APPENDIX A
REFERENCES


Cabral, Bruce (2007) Water Quality Manager, Santa Clara Valley Water District


Del Valle Water Treatment Plant Expansion, Kennedy/Jenks/Chilton, July 1988

Del Valle Water Treatment Plant Booster Pump Station Project, Preliminary Design Report, CDM July 1999

Del Valle Water Treatment Plant Booster Pump Station Drawings (Project No. 131) CDM, December 1999

Department of Water Resources, California Cooperative Snow Surveys, Chronological Reconstructed Sacramento and San Joaquin Valley Water Year Hydrologic Classification Indices 1901 - 2007
Appendix A – References


**Final Preliminary Design Report, 10-MGD DAF Project, MWH, October 2004**


Appendix A – References


Langlais, B. et al, *Ozone in Water Treatment – Application and Engineering*, Published by AWWARF, 1991


Appendix A – References


Montgomery Watson Harza, *Water Treatment Principles and Design*, 2005


MWH. *10 MGD Dissolved Air Flotation Facility Del Valle Water Treatment Plant Drawings*, September 2005


Ozone Feasibility Study, CDM, February 1991


Patterson Pass Water Treatment Plant Modernization, Volume 2 – Drawings, James M. Montgomery, January 1984

Patterson Pass Water Treatment Plant Ultra Filtration Project, Design Drawings, CDM, April 2004


South Bay Aqueduct Pilot Plant Studies, CDM, 1989


Treated Water Facilities Master Plan, February 2000, CDM


Appendix A – References


Zone 7 Del Valley Water Treatment Plant Future Ozonation and Water Level in DAF and Decision Factors (DRAFT) minutes from September 27, 2004 Workshop (MWH)
APPENDIX B
RAW PILOT TESTING DATA
## Zone 7 Water Agency - Ozone & Peracetic Acid Pilot Testing

### Results of 1st Round of Testing: June & July 2008

<table>
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<th>Test ID</th>
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<th>Water pH</th>
<th>NH₄Cl</th>
<th>H₂O₂</th>
<th>Ozone Dose</th>
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<th>Effluent</th>
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<th>Gain</th>
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## Zone 7 Water Agency - Ozone & Peracetic Acid Pilot Testing

### Results of 1st Round of Testing: June & July 2008

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### Notes

- **Rem. Influent**: Rem. Influent
- **Rem. Effluent**: Rem. Effluent
- **% Rem.**: % Rem.
- **Gain**: Gain
- **Gain %**: Gain %
- **Bromide**: Bromide
- **Bromate**: Bromate

- **Zone 7 Water Agency - Ozone & Peracetic Acid Pilot Testing**: Results of 1st Round of Testing: June & July 2008
- **Test ID**: Identifier for each test.
- **Contactor Type**: Type of contactor used (Conventional or Pipeline).
- **Water pH**: pH of the water.
- **NH₄Cl**: Ammonium chloride concentration.
- **H₂O₂**: Hydrogen peroxide concentration.
- **Ozone Dose**: Dose of ozone applied.
- **Influent**: Influent concentration.
- **Effluent**: Effluent concentration.
- **% Rem.**: Percentage of removal.
- **Gain**: Gain in concentration.
- **Gain %**: Percentage gain.
- **Bromide**: Concentration of bromide.
- **Bromate**: Concentration of bromate.

- **Units**: mg/L for all concentrations.

- **Note**: The values in the table represent the data collected for each test, showing the effectiveness of ozone and peracetic acid in removing contaminants from water.

- **Specific Test IDs**: R-20-70, R-30-70, R-40-70, R-50-70, R-60-70.
## Zone 7 Water Agency - Ozone & Peroxone Pilot Testing

