DPR Pilot Testing Results for El Paso's Advanced Water Purification Facility

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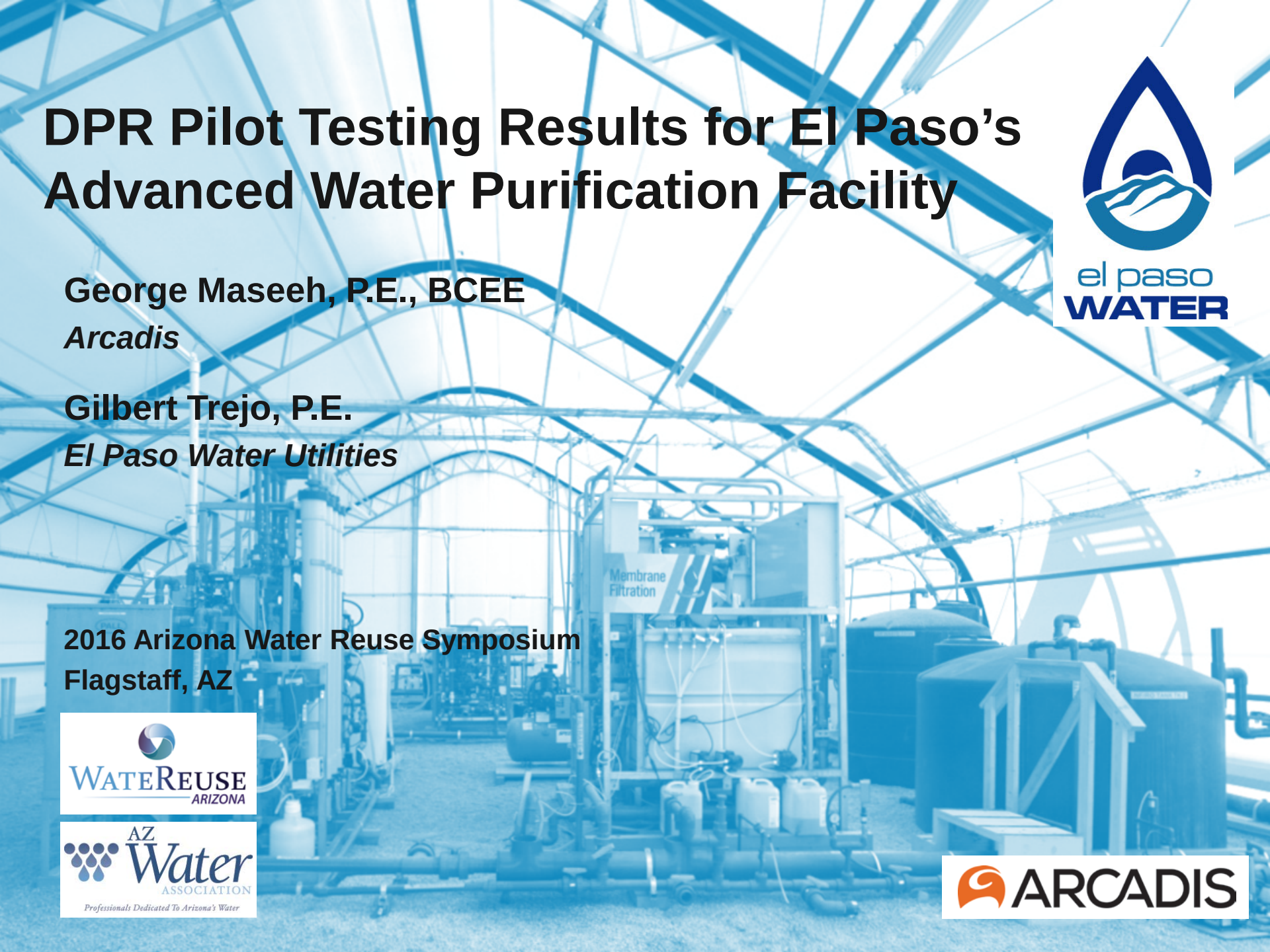
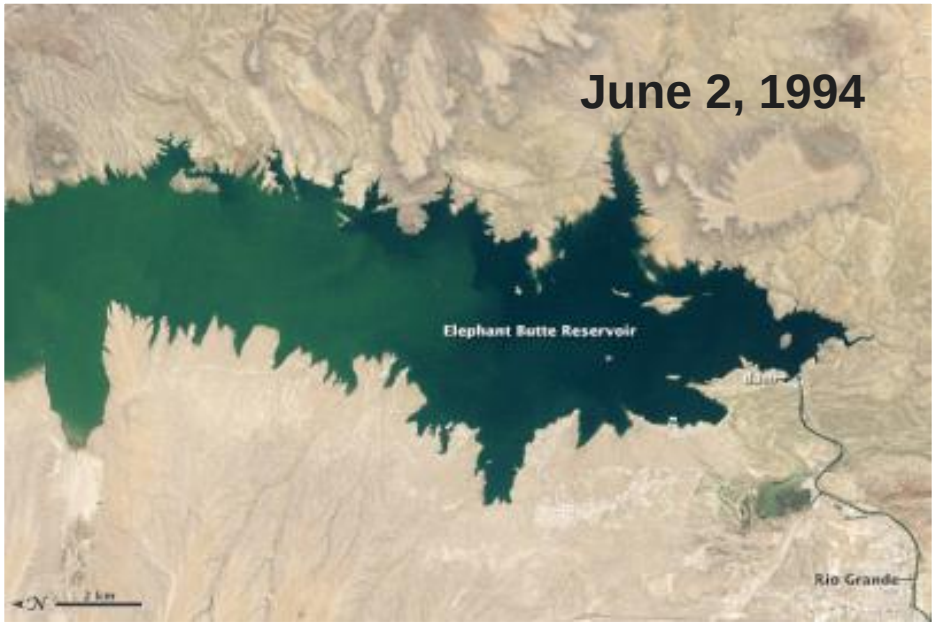
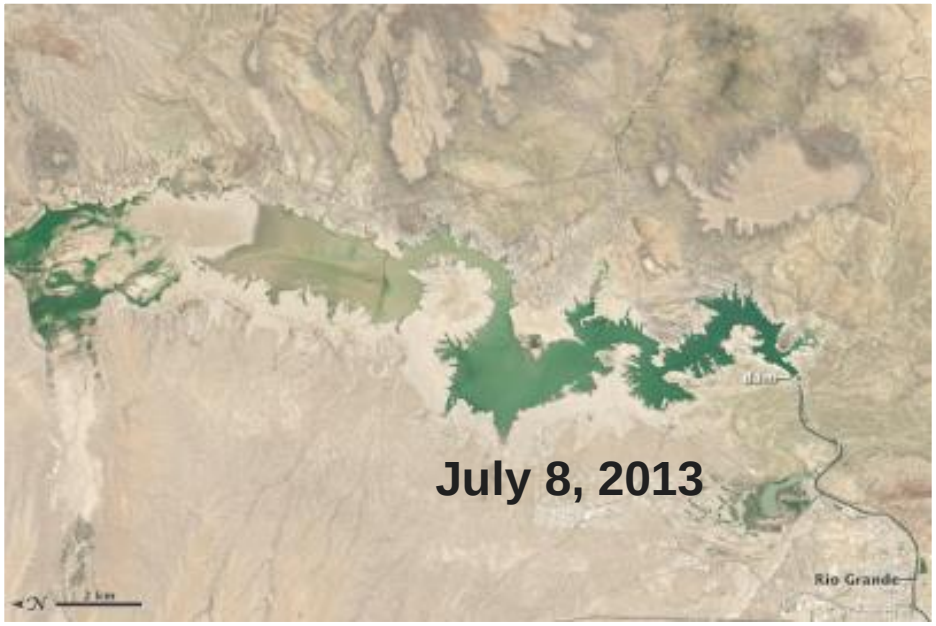
2016 Arizona Water Reuse Symposium
Flagstaff, AZ

