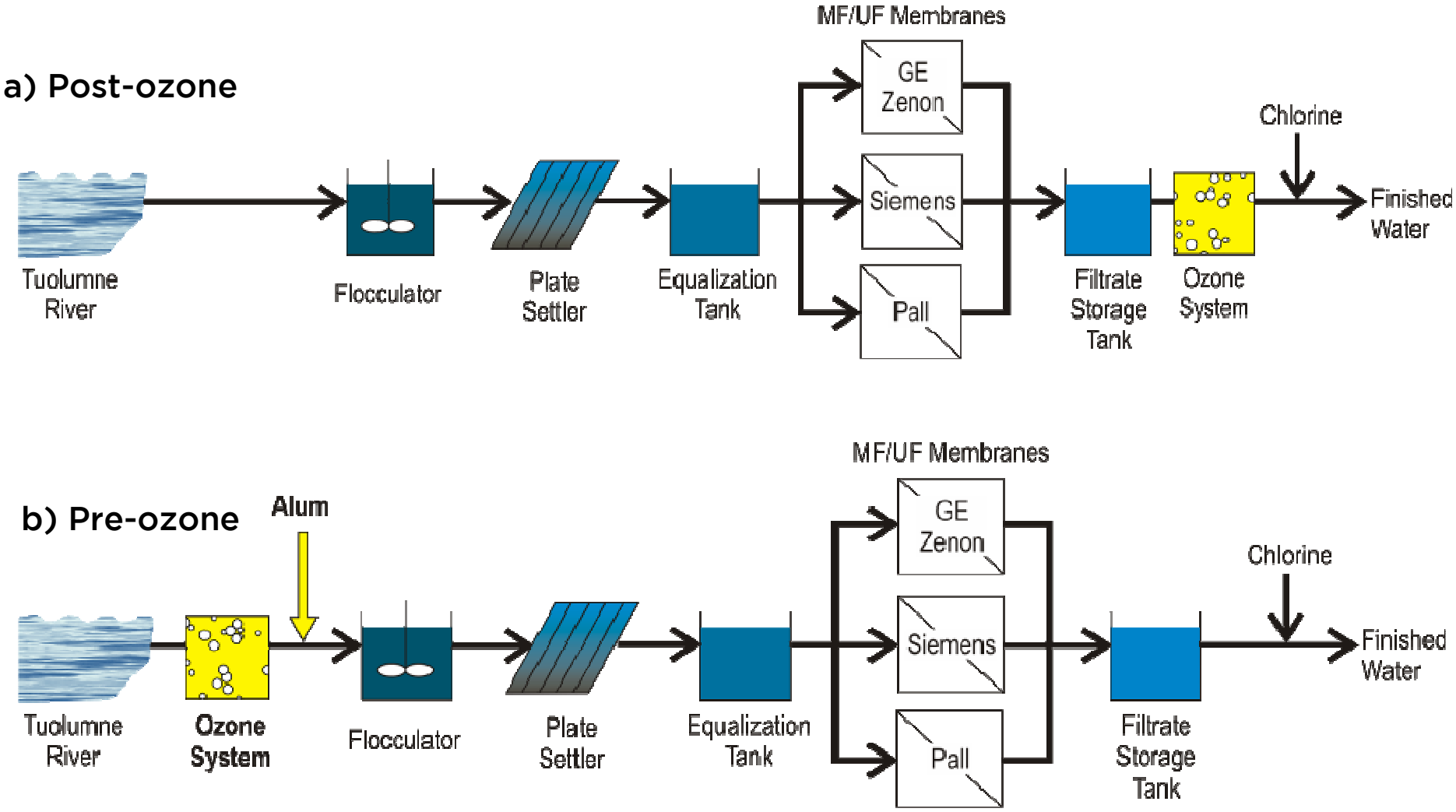
Pilot Testing Program

- Design Support of 40.5 MGD Plant
- Seek Permit Approval from CA DPH
- Evaluate Identified Treatment Alternatives
  - High Rate Clarification
  - Membrane Filtration (MF/UF)
  - Ozonation
- Pilot Operation from 9/06-3/07

Pilot Processes

- Total Pilot Plant Flow – 0.5 MGD
- Base Treatment Trains
  - Flash Mix, Flocculation and Plate Settler
  - 3 MF/UF: Siemens, Pall, GE-Zenon
  - Ozone (Pre- and Post-)
- Independently Piloted 3 High Rate Clarification (HRC) Systems
  - AquaDAF™
  - Clari-DAF™
  - Actiflo®