### Results of 2nd Round of Testing - September 2008

| Test ID | Contactor | Water | pH | NaCl | H2O2 Dose | Al2O3 | Ozone Dose | Transfer Efficiency | Influent | MIB | Effluent | Bromate | Effluent | Bromate | MB | Benzene | Bromine | MB | Benzene | Bromine | MB | Benzene | Bromine |
|---------|-----------|-------|----|------|------------|-------|------------|-------------------|-----------|-----|-----------|----------|-----------|----------|----|-----------|----------|----|-----------|----------|----|-----------|----------|----|-----------|----------|
| 1       | Conventional | Row   | 6.5 | 0    | 0         | 1      | 10         | 96%               | 0.18      | 0.09| 0.08      | 0.08     | 0.43      | 31       | 15       | 15%       | 26       | 10       | 10%      | 364  | 5.1         | 12        |
| 2       | Conventional | Row   | 6.5 | 2    | 1.7    | 2       | 1.4        | 87%               | 0.06      | 0.31| 0.13      | 0.13     | 1.01      | 31       | 12       | 12%       | 26       | 7.1       | 7.1%     | 364  | 5.1         | 12        |
| 3       | Conventional | Row   | 6.5 | 0    | 0.3    | 2.3     | 7.7       | 100%              | 1.00      | 0.15| 0.15      | 0.15     | 2.00      | 31       | 0.3       | 0.3%      | 26       | 0.04      | 0.04%    | 364  | 5.1         | 12        |
| 4       | Conventional | Row   | 6.5 | 6.5  | 0.5    | 0.9     | 0.8        | 97%               | 0.03      | 0.06| 0.05      | 0.05     | 0.02      | 31       | 16       | 16%       | 26       | 12       | 12%      | 364  | 5.1         | 12        |
| 5       | Conventional | Row   | 6.5 | 6.5  | 6.5    | 2.1     | 7.0       | 99%               | 0.08      | 0.46| 0.07      | 0.07     | 0.11      | 31       | 1.6      | 16%       | 26       | 6.3       | 6.3%     | 364  | 5.1         | 12        |
| 6       | Conventional | Row   | 6.5 | 6.5  | 6.5    | 3.2     | 7.0       | 99%               | 1.00      | 0.46| 0.10      | 0.10     | 1.01      | 31       | 1.6      | 16%       | 26       | 6.3       | 6.3%     | 364  | 5.1         | 12        |
| 7       | Conventional | Row   | 6.5 | 6.5  | 6.5    | 3.2     | 7.0       | 99%               | 0.08      | 0.46| 0.10      | 0.10     | 1.01      | 31       | 1.6      | 16%       | 26       | 6.3       | 6.3%     | 364  | 5.1         | 12        |
| 8       | Conventional | Row   | 6.5 | 6.5  | 6.5    | 3.2     | 7.0       | 99%               | 0.08      | 0.46| 0.10      | 0.10     | 1.01      | 31       | 1.6      | 16%       | 26       | 6.3       | 6.3%     | 364  | 5.1         | 12        |
| 9       | Conventional | Row   | 6.5 | 6.5  | 6.5    | 3.2     | 7.0       | 99%               | 0.08      | 0.46| 0.10      | 0.10     | 1.01      | 31       | 1.6      | 16%       | 26       | 6.3       | 6.3%     | 364  | 5.1         | 12        |
| 10      | Conventional | Row   | 6.5 | 6.5  | 6.5    | 3.2     | 7.0       | 99%               | 0.08      | 0.46| 0.10      | 0.10     | 1.01      | 31       | 1.6      | 16%       | 26       | 6.3       | 6.3%     | 364  | 5.1         | 12        |
| 11      | Conventional | Row   | 6.5 | 6.5  | 6.5    | 3.2     | 7.0       | 99%               | 0.08      | 0.46| 0.10      | 0.10     | 1.01      | 31       | 1.6      | 16%       | 26       | 6.3       | 6.3%     | 364  | 5.1         | 12        |
| 12      | Conventional | Row   | 6.5 | 6.5  | 6.5    | 3.2     | 7.0       | 99%               | 0.08      | 0.46| 0.10      | 0.10     | 1.01      | 31       | 1.6      | 16%       | 26       | 6.3       | 6.3%     | 364  | 5.1         | 12        |
| 13      | Conventional | Row   | 6.5 | 6.5  | 6.5    | 3.2     | 7.0       | 99%               | 0.08      | 0.46| 0.10      | 0.10     | 1.01      | 31       | 1.6      | 16%       | 26       | 6.3       | 6.3%     | 364  | 5.1         | 12        |
| 14      | Conventional | Row   | 6.5 | 6.5  | 6.5    | 3.2     | 7.0       | 99%               | 0.08      | 0.46| 0.10      | 0.10     | 1.01      | 31       | 1.6      | 16%       | 26       | 6.3       | 6.3%     | 364  | 5.1         | 12        |
| 15      | Conventional | Row   | 6.5 | 6.5  | 6.5    | 3.2     | 7.0       | 99%               | 0.08      | 0.46| 0.10      | 0.10     | 1.01      | 31       | 1.6      | 16%       | 26       | 6.3       | 6.3%     | 364  | 5.1         | 12        |
| 16      | Conventional | Row   | 6.5 | 6.5  | 6.5    | 3.2     | 7.0       | 99%               | 0.08      | 0.46| 0.10      | 0.10     | 1.01      | 31       | 1.6      | 16%       | 26       | 6.3       | 6.3%     | 364  | 5.1         | 12        |
| 17      | Conventional | Row   | 6.5 | 6.5  | 6.5    | 3.2     | 7.0       | 99%               | 0.08      | 0.46| 0.10      | 0.10     | 1.01      | 31       | 1.6      | 16%       | 26       | 6.3       | 6.3%     | 364  | 5.1         | 12        |
| 18      | Conventional | Row   | 6.5 | 6.5  | 6.5    | 3.2     | 7.0       | 99%               | 0.08      | 0.46| 0.10      | 0.10     | 1.01      | 31       | 1.6      | 16%       | 26       | 6.3       | 6.3%     | 364  | 5.1         | 12        |
| 19      | Conventional | Row   | 6.5 | 6.5  | 6.5    | 3.2     | 7.0       | 99%               | 0.08      | 0.46| 0.10      | 0.10     | 1.01      | 31       | 1.6      | 16%       | 26       | 6.3       | 6.3%     | 364  | 5.1         | 12        |
| 20      | Conventional | Row   | 6.5 | 6.5  | 6.5    | 3.2     | 7.0       | 99%               | 0.08      | 0.46| 0.10      | 0.10     | 1.01      | 31       | 1.6      | 16%       | 26       | 6.3       | 6.3%     | 364  | 5.1         | 12        |
| 21      | Conventional | Row   | 6.5 | 6.5  | 6.5    | 3.2     | 7.0       | 99%               | 0.08      | 0.46| 0.10      | 0.10     | 1.01      | 31       | 1.6      | 16%       | 26       | 6.3       | 6.3%     | 364  | 5.1         | 12        |
### Results of 3rd Round of Testing October 2008