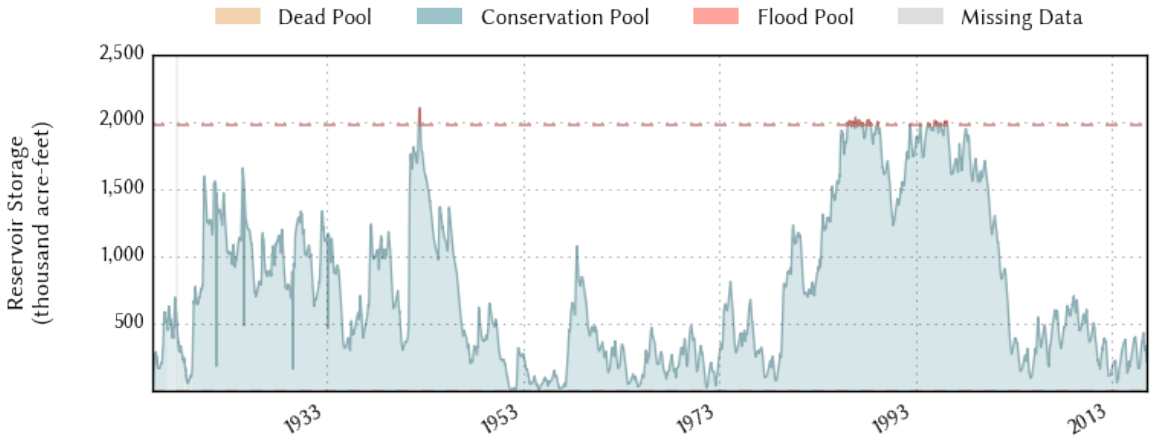


Current Drought Conditions in El Paso





Source: NASA

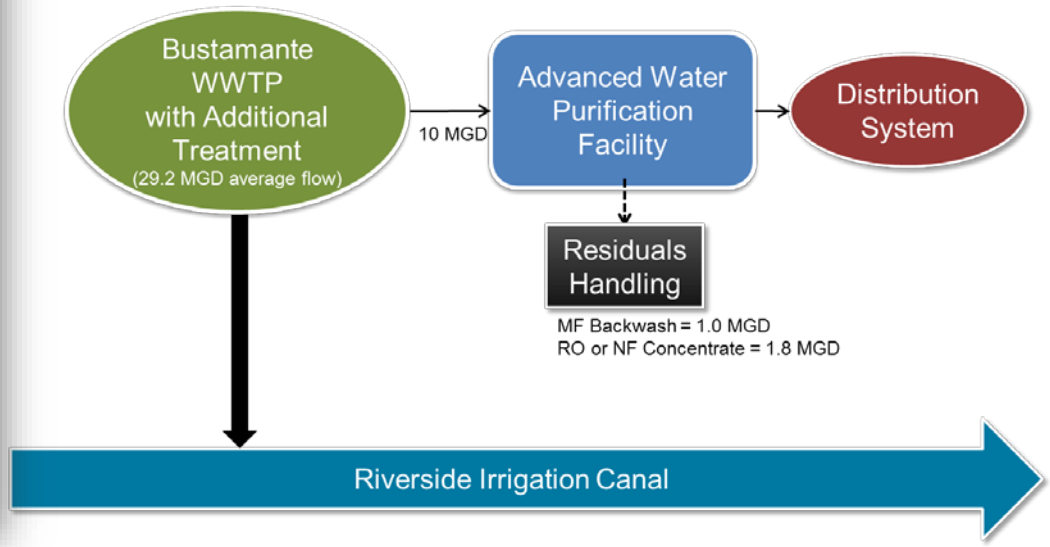


Elephant Butte Reservoir is 10.9% full as of July 24, 2016

- Texas Water Development Board

El Paso's Path

Feasibility Study (2012) → Planning → Pilot Testing → Design → Construct

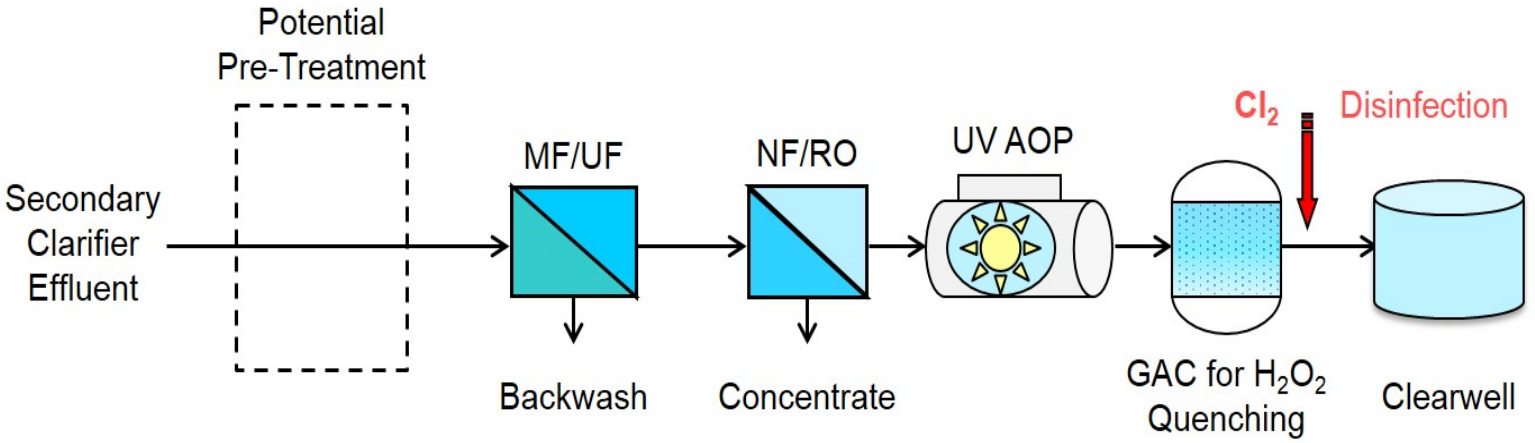


El Paso's Path

Feasibility Study → Planning (2014) → Pilot Testing → Design → Construct

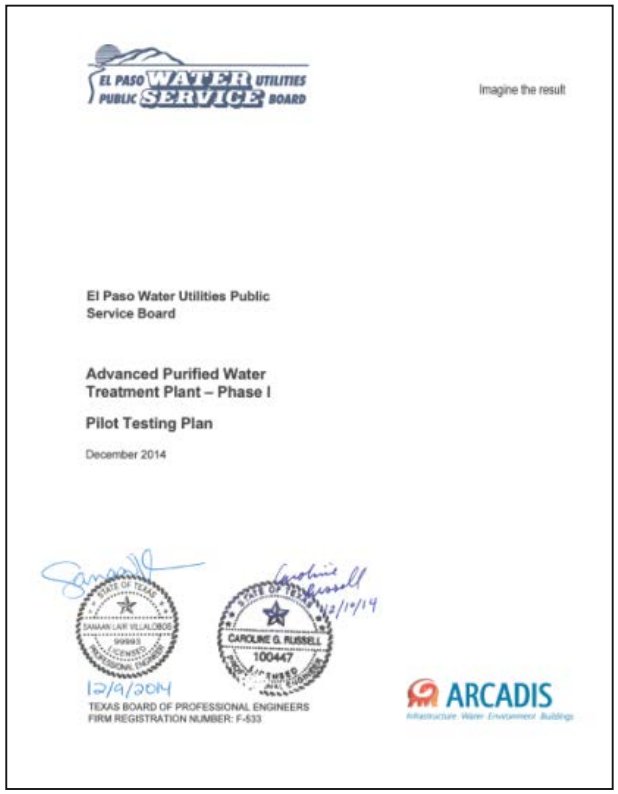
Water Quality Goals

- Address regulatory criteria and public concerns for this DPR project
- Meet all primary water quality standards
- Provide multiple barriers for pathogens
- Provide diverse treatment for chemical microconstituents
- Meet EPWU specific goals



El Paso's Path

Feasibility Study → Planning → **Pilot Testing (2015-16)** → Design → Construct



EL PASO WATER UTILITIES PUBLIC SERVICE BOARD

Imagine the result

El Paso Water Utilities Public Service Board

Advanced Purified Water Treatment Plant – Phase I

Pilot Testing Plan

December 2014

12/9/2014

12/19/14

CAROLINE G. RUSSELL 100447

TEXAS BOARD OF PROFESSIONAL ENGINEERS
FIRM REGISTRATION NUMBER: F-533

ARCADIS

"We find the…pilot study protocol acceptable…"
with amendments to include additional data and information in the final pilot study report.