Piloted Treatment Trains



Flocculation Tank and Plate Settler

Alternative Membrane Systems

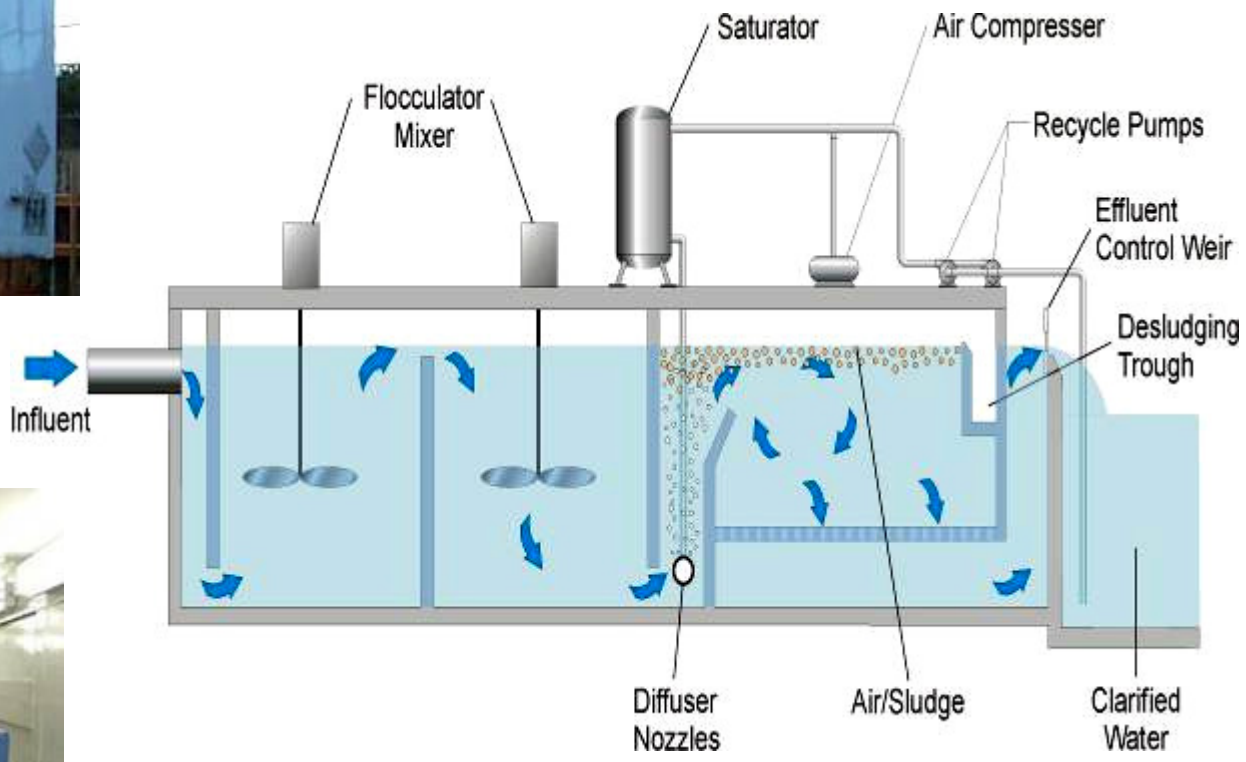
Siemens - Submerged

GE/Zenon - Submerged

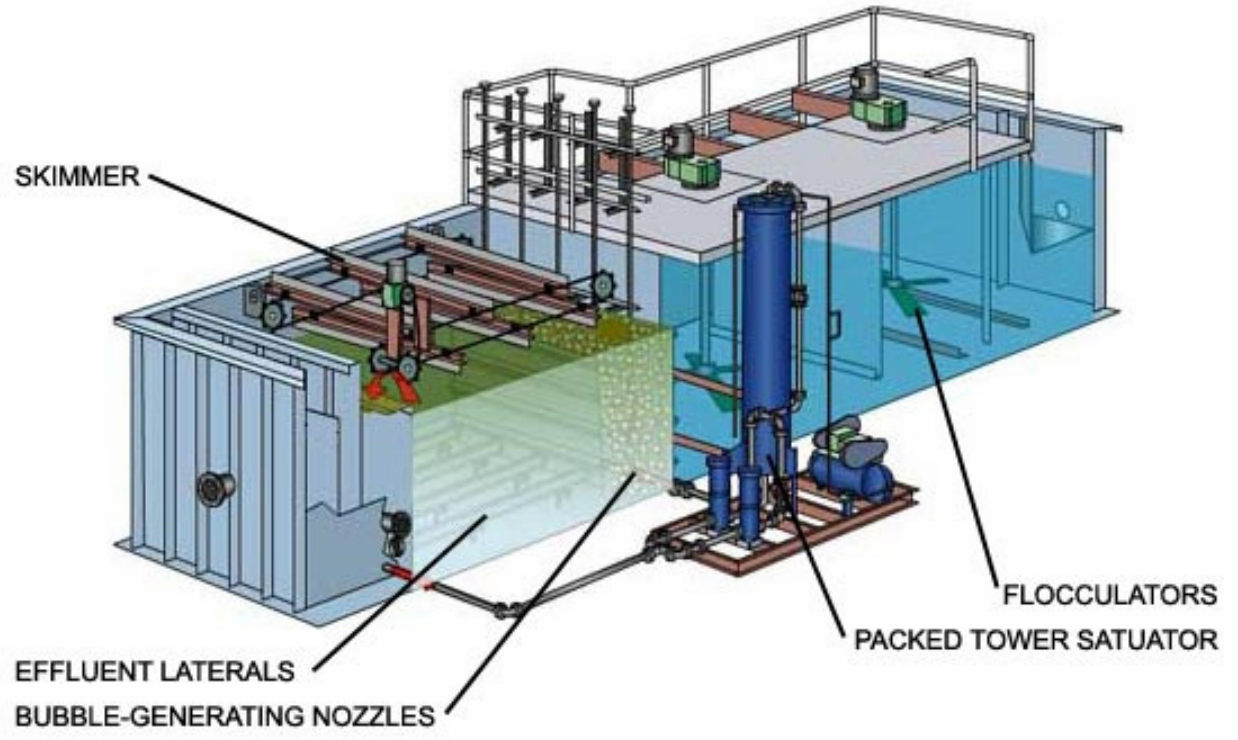
Pall Membranes - Pressure

Ozone Generator and Contactor

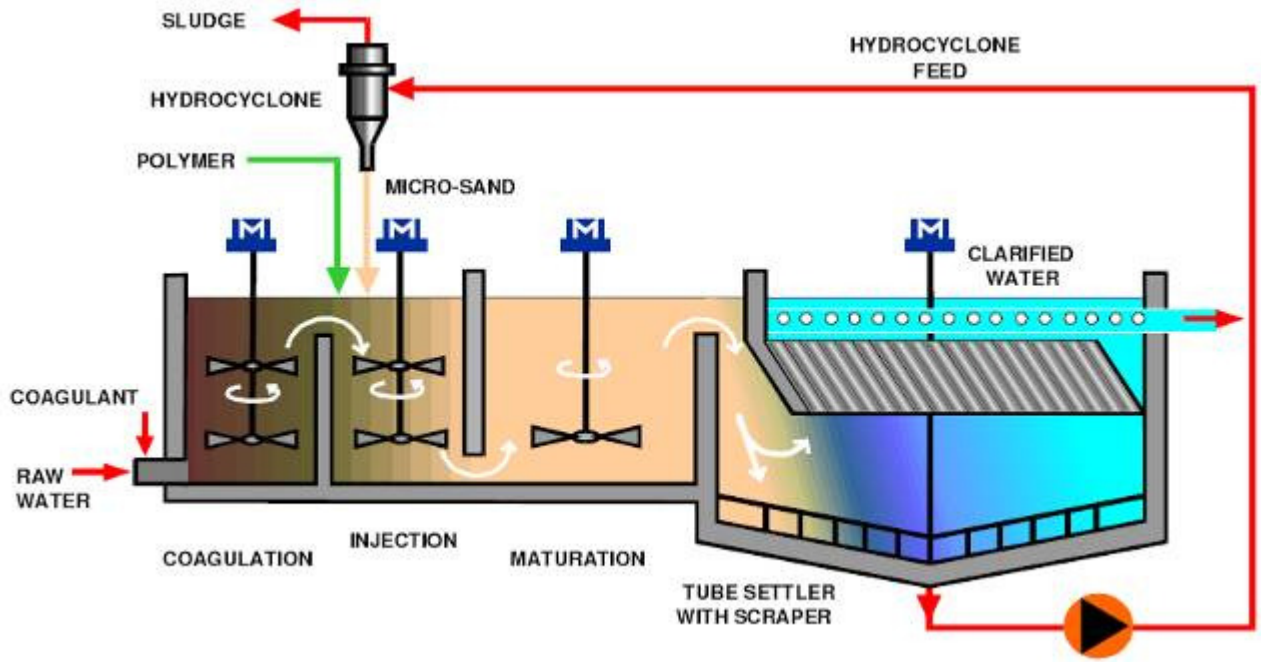
AquaDAF™ Pilot



Clari-DAF™ Pilot



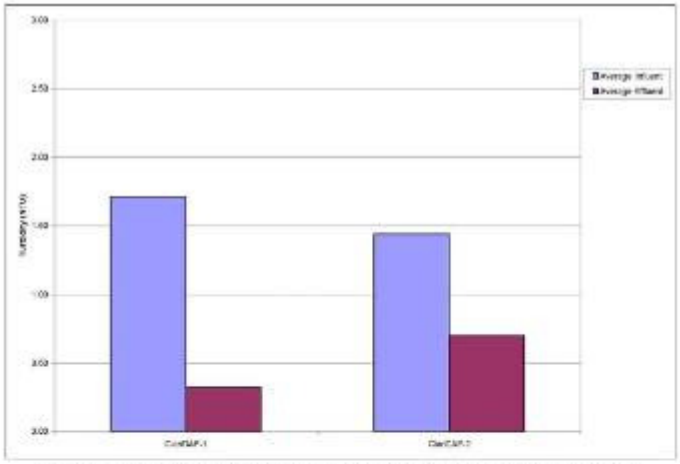
Actiflo® Pilot



