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

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Current Drought Conditions in El Paso

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

Bustamante WWTP with Additional Treatment (29.2 MGD average flow) → Advanced Water Purification Facility → Distribution System

Residuals Handling

MF Backwash = 1.0 MGD
RO or NF Concentrate = 1.8 MGD

Riverside Irrigation Canal
El Paso’s Path

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


“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

Core Treatment Train

Secondary Clarifier Effluent

Denitrification Filters

MF/UF → Backwash

NF/RO → Concentrate

UV AOP

GAC for H₂O₂ Quenching

Clearwell

Disinfection

Secondary Clarifier Effluent

Ozone

MF/UF → Backwash

NF/RO → Concentrate

UV AOP

GAC for H₂O₂ Quenching

Clearwell

Disinfection
Ozone Increased Concentrations of Bromate (~60%) and NDMA (~300%)
## Ozone System Performance

<table>
<thead>
<tr>
<th>Objectives of Ozone Testing</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce membrane fouling</td>
<td>• Fouling was not reduced</td>
</tr>
<tr>
<td></td>
<td>• TMPs were lower when ozone was not operating</td>
</tr>
<tr>
<td>Improve water quality</td>
<td>• Ozone operation increased concentrations of:</td>
</tr>
<tr>
<td></td>
<td>• bromate (regulated carcinogen)</td>
</tr>
<tr>
<td></td>
<td>• NDMA (unregulated probable carcinogen)</td>
</tr>
<tr>
<td></td>
<td>• AOC (membrane fouling agent)</td>
</tr>
<tr>
<td>Disinfection</td>
<td>• No additional pathogen inactivation</td>
</tr>
<tr>
<td>Improve taste and odor</td>
<td>• T&amp;O compounds non-detect and below thresholds in permeate w/o ozone</td>
</tr>
<tr>
<td></td>
<td>• Odor characterization verified no benefit with ozone</td>
</tr>
</tbody>
</table>
Performance of Core Treatment Train
Pall MF: A Series (no O₃) - TMP

Diagram showing TMP (psi), turbidity (NTU), and various stages (1A, 2A, 3A) with specific dates and markers.
Evoqua UF: Stage 2a - TMP (no O₃)

El Paso, TX 2L40: Hydraulic TMP Data

Maximum TMP: 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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Feed</th>
<th>Permeate</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>ESNA1 (NF)</td>
<td>NF90 (NF)</td>
</tr>
<tr>
<td>Chloride</td>
<td>mg/L</td>
<td>285</td>
<td>61</td>
<td>6.9</td>
</tr>
<tr>
<td>Nitrate</td>
<td>mg/L as N</td>
<td>12.0</td>
<td>5.1</td>
<td>1.3</td>
</tr>
<tr>
<td>Nitrite</td>
<td>mg/L as N</td>
<td>1.06</td>
<td>0.9</td>
<td>0.04</td>
</tr>
<tr>
<td>Sulfate</td>
<td>mg/L</td>
<td>274</td>
<td>5.0</td>
<td>0.9</td>
</tr>
<tr>
<td>TDS</td>
<td>mg/L</td>
<td>1,075</td>
<td>174</td>
<td>36</td>
</tr>
<tr>
<td>TOC</td>
<td>mg/L</td>
<td>7.51</td>
<td>0.9</td>
<td>0.4</td>
</tr>
</tbody>
</table>

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

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

Hydrogen Peroxide Quenching

- UV AOP Effluent
- GAC #1 - Catalytic Re-Agg Bit
- GAC #2 - Catalytic Coconut Shell
- GAC #3 - Re-Agg Bit

H₂O₂ Concentration (mg/L) vs. Bed Volumes
Disinfection

7-Day SDS Results - UV AOP Effluent

TTHM MCL = 80 µg/L

HAA5 MCL = 60 µg/L
Disinfection

GAC Effluent - SDS Results

- **TTHM MCL = 80 µg/L**
- **HAA5 MCL = 60 µg/L**
**Cryptosporidium**

![Box plot showing Cryptosporidium levels in various treatment steps.](image-url)

- **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)
Giardia

Giardia (Cysts/L)

- 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

Max, 75th %, Median, 25th %, Min
## Total Culturable Virus (MPN/L)

<table>
<thead>
<tr>
<th>Date</th>
<th>Secondary Clarifier Effluent</th>
<th>UV AOP Effluent</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/10/2015</td>
<td>0.25</td>
<td>ND</td>
</tr>
<tr>
<td>7/8/2015</td>
<td>0.46</td>
<td>ND</td>
</tr>
<tr>
<td>8/6/2015</td>
<td>0.403</td>
<td>ND</td>
</tr>
<tr>
<td>9/14/2015</td>
<td>0.09</td>
<td>ND</td>
</tr>
<tr>
<td>10/7/2015</td>
<td>0.575</td>
<td>ND</td>
</tr>
<tr>
<td>10/28/2015</td>
<td>0.48</td>
<td>ND</td>
</tr>
<tr>
<td>11/30/2015</td>
<td>0.4</td>
<td>ND</td>
</tr>
<tr>
<td>12/28/2015</td>
<td>0.299</td>
<td>ND</td>
</tr>
<tr>
<td>1/13/2016</td>
<td>0.21</td>
<td>ND</td>
</tr>
<tr>
<td>1/18/2016</td>
<td>0.197</td>
<td>ND</td>
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## Pathogen Removal Requirements and Preliminary Results

<table>
<thead>
<tr>
<th>Unit Process</th>
<th>Anticipated Log Removal / Inactivation Credits</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Crypto</td>
</tr>
<tr>
<td>Pretreatment</td>
<td>0</td>
</tr>
<tr>
<td>MF/UF</td>
<td>4</td>
</tr>
<tr>
<td>NF/RO</td>
<td></td>
</tr>
<tr>
<td>UV AOP</td>
<td>4-6</td>
</tr>
<tr>
<td>GAC</td>
<td>0</td>
</tr>
<tr>
<td>Cl₂</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>8-10</td>
</tr>
<tr>
<td><strong>Projected Requirement</strong></td>
<td>5.5</td>
</tr>
</tbody>
</table>

**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

- ESPA2 Permeate 10/20/2015
- NF90 Permeate 12/16/2015
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
Pilot-Scale Online Monitoring

Secondary Clarifier Effluent

TOC, Turbidity, Ammonia, Nitrate, Nitrite & UV-254

Ozone

TOC, Turbidity, Ammonia, Nitrate, Nitrite & UV-254

Ozone Residual

Turbidity, Flow, & Temperature

Turbidity, Flow, & Temperature

Chloramines, TOC, Conductivity, ORP, Pressure, Flow, Temperature, & pH

UV AOP

TOC, Conductivity, Pressure, Ammonia, Nitrate, Nitrite, UV-254

GAC for H₂O₂ Quenching

Clearwell

Turbidity

UVT, Reactor Power Level, & UV Intensity

Power Level, & UV Intensity

Turbidity

Ozone Residual

Ozone

O₃

TOC, Turbidity, TMP

Turbidity, TMP

Turbidity, Flow, & Temperature

Chloramines, TOC, Conductivity, ORP, Pressure, Flow, Temperature, & pH

UV AOP
Recap of 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
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)
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- NWRI Independent Advisory Panel
- University of Texas at El Paso
- Texas Commission on Environmental Quality
Questions?

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