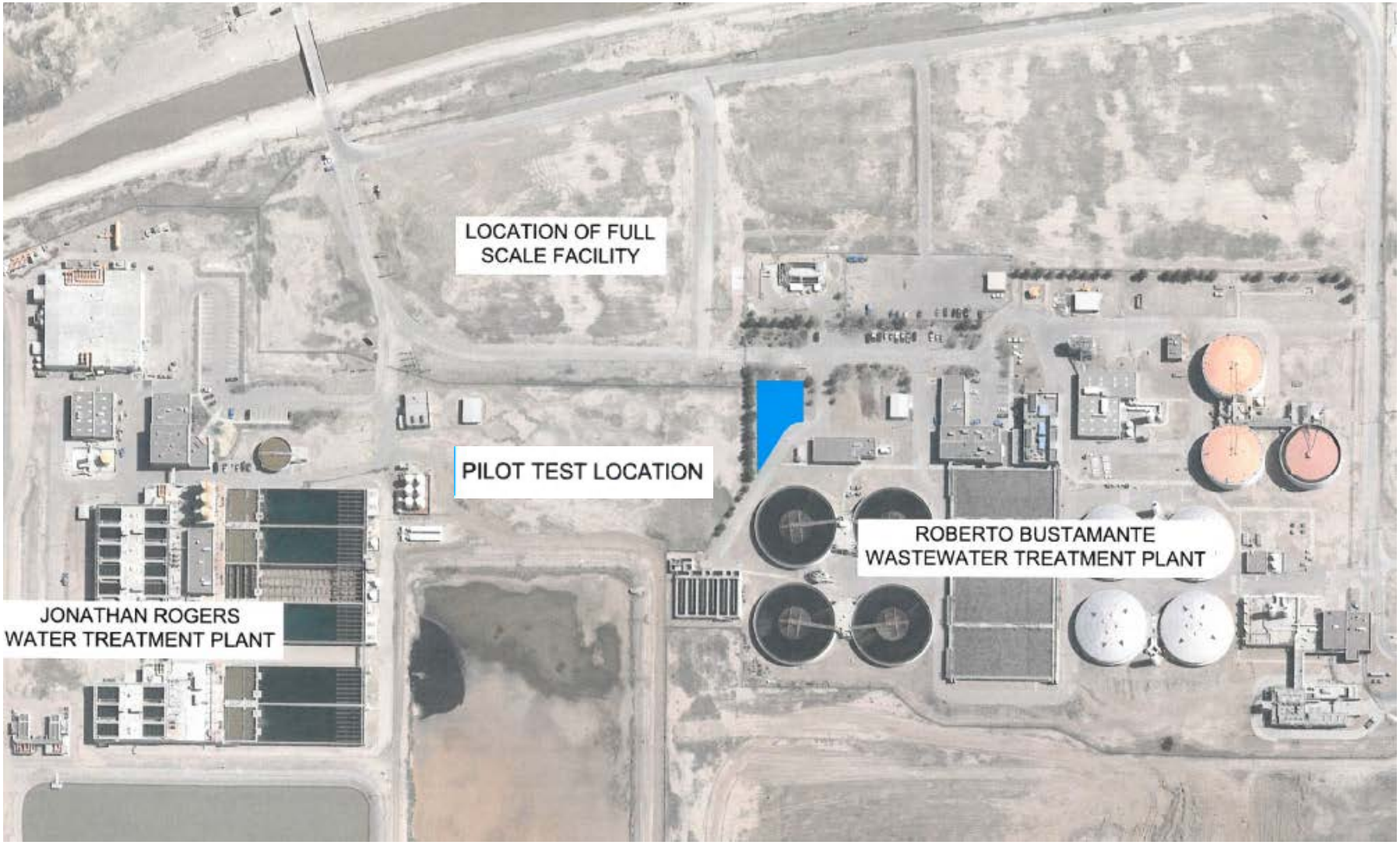
TCEQ Approval Letter
April 17, 2015

Pilot Testing Overview

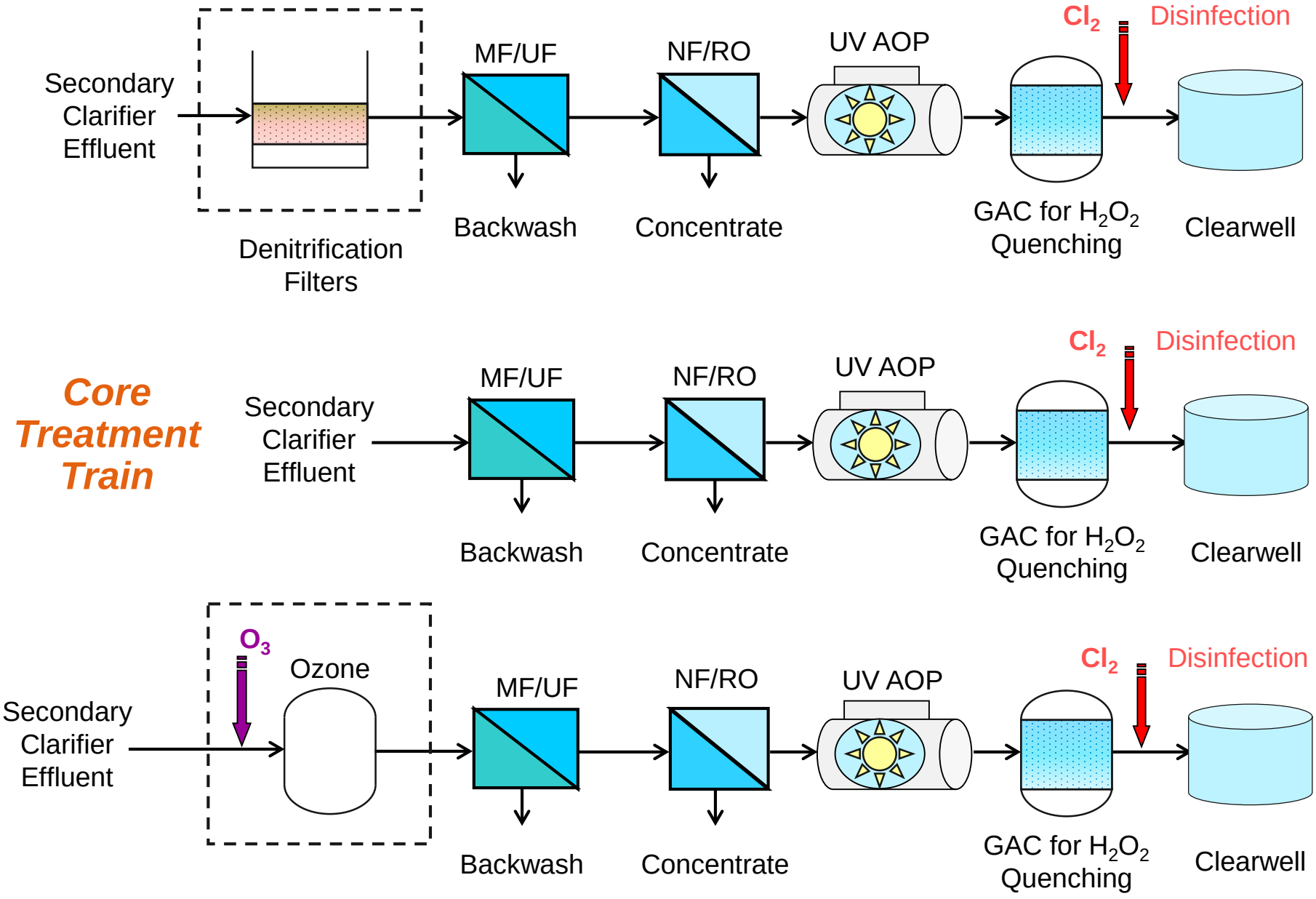
Pilot Testing Objectives

- Meet TCEQ requirements for pilot testing
-  Demonstrate stable and reliable performance
-  Demonstrate AWPF treatment train meets water quality goals
-  Test and demonstrate online water quality monitoring for full scale application
-  Verify major processes and systems for full-scale design