Comparison of High Rate Clarification Operating Parameters

	Plate Settler	AquaDAF™	ClariDAF™	Actiflo®
Floc Time, min	12	12	18	10
Loading Rate, gpm/sf	0.56 (Projected Area)	12	12	30
Recirculation Ratio, %	0	8	8	19.7
Enhancing Agent		Air	Air	Micro-sand/ Polymer

HRC Turbidity Removal Performance



Clari-DAF Average Influent Turbidity and Effluent Turbidity for Each Performance Evaluation

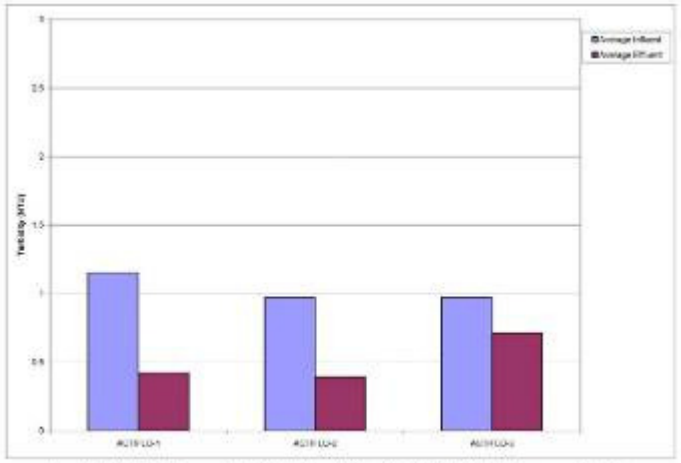
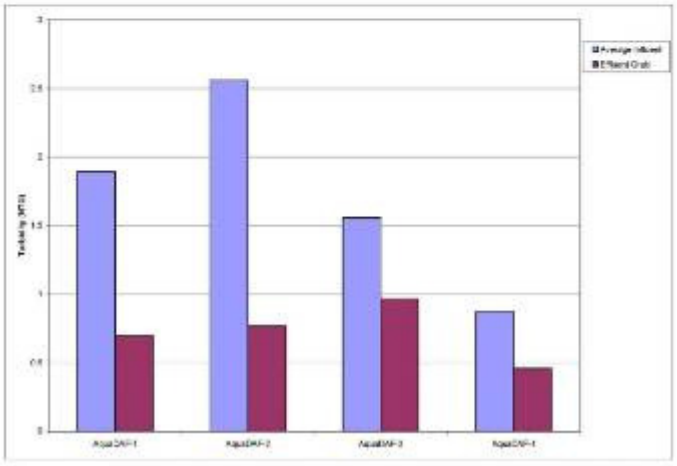