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**Note:** The table above contains the results of ozone transfer testing for different conditions, including ozone addition, ozone concentration, and transferred ozone concentration. The data includes parameters such as pH, NH₂Cl, H₂O₂ dose, H₂O₂:O₃ dose ratio, dose efficiency, and removal percentages for both influent and effluent samples.
Conventional Contactor
HRT = 10 minutes
Raw Water
pH = Amb (7.9 to 8.3)
Prechloramine Dose = 0.75 mg/L

Round 1 (Bromide = 675 µg/L)
Round 2 (Bromide = 350 µg/L)
Round 3 (Bromide = 400 µg/L)

Goal < 8 µg/L

Bromate Formed, µg/L

Ozone Dose, mg/L

0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5

0 10 20 30 40 50 60 70 80 90

Dose = 1.3 mg/L
Dose = 2.4 mg/L
BrO₃ = 14 µg/L

Ozone Residual in Contactor Effluent, mg/L

0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

Goal < 0.1 mg/L

Dose = 1.3 mg/L
Dose = 2.4 mg/L
Pipeline AOP Contactor
HRT = 2 minutes
Raw Water
pH = Ambient (8.3 to 8.7)
Prechloramine Dose = 0.75 mg/L
H2O2:O3 Ratio = 0.5:1

Ozone Dose, mg/L

Percent MIB Destruction

Dose = 1.2 mg/L
Dose = 2.2 mg/L

Goal > 71%

Round 2 (MIB = 44 ng/L)
Round 3 (MIB = 47 ng/L)