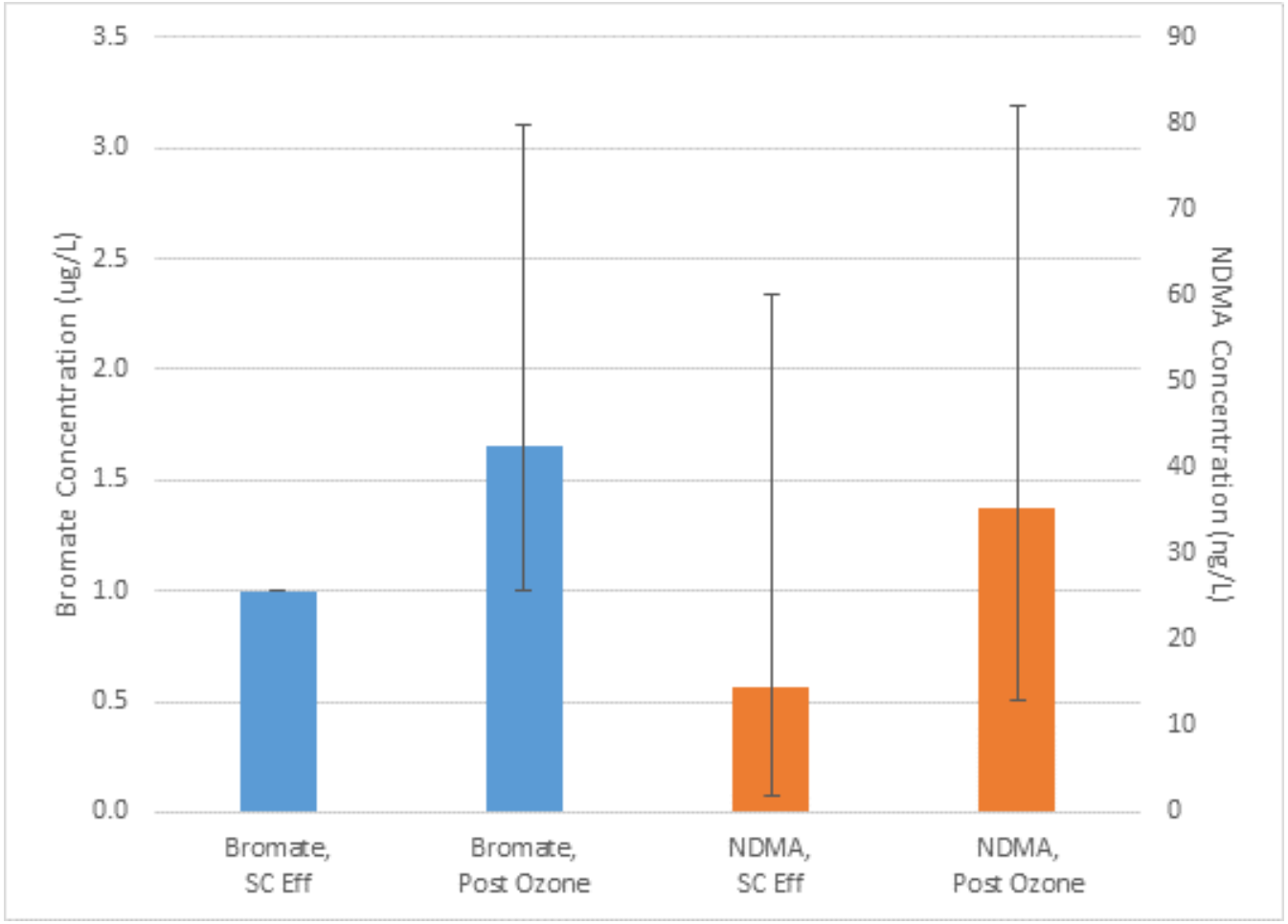
Pilot and Full-Scale Locations



Three Configurations Tested



Ozone Increased Concentrations of Bromate (~60%) and NDMA (~300%)



Ozone System Performance

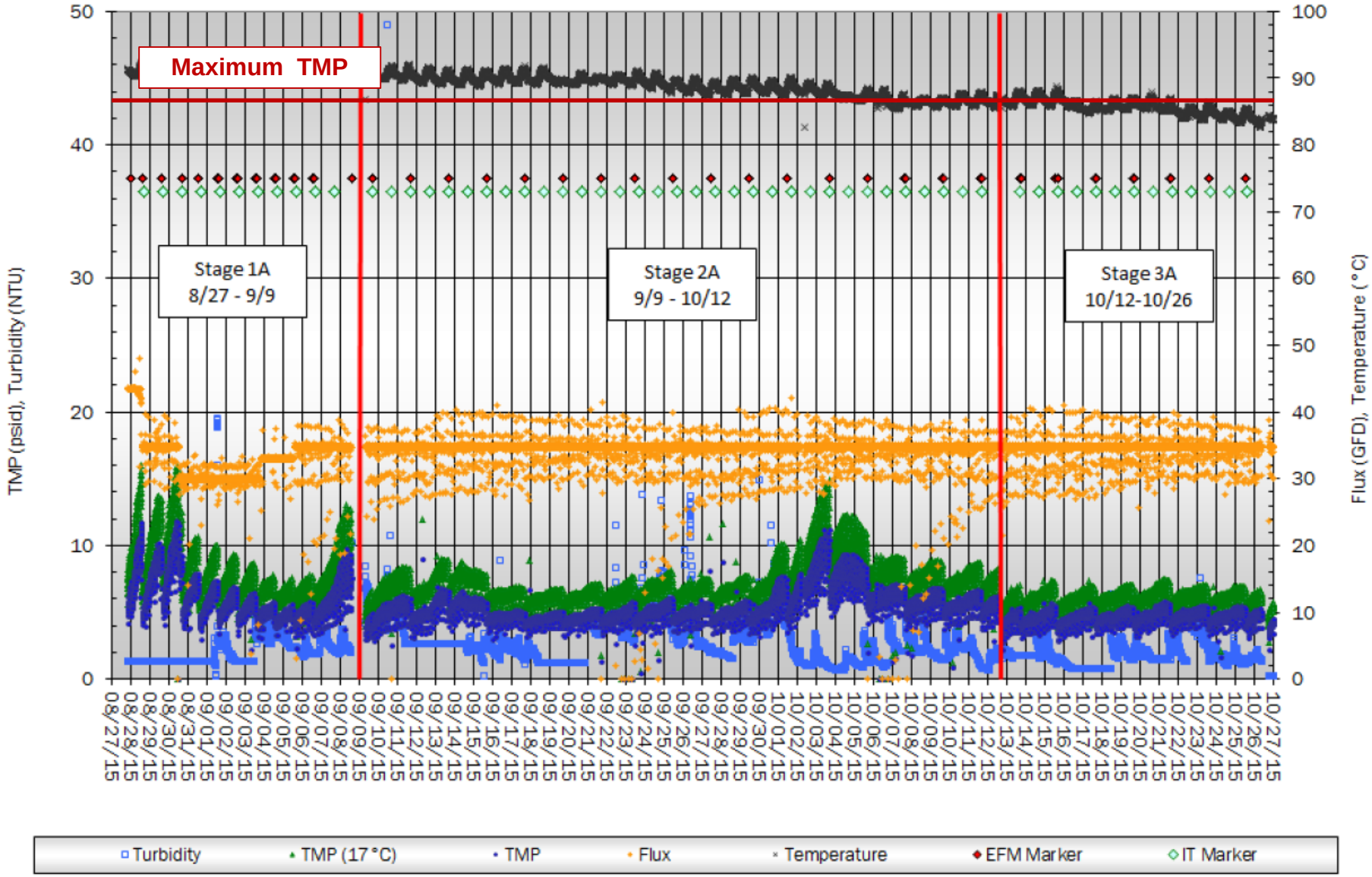
Objectives of Ozone Testing	Results
Reduce membrane fouling	• Fouling was not reduced • TMPs were lower when ozone was not operating

Improve water quality	• Ozone operation increased concentrations of:
	  • bromate (regulated carcinogen)
	  • NDMA (unregulated probable carcinogen)
	  • AOC (membrane fouling agent)

Disinfection	• No additional pathogen inactivation
Improve taste and odor	• T&O compounds non-detect and below thresholds in permeate w/o ozone • Odor characterization verified no benefit with ozone