Figure 4-2. ACTIFLO® Average Influent Turbidity and Effluent Turbidity for Each Performance Evaluation



AgueDAF Average Influent Turbidity and Effluent Turbidity for Each Performance Evaluation

HRC TOC Removal Performance

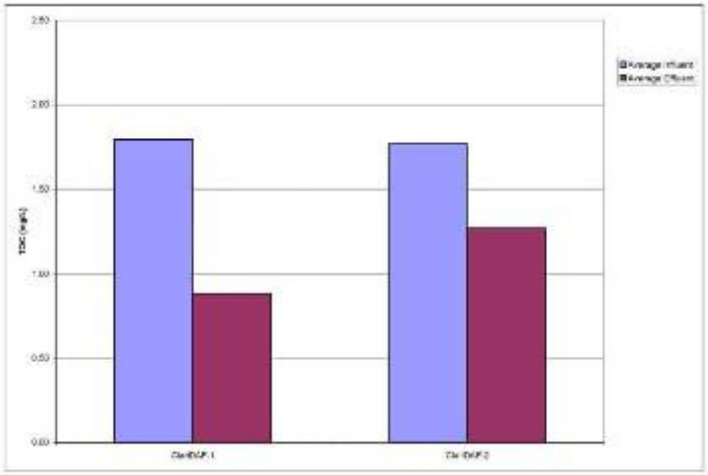


Figure 4-4. Clari-DAF Influent TOC and Effluent TOC for Each Performance Evaluation

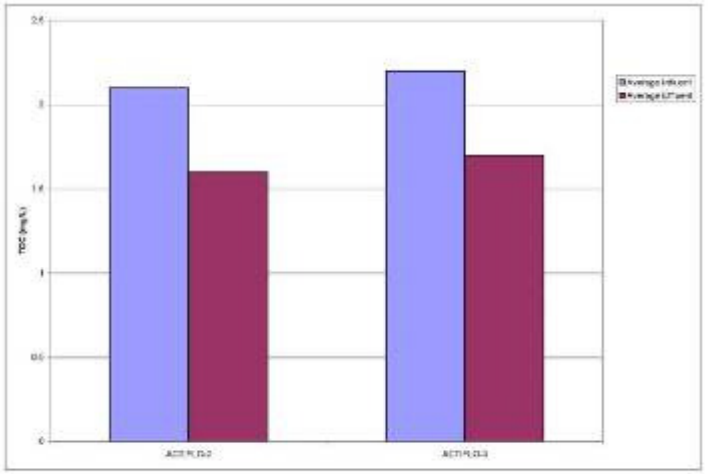
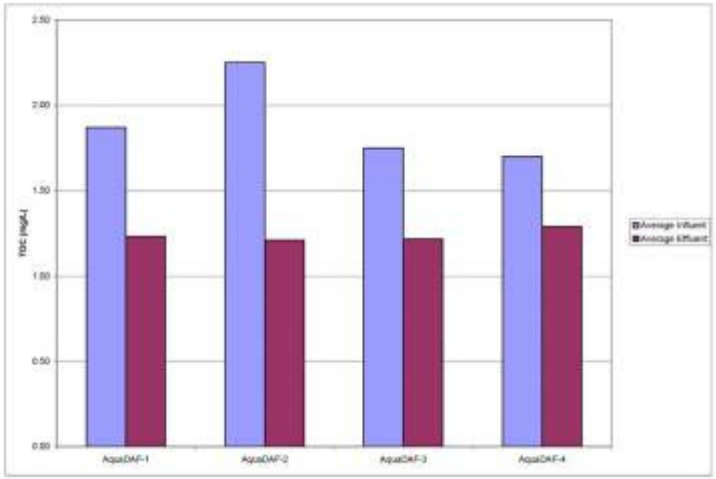


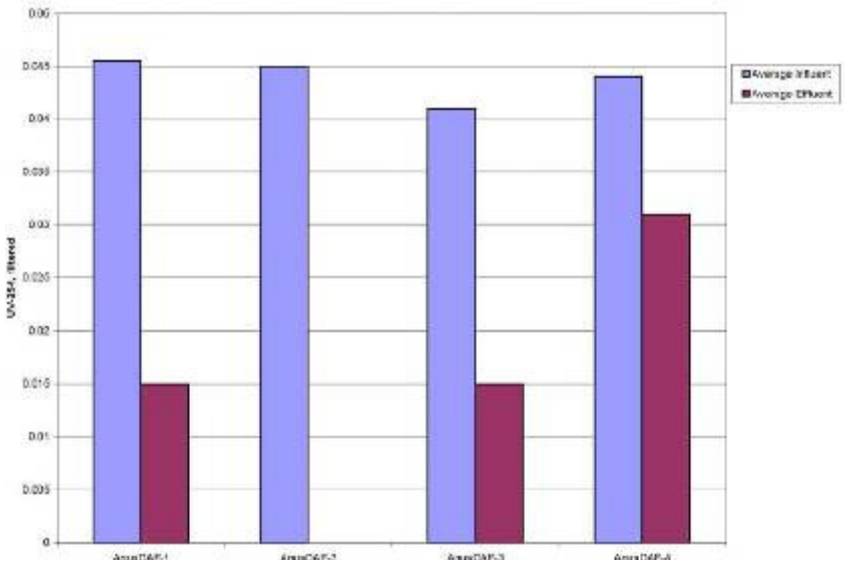
Figure 4-6. ACTIFLO® Influent TOC and Effluent Turbidity for Each Performance Evaluation[1]

[1]TOC data were not available for ACTIFLO®-1 performance evaluation.