Ozone Dose, mg/L

Percent Geosmin Destruction

Dose = 1.0 mg/L
Dose = 1.8 mg/L

Goal > 71%

Round 2 (Geosmin = 35 ng/L)
Round 3 (Geosmin = 46 ng/L)
Pipeline AOP Contactor
HRT = 2 minutes
Raw Water
pH = Ambient (8.3 to 8.7)
Prechloramine Dose = 0.75 mg/L
H2O2:O3 Ratio = 0.5:1

Round 2 (Bromide = 524 µg/L)
Round 3 (Bromide = 398 µg/L)

Dose = 1.2 mg/L
BrO₃ = 11 µg/L
Dose = 2.2 mg/L
BrO₃ = 41 µg/L
Goal < 8 µg/L

Ozone Dose, mg/L

Pipeline AOP Contactor
HRT = 2 minutes
Raw Water
pH = Ambient (8.3 to 8.7)
Prechloramine Dose = 0.75 mg/L
H2O2:O3 Ratio = 0.5:1

Round 2
Round 3

Dose = 1.2 mg/L
Dose = 2.2 mg/L
Goal < 0.1 mg/L

Ozone Residual in Contactor Effluent, mg/L

Ozone Dose, mg/L
Conventional Contactor
HRT = 10 minutes
Raw Water
pH = 7.5
No Prechloramine Added

Round 2 (Bromide = 265 to 394 µg/L)
Round 3 (Bromide = 423 µg/L)

Bromate Formed, µg/L

Ozone Dose, mg/L

Conventional Contactor
HRT = 10 minutes
Raw Water
pH = 7.5
No Prechloramine

Round 2
Round 3

Conventional Contactor
HRT = 10 minutes
Raw Water
pH = 7.5
No Prechloramine

Ozone Residual in Contactor Effluent, mg/L

Ozone Dose, mg/L

Goal < 8 µg/L

Goal < 0.1 mg/L
Pipeline AOP Contactor
HRT = 2 minutes
Raw Water
pH = 7.5
No Prechloramine Added
H2O2:O3 Ratio = 0.5:1

Ozone Dose, mg/L

Percent MIB Destruction

Dose = 1.2 mg/L
Goal > 71%
Dose = 1.4 mg/L

Percent Geosmin Destruction

Dose = 1.0 mg/L
Goal > 73%
Dose = 1.1 mg/L

Ozone Dose, mg/L
Conventional Contactor
HRT = 10 minutes
Raw Water
pH = 7.5
Prechloramine Dose = 0.75 mg/L

Goal > 71%

Dose = 1.4 mg/L

Dose = 2.8 mg/L

Round 2 (MIB = 26 to 31 ng/L)
Round 3 (MIB = 47 ng/L)

Conventional Contactor
HRT = 10 minutes
Raw Water
pH = 7.5
Prechloramine Dose = 0.75 mg/L

Goal > 73%

Dose = 1.2 mg/L

Dose = 2.4 mg/L

Round 2 (Geosmin = 22 to 28 ng/L)
Round 3 (Geosmin = 46 ng/L)
Pipeline AOP Contactor
HRT = 2 minutes
Raw Water
pH = 7.5
Prechloramine Dose = 0.75 mg/L
H₂O₂:O₃ Ratio = 0.5:1

Round 3 (MIB = 46 ng/L)

Ozone Dose, mg/L

Percent MIB Destruction

Dose = 1.3 mg/L
Goal > 71%

Round 3 (Geosmin = 44 ng/L)

Ozone Dose, mg/L

Percent Geosmin Destruction

Dose = 0.9 mg/L
Goal > 73%
Pipeline AOP Contactor  
HRT = 2 minutes  
Raw Water  
pH = 7.5  
Prechloramine Dose = 0.75 mg/L  
H2O2:O3 = 0.5:1

Round 3 (Bromide = 370 µg/L)

Bromate Formed, µg/L

Ozone Dose, mg/L

Dose = 1.3 mg/L  
BrO₃⁻ = 4 µg/L  
Goal < 8 µg/L

Pipeline AOP Contactor  
HRT = 2 minutes  
Raw Water  
pH = 7.5  
Prechloramine Dose = 0.75 mg/L  
H2O2:O3 Ratio = 0.5:1