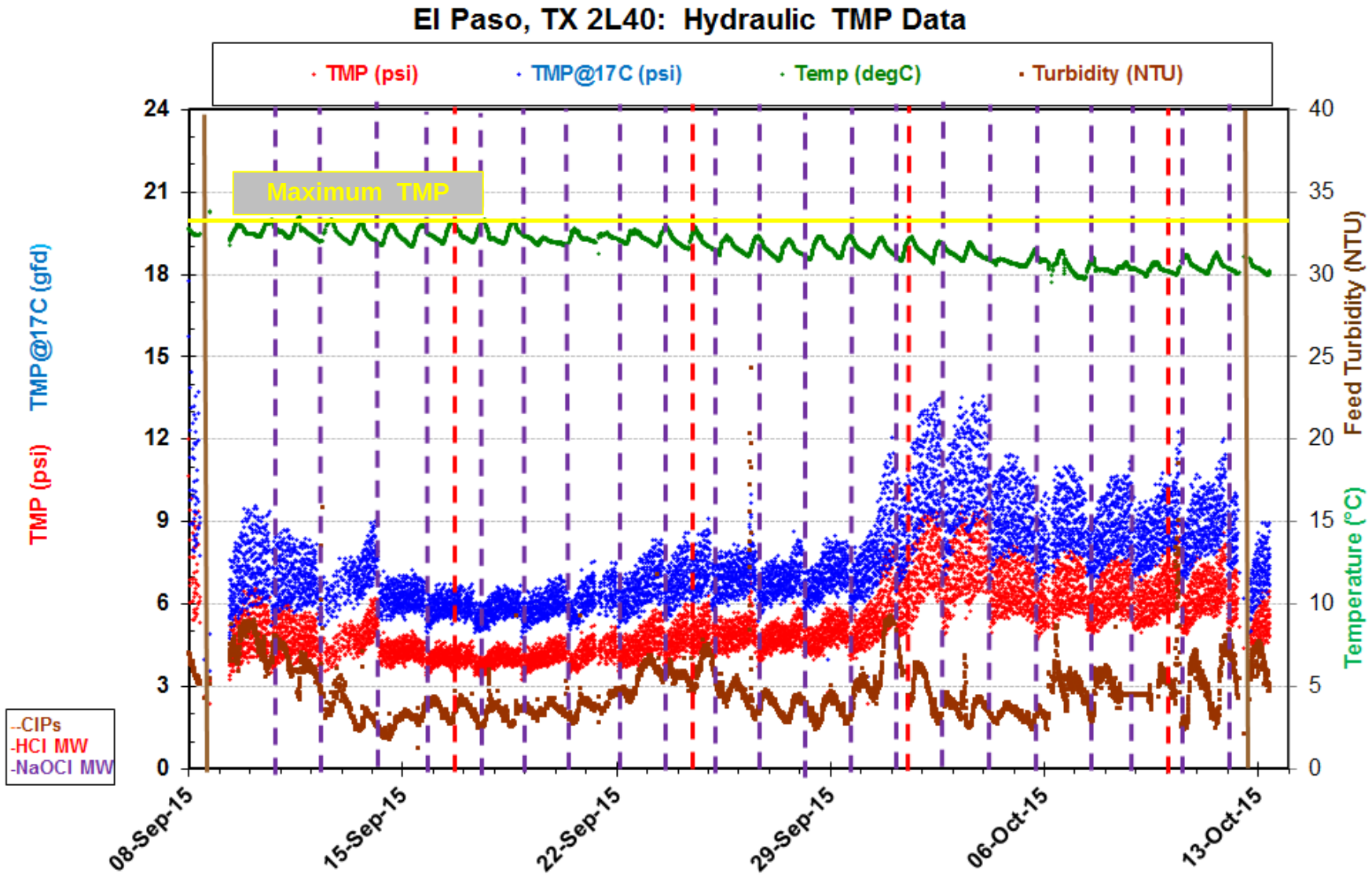
Performance of Core Treatment Train

Pall MF: A Series (no O_3) - TMP



Evoqua UF: Stage 2a - TMP (no O_3)

35 gfd flux



Membrane Filtration: Key Points

- Both Pall and Evoqua systems successfully completed Stage 1-2-3 testing without pretreatment *(no ozone or denitrification filters)*
- Operation at conservative flux values
- No “irreversible” fouling observed
  - Successful confirmation via Stage 3 testing
- All daily LRVs exceeded 4.0

NF/RO System Overview

- 4”-dia. membrane elements:
  - ESPA2-LD
  - NF90-400/34i
  - ESNA1-LF2-LD
- 2:1 array
- Recovery: **80%**
- Flux: **11.7 gfd**
- Pretreatment: **acid + scale inhibitor**

Removed from pilot testing due to poor rejection of nitrate and nitrite

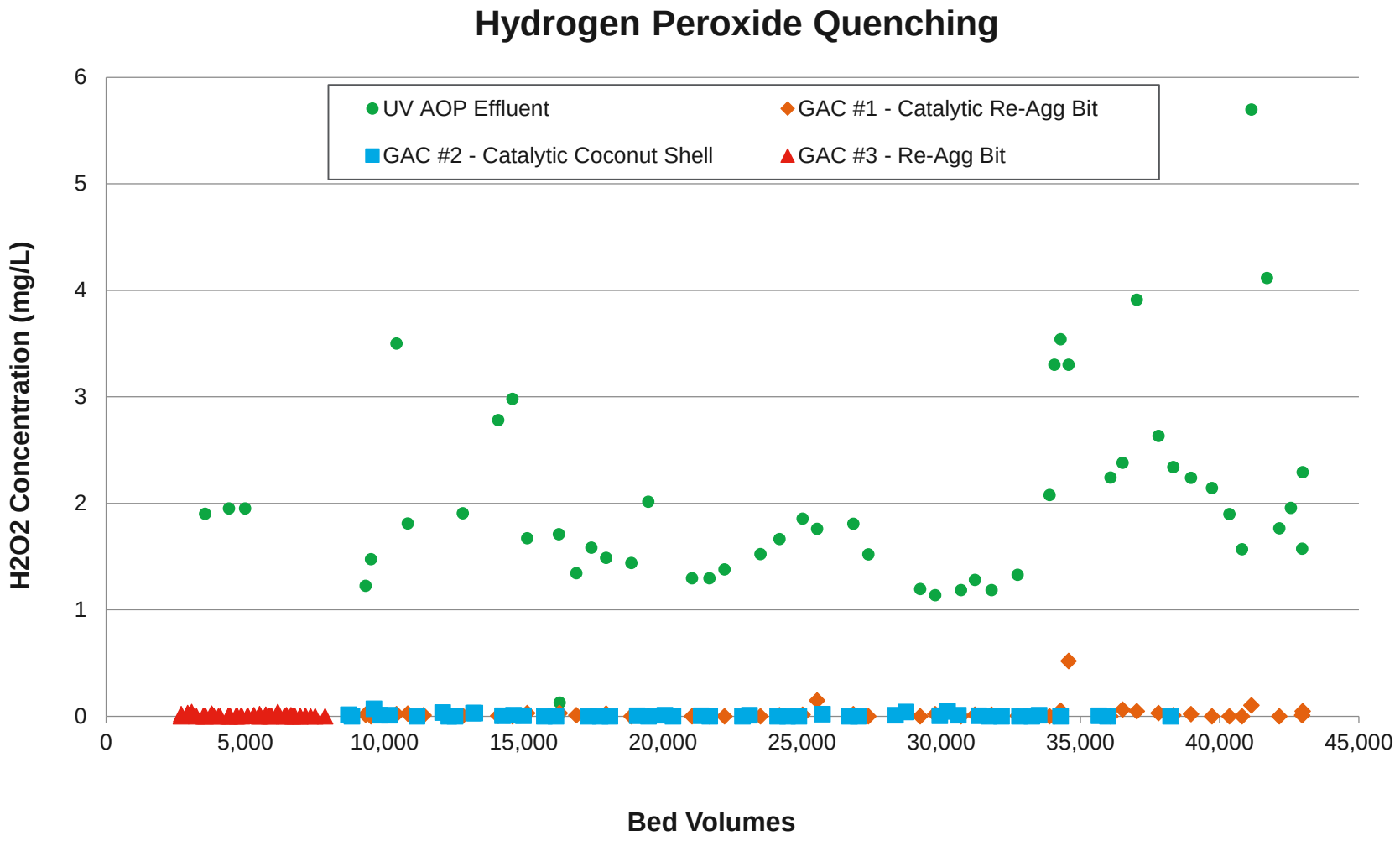
NF/RO Rejection Summary

Parameter	Units	Feed	Permeate			Goal
			ESNA1 (NF)	NF90 (NF)	ESPA2-LD (RO)	
Chloride	mg/L	285	61	6.9	22	300
Nitrate	mg/L as N	12.0	5.1	1.3	2.2	< 6
Nitrite	mg/L as N	1.06	0.9	0.04	0.04	< 0.6
Sulfate	mg/L	274	5.0	0.9	6.8	300
TDS	mg/L	1,075	174	36	78	900
TOC	mg/L	7.51	0.9	0.4	0.4	TBD

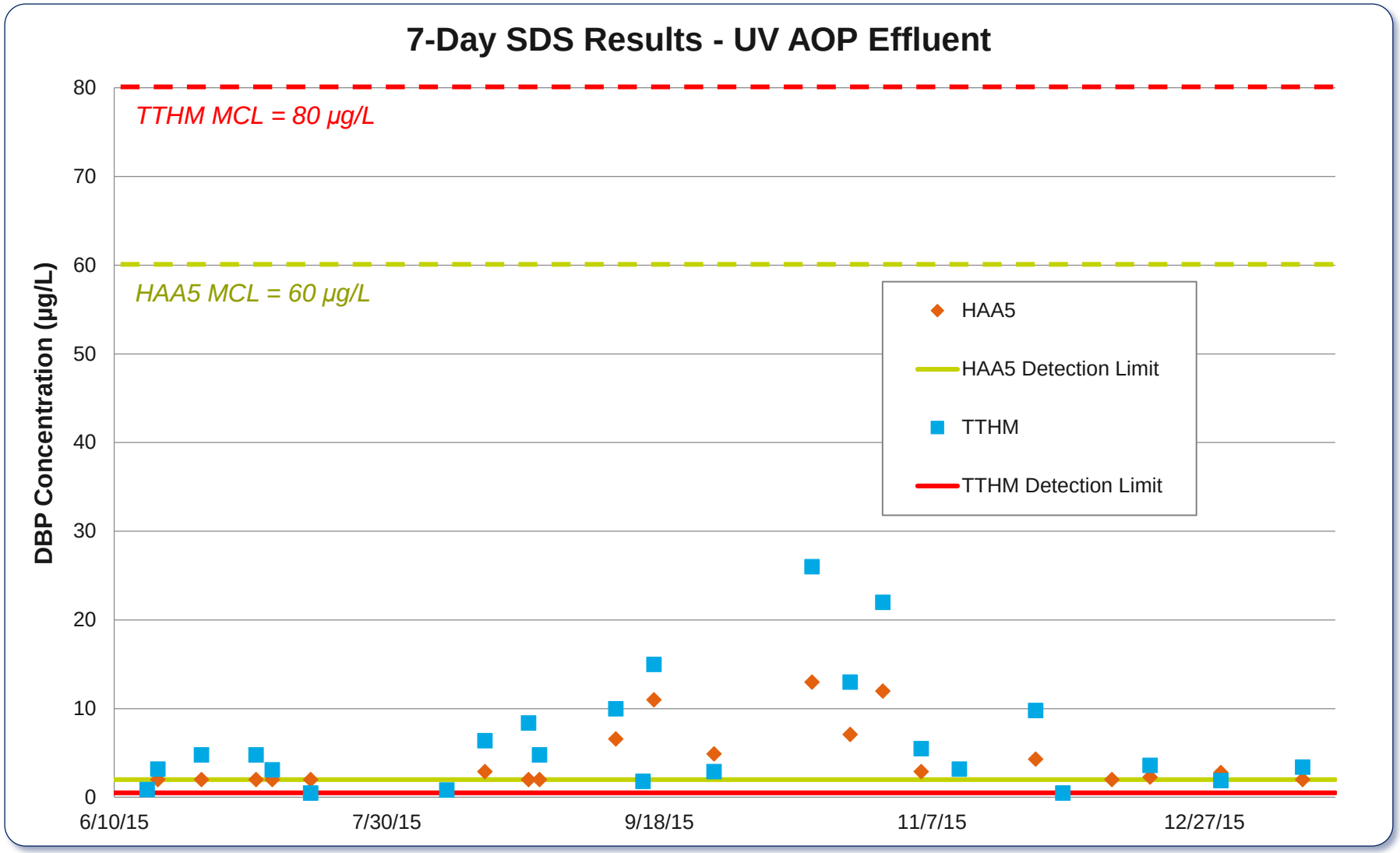
ESPA2 and NF90 demonstrated
70-90% rejection of nitrate and nitrite.