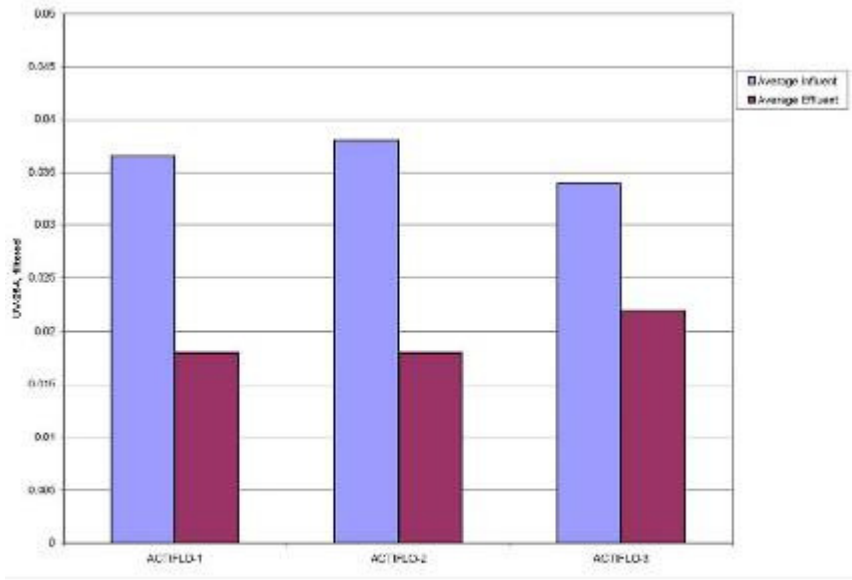


AquaDAF Influent TOC and Effluent Turbidity for Each Performance Evaluation

HRC UV254 Removal Performance

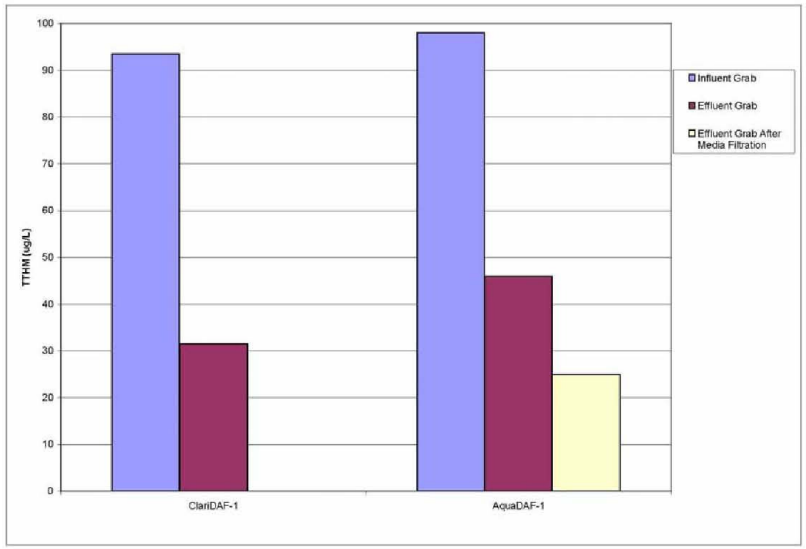


AquaDAF Average Influent UV254 and Average Effluent UV254 for Each Performance Evaluation

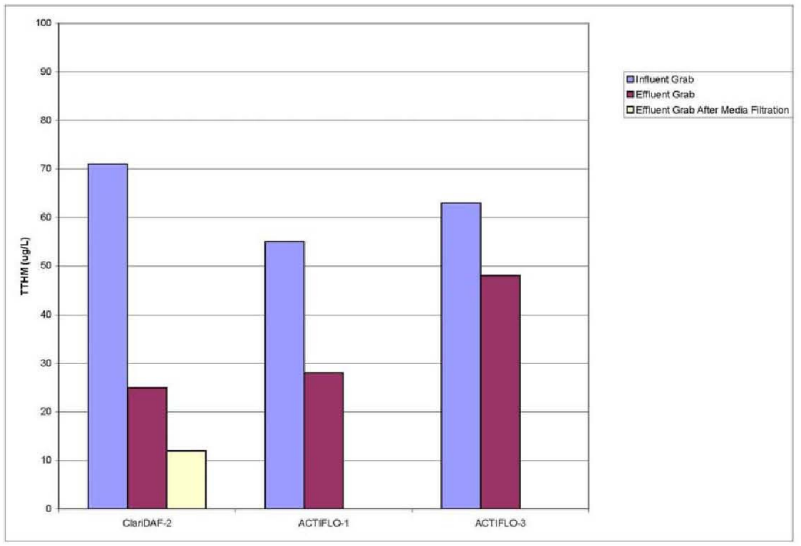


ACTIFLO® Average Influent UV254 and Average Effluent UV254 for Each Performance Evaluation