Round 3

Ozone Residual in Contactor Effluent, mg/L

Ozone Dose, mg/L

Dose = 1.3 mg/L  
Goal < 0.1 mg/L

B-15
Conventional Contactor
HRT = 10 minutes
Raw Water
pH = 6.5
No Prechloramine Added

Round 1 (MIB = 42 ng/L)
Round 2 (MIB = 31 ng/L)
Round 3 (MIB = 40 ng/L)

Dose = 1.8 mg/L
Goal > 71%
Dose = 2.5 mg/L

Round 1 (Geosmin = 33 ng/L)
Round 2 (Geosmin = 26 ng/L)
Round 3 (Geosmin = 40 ng/L)

Dose = 1.4 mg/L
Goal > 73%
Dose = 2.1 mg/L
Conventional Contactor
HRT = 10 minutes
Raw Water
pH = 6.5
No Prechloramine Added

Round 1 (Bromide = 620 µg/L)
Round 2 (Bromide = 394 µg/L)
Round 3 (Bromide = 423 µg/L)

Conventional Contactor
HRT = 10 minutes
Raw Water
pH = 6.5
No Prechloramine Added

Bromate Formed, µg/L

0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5
Ozone Dose, mg/L

0 10 20 30 40 50

Dose = 1.8 mg/L
BrO₃⁻ = 13 µg/L
Dose = 2.5 mg/L
BrO₃⁻ = 18 µg/L
Goal < 8 µg/L

Ozone Residual in Contactor Effluent, mg/L

0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6
Ozone Dose, mg/L

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
Dose = 1.8 mg/L
Dose = 2.5 mg/L
Goal < 0.1 mg/L
Round 2 (MIB = 44 ng/L)

Dose = 1.3 mg/L

Goal > 71%

Pipeline AOP Contactor
HRT = 2 minutes
Raw Water
pH = 6.5
No Prechloramine Added
H2O2:O3 Ratio = 0.5:1

Round 2 (Geosmin = 35 ng/L)

Dose = 1.1 mg/L

Goal > 73%

Pipeline AOP Contactor
HRT = 2 minutes
Raw Water
pH = 6.5
No Prechloramine Added
H2O2:O3 Ratio = 0.5:1
Pipeline AOP Contactor
HRT = 2 minutes
Raw Water
pH = 6.5
No Prechloramine Added
H2O2:O3 = 0.5:1

Round 2 (Bromide = 524 µg/L)

Dose = 1.3 mg/L
BrO3 = 24 µg/L

Goal < 8 µg/L

Ozone Residual in Contactor Effluent, mg/L
Ozone Dose, mg/L

Pipeline AOP Contactor
HRT = 2 minutes
Raw Water
pH = 6.5
No Prechloramine Added
H2O2:O3 Ratio = 0.5:1

Round 2

Dose = 1.3 mg/L
Goal < 0.1 mg/L

Ozone Residual in Contactor Effluent, mg/L
Ozone Dose, mg/L
Ozone Dose, mg/L

Percent MIB Destruction

Goal > 71%

Round 1 (MIB = 38 ng/L)
Round 2 (MIB = 18 ng/L)

Conventional Contactor
HRT = 10 minutes
Settled Water
pH = 6.6
Prechloramine Dose = 0.75 mg/L

Ozone Dose, mg/L

Percent Geosmin Destruction

Goal > 73%

Round 1 (Geosmin = 33 ng/L)
Round 2 (Geosmin = 17 ng/L)

Conventional Contactor
HRT = 10 minutes
Settled Water
pH = 6.6
Prechloramine Dose = 0.75 mg/L
Pipeline AOP Contactor
HRT = 2 minutes
Settled Water
pH = 6.8
Prechloramine Dose = 0.75 mg/L

Round 2 (MIB = 33 ng/L)
Round 3 (MIB = 72 ng/L)

Goal > 71%
Dose = 1.3 mg/L

Goal > 73%
Dose = 1.7 mg/L

Round 2 (Geosmin = 27 ng/L)
Round 3 (Geosmin = 63 ng/L)
Pipeline AOP Contactor
HRT = 2 minutes
Settled Water
pH = 6.8
Prechloramine Dose = 0.75 mg/L
H2O2:O3 Ratio = 0.5:1