Data are average values
ND: Not Detected
TBD: To Be Determined

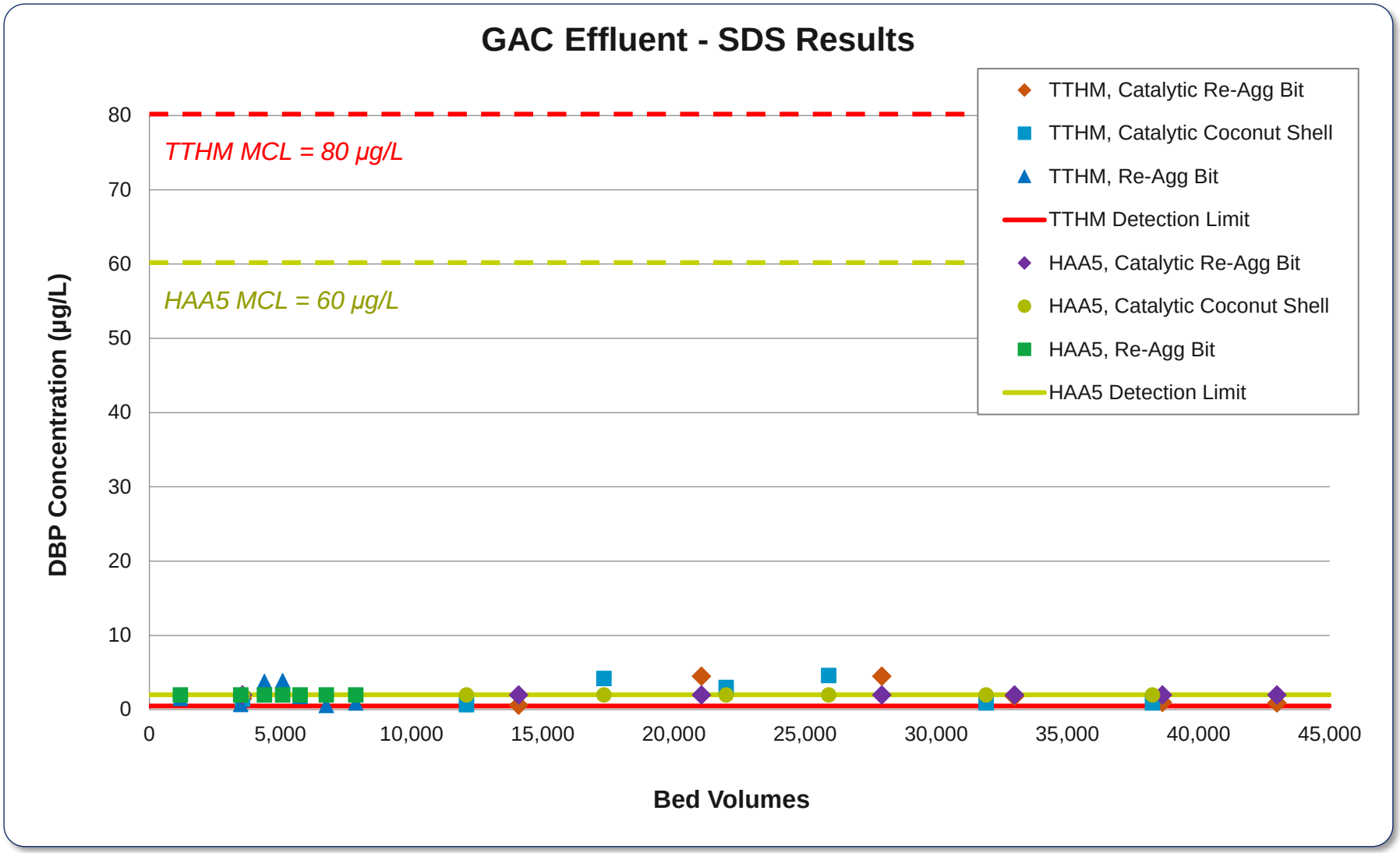
Granular Activated Carbon



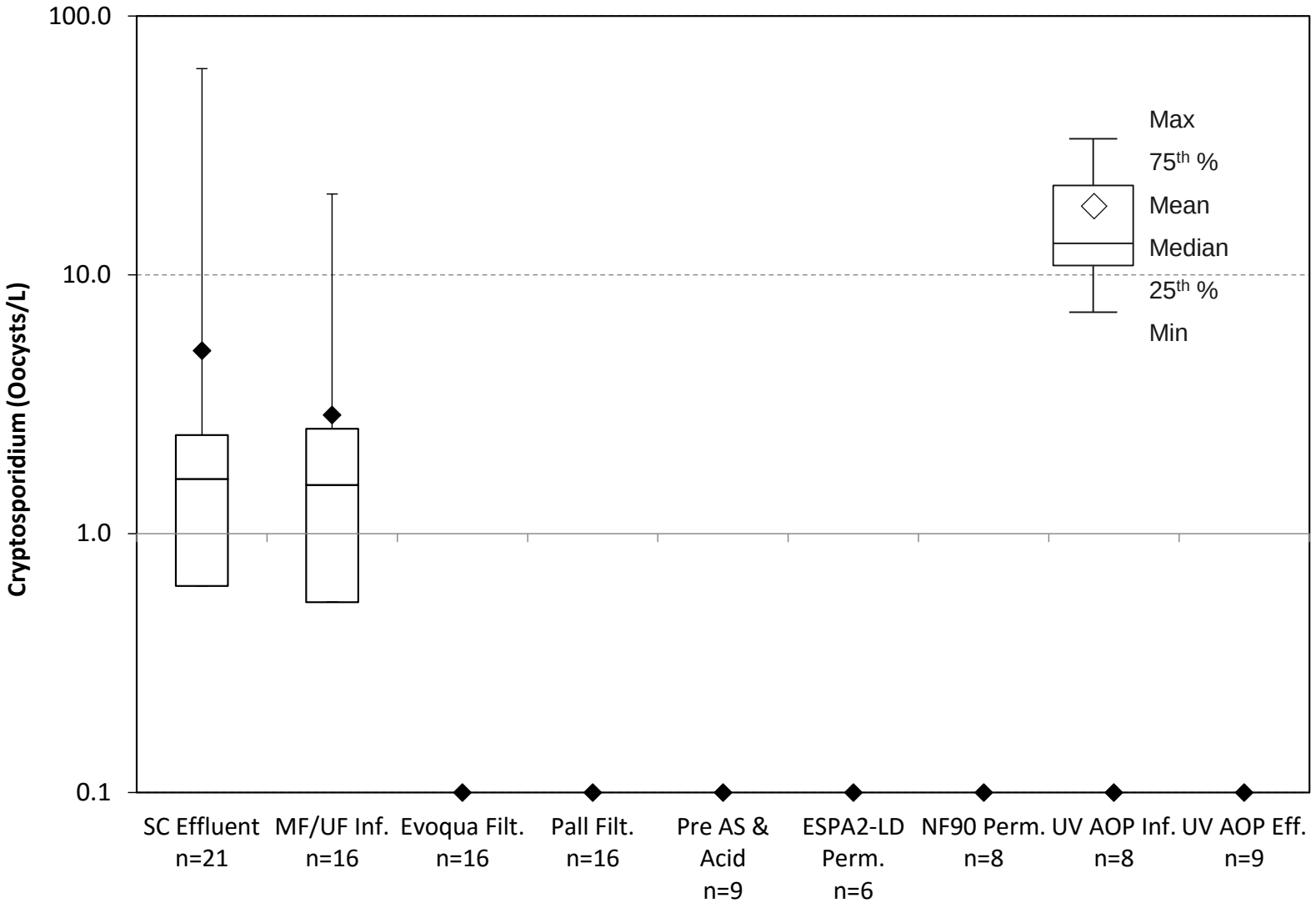
Disinfection



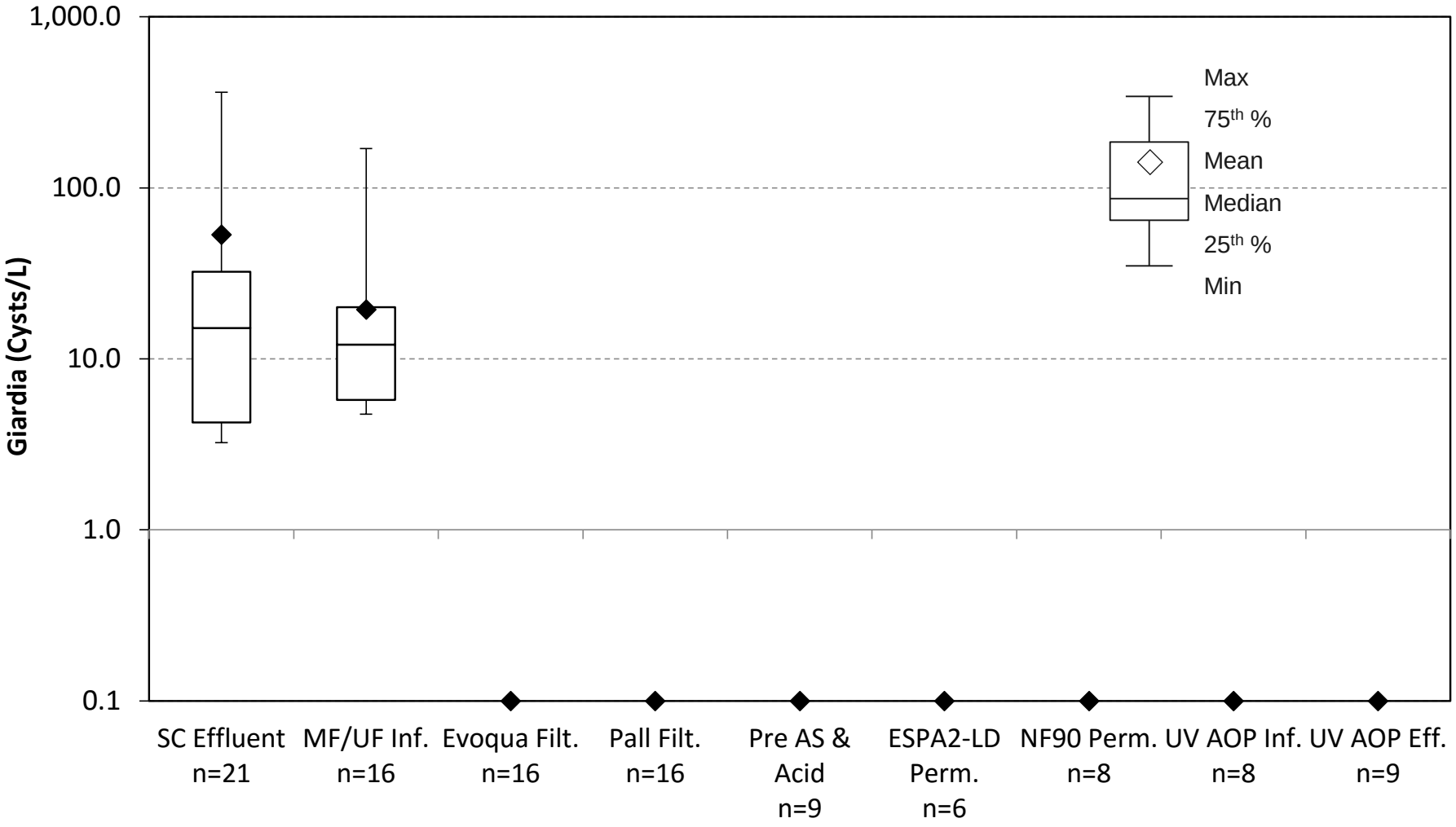
Disinfection



Cryptosporidium



Giardia


1,000.0
100.0
10.0
1.0
0.1
Giardia (Cysts/L)
Max
75th %
Mean
Median
25th %
Min
SC Effluent n=21
MF/UF Inf. n=16
Evoqua Filt. n=16
Pall Filt. n=16
Pre AS & Acid n=9
ESPA2-LD Perm. n=6
NF90 Perm. n=8
UV AOP Inf. n=8
UV AOP Eff. n=9

Total Culturable Virus (MPN/L)

Date	Secondary Clarifier Effluent	UV AOP Effluent
6/10/2015	0.25	ND