HRC TTHMFP Removal Performance

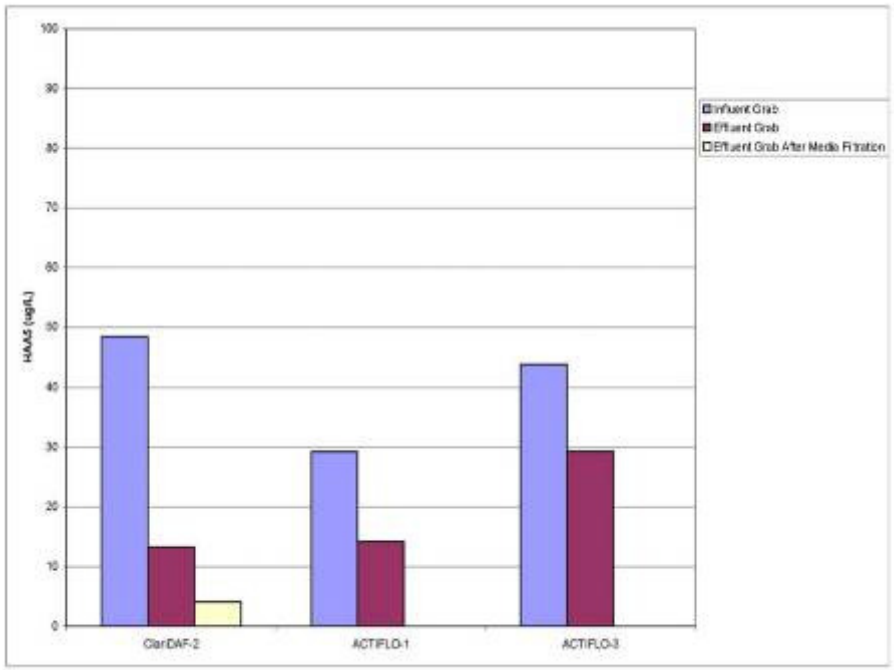


TTHM Formation Potential for Raw Water, Clarified Water and Filtered Water for Selected HRC Performance Evaluations Using Ferric Chloride

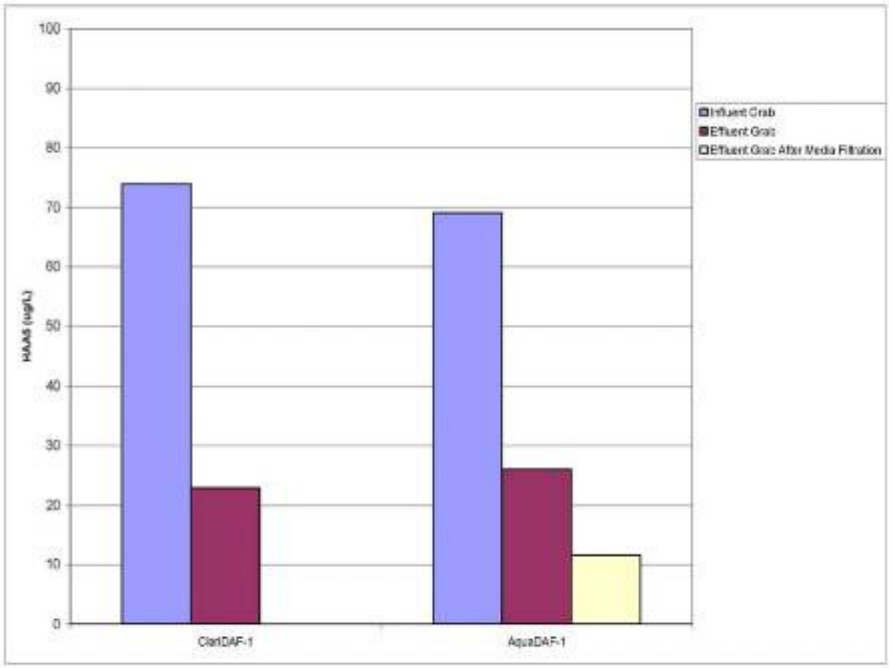


TTHM Formation Potential for Raw Water, Clarified Water and Filtered Water for Selected HRC Performance Evaluations Using Alum or PACl

HRC HAA5FP Removal Performance



HAA5 Formation Potential for Raw Water, Clarified Water, and Filtered Water for Selected HRC Performance Evaluations Using Alum and PACl



HAA5 Formation Potential for Raw Water, Clarified Water and Filtered Water for Selected HRC Performance Evaluations Using Ferric Chloride