Ozone Dose, mg/L

Bromate Formed, µg/L

<table>
<thead>
<tr>
<th>Ozone Dose, mg/L</th>
<th>Round 2 (Bromide = 531 µg/L)</th>
<th>Round 3 (Bromide = 470 µg/L)</th>
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<tbody>
<tr>
<td>1.3 mg/L</td>
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<tr>
<td>1.7 mg/L</td>
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</table>

BrO₃ = 10 µg/L

Goal < 8 µg/L

Ozone Residual in Contactor Effluent, mg/L

<table>
<thead>
<tr>
<th>Ozone Dose, mg/L</th>
<th>Round 2</th>
<th>Round 3</th>
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<tr>
<td>1.3 mg/L</td>
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<tr>
<td>1.7 mg/L</td>
<td>●</td>
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</table>

Goal < 0.1 mg/L
Conventional Contactor
HRT = 10 minutes
Settled Water
pH = 6.5 - 6.7
No Prechloramine Added

Round 1 (MIB = 38 ng/L)
Round 2 (MIB = 19 ng/L)

Round 1 (Geosmin = 40 ng/L)
Round 2 (Geosmin = 16 to 17 ng/L)
Pipeline AOP Contactor
HRT = 2 minutes
Settled Water
pH = 6.7
No Prechloramine Added

Round 2 (MIB = 33 ng/L)
Round 3 (MIB = 44 ng/L)

Goal > 71%
Dose = 1.1 mg/L
Dose = 1.2 mg/L

Ozone Dose, mg/L

Percent MIB Destruction

Round 2 (Geosmin = 27 ng/L)
Round 3 (Geosmin = 43 ng/L)

Goal > 73%
Dose = 1.0 mg/L
Dose = 1.1 mg/L

Ozone Dose, mg/L

Percent Geosmin Destruction
Bromate Formed, µg/L

Ozone Dose, mg/L

Ozone Residual in Contactor Effluent, mg/L

Ozone Dose, mg/L
Conventional Contactor
HRT = 10 minutes
Settled Water
pH = 6.0
No Prechloramine Added

Dose > 4.5 mg/L (7)

Goal > 71%

Round 1 (MIB = 38 ng/L)
Round 2 (MIB = 20 ng/L)

Percent MIB Destruction
Ozone Dose, mg/L

Dose = 4.0 mg/L (7)

Percent Geosmin Destruction
Ozone Dose, mg/L

Round 1 (Geosmin = 40 ng/L)
Round 2 (Geosmin = 16 ng/L)
Conventional Contactor
HRT = 10 minutes
Settled Water
pH = 6.0
No Prechloramine Added

Round 1 (Bromide = 615 µg/L)
Round 2 (Bromide = 415 µg/L)

Goal < 8 µg/L

Dose > 4.5 mg/L (not specified)

Conventional Contactor
HRT = 10 minutes
Settled Water
pH = 6.0
No Prechloramine Added

Round 1
Round 2

Goal < 0.1 mg/L

Dose = 4.0 mg/L (not specified)
Pipeline AOP Contactor
HRT = 2 minutes
Settled Water
pH = 6.0
No Prechloramine Added

Goal > 71%

Pipeline AOP Contactor
HRT = 2 minutes
Settled Water
pH = 6.0
No Prechloramine Added

Goal > 73%
Pipeline AOP Contactor
HRT = 2 minutes
Settled Water
pH = 6.0
No Prechloramine Added
H2O2:O3 Ratio = 0.5:1

○ Round 2 (Bromide = 531 µg/L)
■ Round 3 (Bromide = 436 µg/L)

Bromate Formed, µg/L

0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5
Ozone Dose, mg/L

0 10 20 30 40 50 60

BrO₃⁻ = 28 µg/L
Dose = 2.1 mg/L

BrO₃⁻ = 18 µg/L

Goal < 8 µg/L

Pipeline AOP Contactor
HRT = 2 minutes
Settled Water
pH = 6.0
No Prechloramine Added
H2O2:O3 Ratio = 0.5:1