7/8/2015	0.46	ND
8/6/2015	0.403	ND
9/14/2015	0.09	ND
10/7/2015	0.575	ND
10/28/2015	0.48	ND
11/30/2015	0.4	ND
12/28/2015	0.299	ND
1/13/2016	0.21	ND
1/18/2016	0.197	ND

Pathogen Removal Requirements and Preliminary Results

Unit Process	Anticipated Log Removal / Inactivation Credits		
	Crypto	Giardia	Viruses
Pretreatment	0	0	0
MF/UF	4	4	0
NF/RO	0	0	0
UV AOP	4-6	4-6	4-6
GAC	0	0	0
Cl_2	0	3	4
Total	**8-10**	**11-13**	**8-10**
Projected Requirement	**5.5**	**6**	**8**

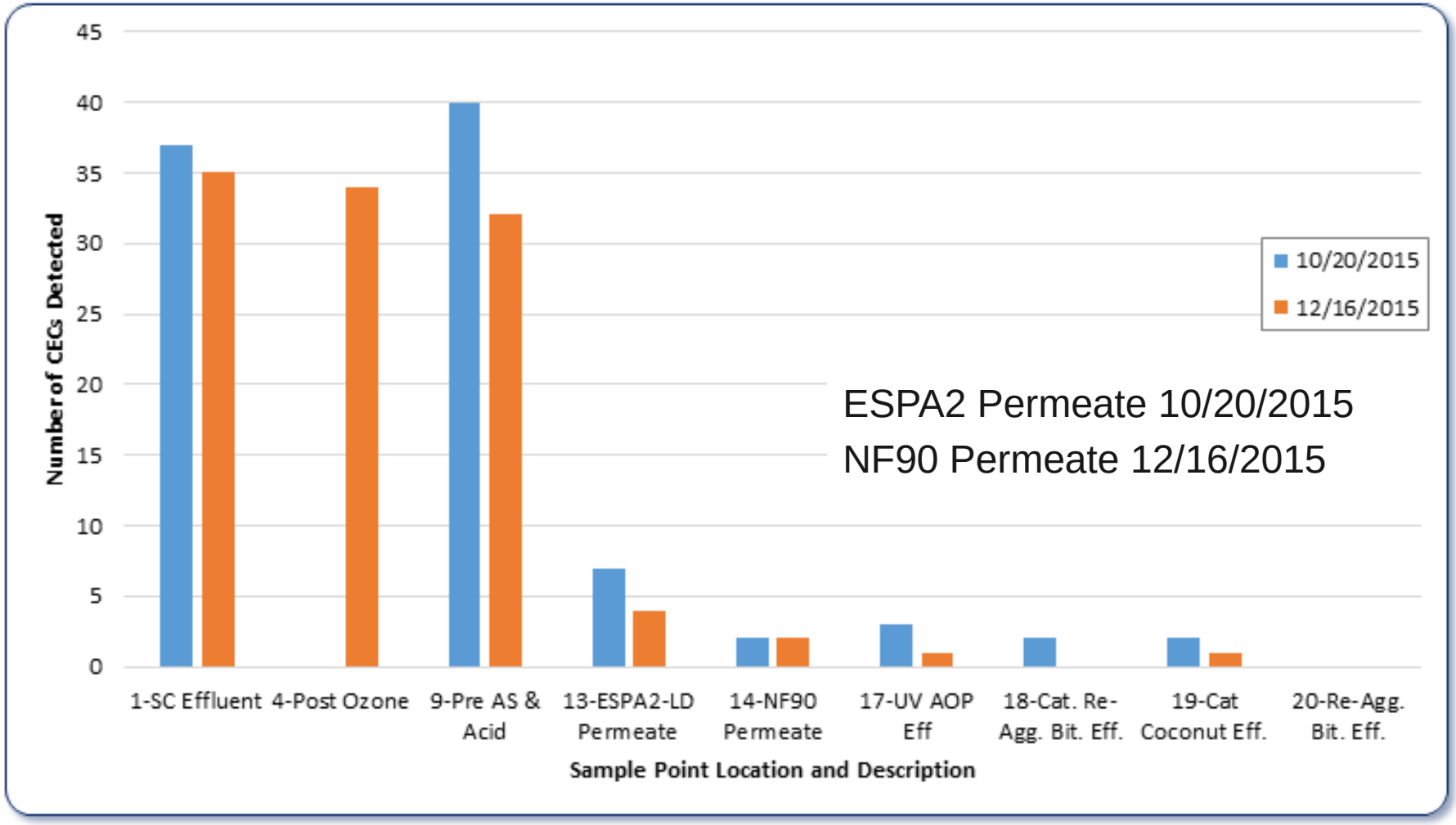
Anticipated removal requirements achieved through AWPF unit processes without secondary effluent chlorination