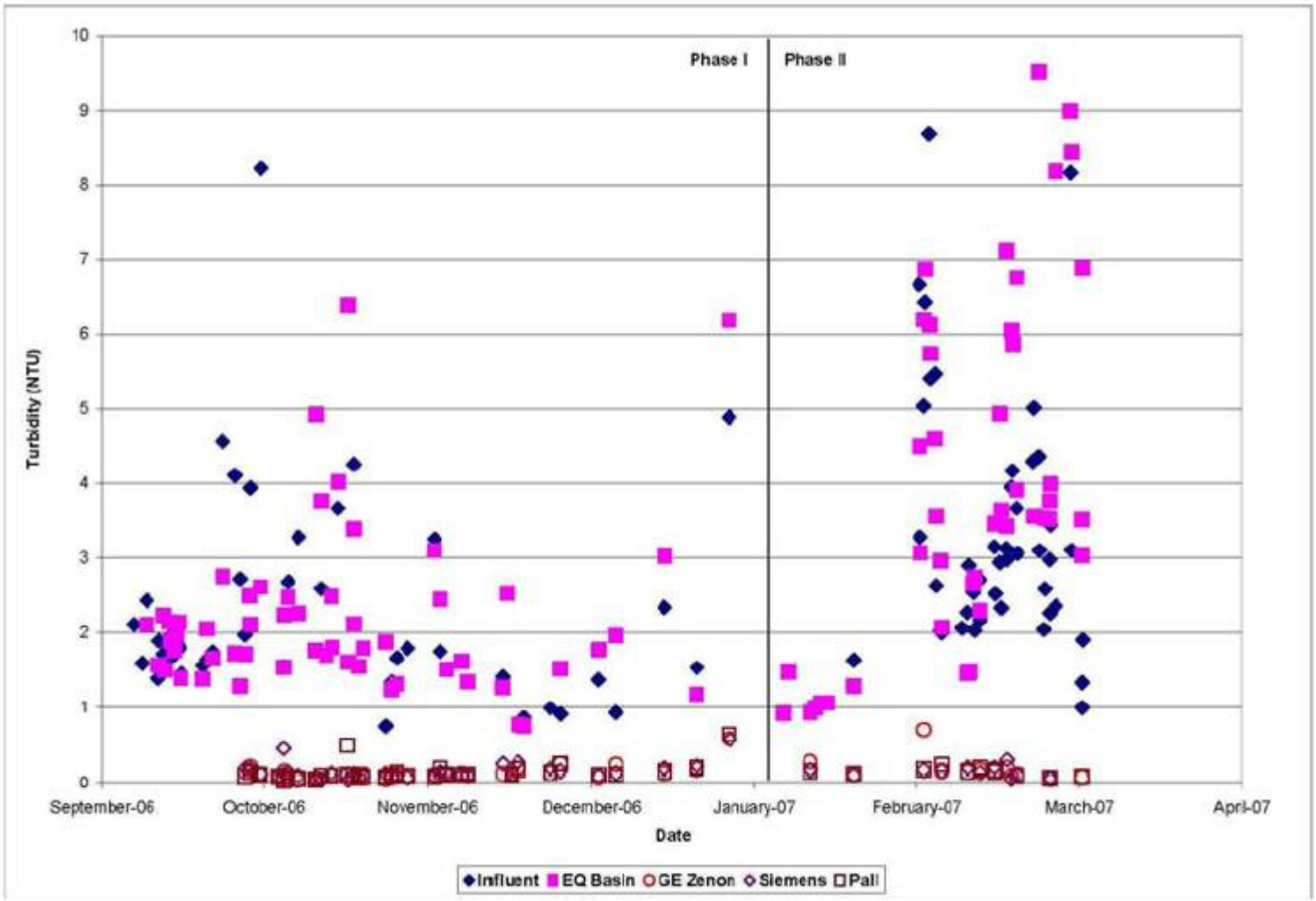
HRC Residual Water Quality

HRC System and Performance Evaluation	Flow (gpm)	Discharge Rate or Volume	pH	TSS (mg/L)	TDS (mg/L)	COD (mg/L)
Clari-DAF-1	120	8.2 L/hr	5.7	31,500	92	1,300
Clari-DAF-2	99	3.3 L/hr	6.9	35,000	81	890
AquaDAF-4[1]	117	50 – 60 gal/day	6.8	16,000	41	NM
ACTIFLO®-1	127	5 gpm	7.3	50	65	NM
ACTIFLO®-2	127	5 gpm	6.7	94	55	NM
ACTIFLO®-3	127	5 gpm	7.2	22	57	NM

[1]Grab samples for residual evaluation on the AquaDAF system were only collected during the fourth performance evaluation due to time constraints.

NM = not measured

Turbidity Removal Performance of Pilot Train



Turbidity Concentrations for the Duration of the Piloting Program

TOC Percent Removal of Pilot Train

Percent TOC Removal							
Process Configuration	Pre-Ozone	EQ Basin	GE-Zenon	Siemens	Pall	Filtered Water Tank	Post-Ozone
No Chemical Addition	NA	3%	14%	8%	3%	-1.5%	NM
Pre-Ozone	NM	1%	22%	20%	17%	NM	NA
Pre-Ozone w/Alum	NM	-14%	33%	35%	39%	NM	NA