○ Round 2
■ Round 3

Ozone Residual in Contactor Effluent, mg/L

0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2
Ozone Dose, mg/L

0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2
Goal < 0.1 mg/L
APPENDIX C
EMERGING DBPs SAMPLING PROTOCOL
Protocol for setting up and collecting samples to be analyzed for DBPs at Clemson

Background: A total of 20 samples will be collected from the pilot plant and sent to Clemson University for analysis of non-regulated DBPs (1-THMs and HNMs). Samples will be shipped from Zone 7’s Del Valle WTP on Tuesday, October 7 for arrival at Clemson on Wednesday October 8th. For each process (i.e., ozone vs. ozone/peroxide), there will be 10 samples collected and shipped. Various conditions will be established to examine the effects of different parameters such as chemical doses and pH values consistent with expected plant operation.

Materials needed:

<table>
<thead>
<tr>
<th>Ice chest</th>
<th>Blue ice</th>
</tr>
</thead>
<tbody>
<tr>
<td>DBP Sample bottles (60-mL pre-cleaned amber glass vials), total of 40</td>
<td>Labels</td>
</tr>
<tr>
<td>1-L clean amber glass bottles, total of seven</td>
<td>Caustic solution for adjusting pH</td>
</tr>
<tr>
<td>Sodium hypochlorite solution (1 mg/mL)</td>
<td>Ammonia solution (1 mg/mL as N)</td>
</tr>
<tr>
<td>1-L glass graduated cylinder</td>
<td>Pipettes</td>
</tr>
</tbody>
</table>

Sample Description: The 20 samples will be as follows (CC means Conventional Contactor – ozone only, and PC means Pipeline Contactor – ozone + peroxide):

| 1-RW | Raw water |
| 2-CC | Raw water dosed with 0.75 mg/L chloramine |
| 3-CC | Raw water that has been pre-chloraminated and then ozonated |
| 4-CC | Raw water that has been pre-chloramination, ozonated, and then dosed with chlorine for 10 minutes, followed by ammonia to form chloramine. This sample will be stored at room temperature for 24 hrs before shipping. |
| 5-CC | Raw water with pH depressed to 7.0 and ozonated |
| 6-CC | Raw water with pH depressed to 7.0, ozonated, then pH raised back to 8.0, dosed with chlorine for 10 minutes, and followed by ammonia to form chloramine. The sample will be stored at room temperature for 24 hrs before shipping. |
| 7-SW | Settled water |
| 8-CC | Settled water dosed with 0.75 mg/L chloramine |
| 9-CC | Settled water dosed with chloramine, then ozonated |
| 10-CC | Settled water dosed with chloramine, ozonated, then pH adjusted to pH 8.0, dosed with chlorine for 10 minutes, and followed by ammonia to form chloramine. This sample will be stored at room temperature for 24 hrs before shipping. |
| 11-DV | Del Valle Plant Effluent |
| 12-SW | Settled water, pH adjusted to 8, dosed with chlorine for 10 minutes, and followed by ammonia to form chloramine. This sample will be stored at room temperature for 24 hrs before shipping. |
Instructions:

Day 1 (Monday, October 6th)