CEC Removal

CEC Sampling Overview

- Conducted monthly sampling of SC Eff and UV AOP Eff
- Conducted two special sampling events to evaluate removal of CECs across treatment train
  - 96 CECs
  - 1,4-dioxane
  - Perfluorinated compounds (e.g., PFOS and PFOA)
  - 16 a-hydroxyestradiol (estriol) and equilin

Removal of CECs Across Treatment Train



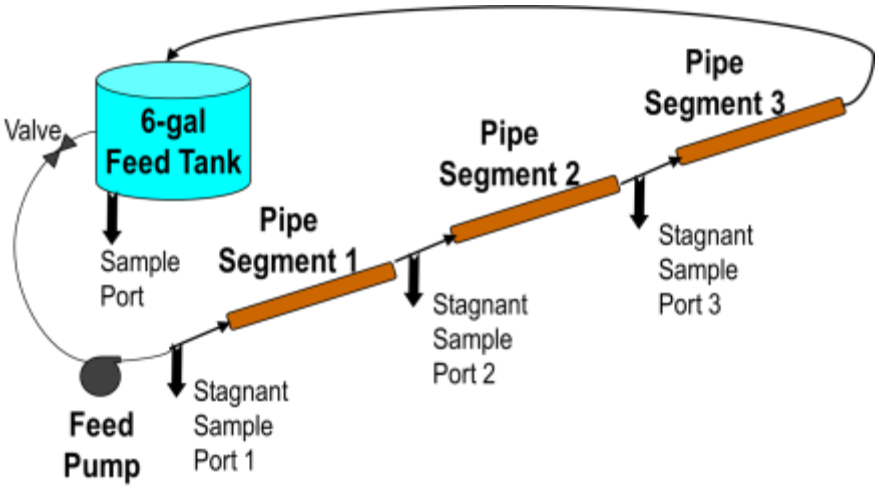
Key Findings from Special CEC Sampling Events

- 95% reduction in total measured concentrations of CECs between pilot influent and UV AOP effluent
- At least 89 or more of 96 CECs measured were “non-detect” in the NF/RO permeate samples
- UV AOP further reduced concentrations of the CECs detected in NF/RO permeate
  - At least 93 or more of 96 CECs measured were “non-detect” in the UV AOP treated samples
- Ultra-low concentrations are difficult to track through the downstream processes

Pipe Loop Testing

Pipe Loop Testing / Corrosion Control

- Assessed corrosivity of NF/RO permeates
- Galvanized steel and copper pipes harvested from distribution system
- Monitored iron, copper, lead
- Testing conditions included stabilization by:
  - pH adjustment
  - Alkalinity adjustment (calcite contactor)
  - Corrosion inhibitor addition
  - Groundwater blending



Testing demonstrated successful stabilization methods

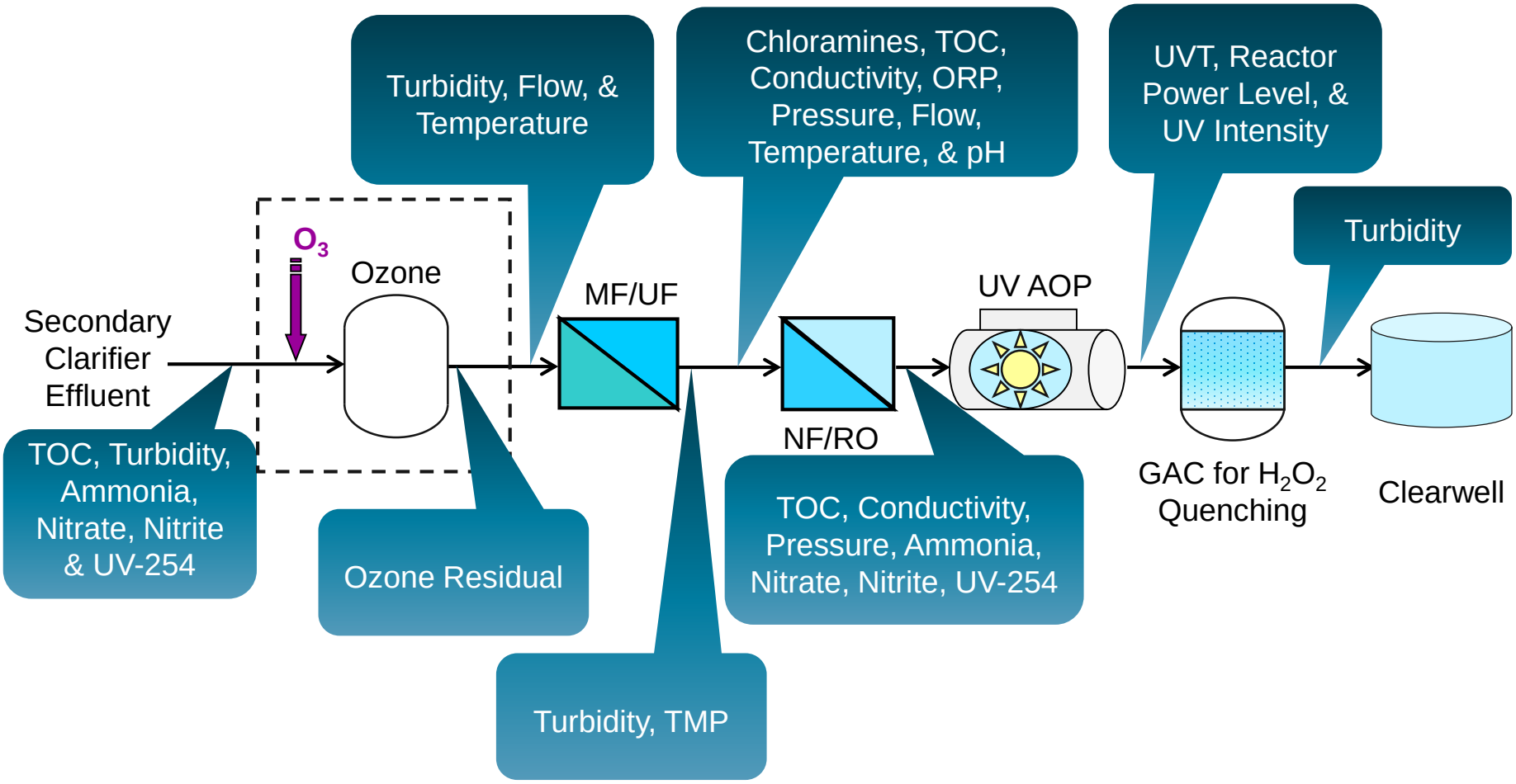
- Purified water metals concentrations were lower than baseline tap supply in pipe loops
- Post-treatment stabilization resulted in lower metals concentrations
- Preliminary approach for full-scale treatment:
  - Finished water quality targets:
    - CCPP between 4-10 mg/L as $CaCO_3$
    - LSI > 0
    - pH between 7.5-8.0
  - Multiple options for stabilization

No notable challenges for introducing purified water into the distribution system

Critical Control Points


ChemScan
Sievers M5310 C
Sievers M5310 C

Pilot-Scale Online Monitoring



Recap of Pilot Testing Objectives

- Meet TCEQ requirements for pilot testing
-  Demonstrate stable and reliable performance
-  Demonstrate AWPF treatment train meets water quality goals
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-  Verify major processes and systems for full-scale design

Beneficial Outcomes Demonstrated by Pilot Testing

Clear path to TCEQ approval of AWPF process

Stable operation meeting all water quality goals

Denitrification filter and ozone pretreatment not needed

Cost projection reduced by $25 million (capital) and $38 million (life-cycle)

Acknowledgements

- El Paso Water Utilities:
  - John Balliew
  - Fernie Rico
  - Carlos Dominguez
  - Aide Zamarron
- Arcadis
  - Corin Marron
  - Sanaan Villalobos
  - Caroline Russell
  - Dan Olson
  - Chelsea Francis
- NWRI Independent Advisory Panel
- University of Texas at El Paso
- Texas Commission on Environmental Quality

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Questions?

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