NM = not measured

NA = not applicable

UV254 & SUVA Percent Removal of Pilot Train

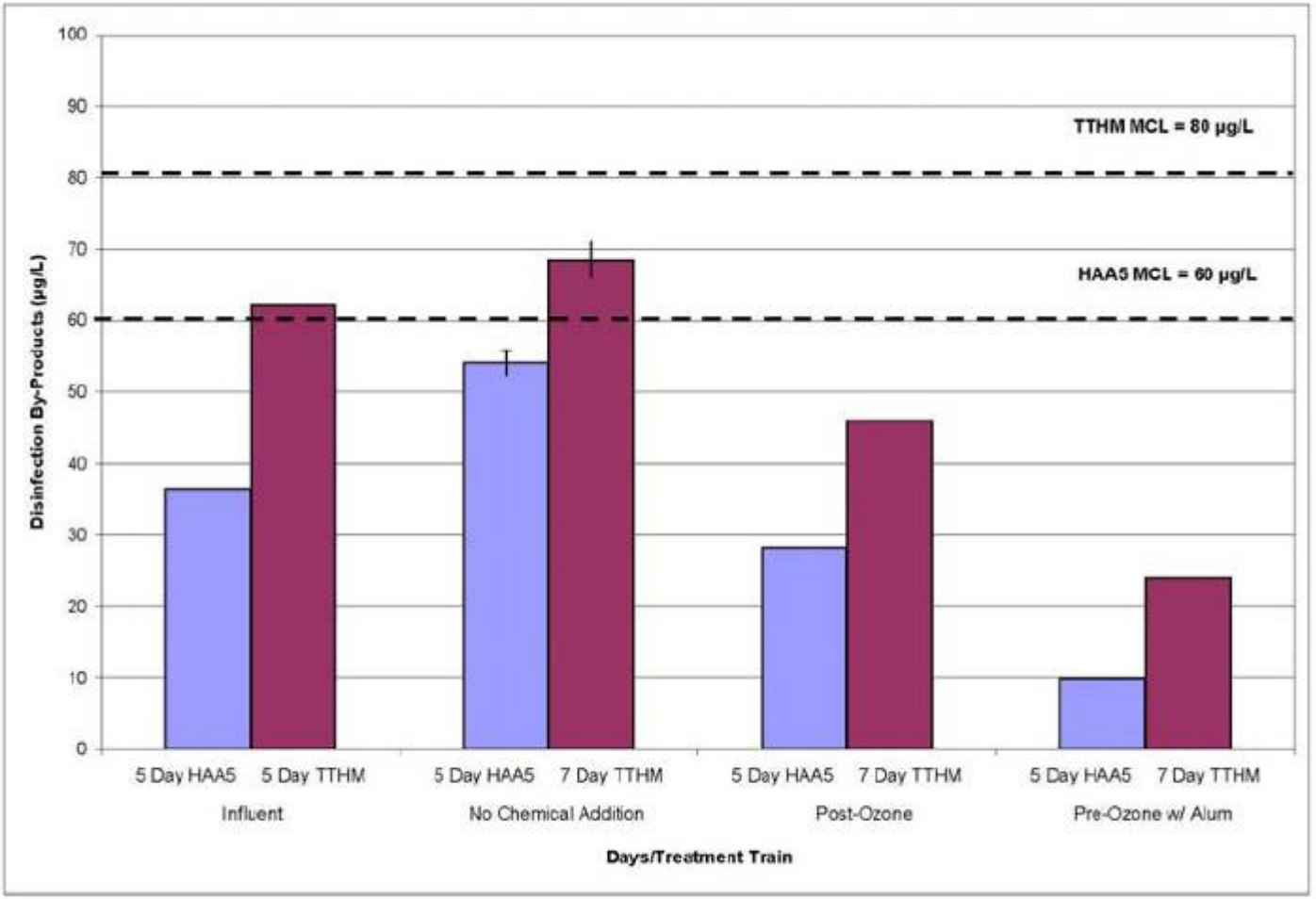
Total Percent Change in SUVA Values							
Process Configuration	Pre-Ozone	EQ Basin	GE-Zenon	Siemens	Pall	Filtered Water Tank	Post-Ozone
No Chemical Addition	NA	3%	- 6%	0%	4%	8%	51%
Pre-Ozone	28%	29%	17%	18%	23%	NA	NA
Pre-Ozone w/Alum	48%	76%	60%	57%	71%	NA	NA

NA = not applicable

Total Percent Change in UV254 Absorbance							
Process Configuration	Pre-Ozone	EQ Basin	GE-Zenon	Siemens	Pall	Filtered Water Tank	Post-Ozone
No Chemical Addition	NA	7%	8%	8%	6%	5%	51%
Pre-Ozone	28%	30%	36%	35%	36%	NA	NA
Pre-Ozone w/Alum	48%	73%	73%	72%	83%	NA	NA

NA = not applicable

HAA5 & TTHM Formation Potential Comparison



Comparison of HAA5 and TTHM Formation Potential of the Influent to Membrane Filtrate for the Different Treatment Schemes during Phase II (12/01/07 and 03/07/07)[1]

Membrane System Design Conditions

MF/UF Model	Inst. Flux	Filtration Cycle
GE-Zenon ZW 1000	40 gfd	32 min
Pall UNA-620A	60 gfd	20 min
Siemens CMF-S	28 gfd	22 min

Cleaning Requirements for GE-Zenon ZW-1000 Membrane System

- Maintenance Clean (Daily)
  - 20 min
  - 100 ppm NaOCl
- Recovery Clean (40 days Interval)
  - 300 min w/ 500 ppm NaOCl
  - 300 min w/ 1000 ppm H_3PO_4

Cleaning Requirements for Pall UNA-620A Membrane System

- Enhanced Flux Maintenance
  - 36 min w/ 500 ppm NaOCl (daily)
  - 36 min w/ 0.2% H_2SO_4 (2/week)
- CIP (40 days Interval)
  - 240 min w/ 1%NaOH/0.1%NaOCl
  - 120 min 0.5%H_2SO_4

Cleaning Requirements for Siemens CM-S Membrane System

- Maintenance Wash
  - 42.5 min w/ 200 ppm NaOCl (daily)
  - 42.5 min w/ HCl @ pH 2 (2/week)
- CIP (40 days Interval)
  - 200 min w/ 2% Citric acid
  - 140 min w/ 1000 ppm NaOCl

Summary of Membrane System Performance

Summary of Membrane System Performance				
Parameter	**Goal**	**GE-Zenon**	**Pall**	**Siemens**
95 percent of the filtrate turbidity	< 0.08 NTU	0.0246	0.0111	0.0309
99 percent of the filtrate turbidity	< 0.10 NTU	0.0303	0.013	0.0315
Maximum filtrate turbidity	1 NTU	0.7169	0.31	0.08
Net system recovery	> 90%	96.6	96.4	94.2
Chemical cleaning interval	40 days	Yes	Yes	Yes
Overall on-line factor including backwash and other downtime - Full PET 1 and PET 2	> 90%	92.35	97.95	99.7
Unintentional integrity failure	No more than 2	1	0	2
LRV for *Cryptosporidium*	> 4	Yes	Yes	Yes
Permeability after Final CIP vs. Original Permeability- **24 hr Average after Clean**	≥ 90%	93	111	85

Conclusions

- Both Alternative Treatment Trains tested can achieve Treated Water Quality Objectives
- The recommended treatment train is Pre-Ozone w/ Alum Coagulation for Better DBP Control
- High Rate Clarification Processes (AquaDAF, ClariDAF, Actiflo) are effective in treating Tuolumne River water
- Two out of three Membrane Systems met all performance objectives of pilot testing