1. Start up both trains of pilot plant with raw water, adding chloramine to each train. Establish the following conditions:
   a. CC flow = 6.5 gpm, PC flow = 3.5 gpm
   b. Chlorine dose = 0.75 mg/L to inlet of both contactors
   c. Ammonia dose = 0.19 mg/L to inlet of both contactors
2. Allow to stabilize for 10 minutes
3. Collect the following samples
   a. 1-RW from pilot plant influent tap
   b. 2-CC from effluent of first cell (CC-1)
   c. 2-PC from mid-point of pipeline contactor (PC-3)
4. Start ozone feed to both contactors. Use an ozone dose of 2 mg/L for both contactors
5. Start peroxide feed to pipeline contactor at a dose of 1 mg/L
6. Allow to stabilize for 20 minutes
7. Collect the following samples
   a. 3-CC from the effluent of the conventional contactor (CC-5)
   b. 3-PC from the effluent of the pipeline contactor (PC-6)
   c. Fill two 1-L amber bottles, one from the effluent of each contactor (collect exactly one liter in each bottle). These will be used for 4-CC and 4-PC; set aside
8. Turn chlorine and ammonia feed off to both contactors
9. Start acid feed to source tank, adjusting until pH reaches 7.0
10. Allow to stabilize for 30 minutes (three HRT through contactor)
11. Collect the following samples
    a. 5-CC from effluent of conventional contactor (CC-5)
    b. 5-PC from effluent of pipeline contactor (PC-6)
    c. Fill two 1-L amber bottles, once from the effluent of each contactor (collect exactly one liter in each bottle). These will be used for 6-CC and 6-PC; set aside
12. Switch source water to pilot plant from raw to settled water
13. Collect sample 7-SW from source water tank. At the same time, collect exactly 1-L of settled water into a 1-L amber glass bottle, this will be used for 12-SW
14. Start up chlorine and ammonia feeds to each contactor
    a. Chlorine dose = 0.75 mg/L
    b. Ammonia dose = 0.19 mg/L
15. Allow to stabilize for 10 minutes
16. Collect the following samples
    a. 8-CC from effluent of first chamber (CC-1)
    b. 8-PC from mid-point of pipeline contactor (PC-3)
17. Start ozone feed to both contactors at 1.0 mg/L
18. Start peroxide feed to pipeline contactor at 0.5 mg/L
19. Allow to stabilize for 20 minutes
20. Collect the following samples
    a. 9-CC from effluent of conventional contactor (CC-5)
    b. 9-PC from effluent of pipeline contactor (PC-6)
c. Fill two 1-L amber glass bottles, one from each contactor (collect exactly one liter in each bottle). These will be used for 10-CC and 10-PC; set aside
21. Collect sample 11-DV from plant effluent tap into DBP bottle
22. Shut down both contactors and all chemical feeds
23. Take the seven 1-L bottles (4-CC, 4-PC, 6-CC, 6-PC, 10-CC, 10-PC, and 12-SW) to the lab
24. Place the 13 filled 60-mL DBP samples in the refrigerator (those starting with 1, 2, 3, 5, 7, 8, 9, 11)
25. For bottles 6-CC, 6-PC, 10-CC, 10-PC, and 12-SW perform the following steps:
   a. Place bottle on magnetic stirrer, add stir bar and mix
   b. Make sure pH probe is clean, place pH probe in bottle
   c. Slowly add caustic solution and measure pH. Continue adding caustic solution until pH reaches 8.0 ± 0.2
   d. Continue mixing for 5 more minutes, ensure that pH is stable at 8.0 ± 0.2
   e. Measure and record pH of each bottle

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>pH after caustic addition</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-CC</td>
<td>8.06</td>
</tr>
<tr>
<td>6-PC</td>
<td>8.04</td>
</tr>
<tr>
<td>10-CC</td>
<td>8.01</td>
</tr>
<tr>
<td>10-PC</td>
<td>7.98</td>
</tr>
<tr>
<td>12-SW</td>
<td>7.96</td>
</tr>
</tbody>
</table>

26. For all seven samples in amber bottles, perform the following steps:
   a. Add 2.5 mg of hypochlorite, gently stir
   b. Wait 10-minutes
   c. Add 0.63 mg of ammonia, gently stir
   d. Cap bottle and store at room temperature overnight
27. Make sure there is sufficient frozen blue ice in freezer, add more if needed

Day 2 (Tuesday, October 7th)

1. Twenty-four hours after completion of step 26, measure and record the following from each amber glass bottle: pH, temperature, total chlorine residual

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>temperature</th>
<th>pH</th>
<th>Total chlorine, mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-CC</td>
<td>20.7</td>
<td>2.01</td>
<td>1.01</td>
</tr>
<tr>
<td>4-PC</td>
<td>20.6</td>
<td>7.61</td>
<td>0.53</td>
</tr>
<tr>
<td>6-CC</td>
<td>20.6</td>
<td>7.86</td>
<td>0.82</td>
</tr>
<tr>
<td>6-PC</td>
<td>20.6</td>
<td>7.87</td>
<td>0.12</td>
</tr>
<tr>
<td>10-CC</td>
<td>20.6</td>
<td>7.77</td>
<td>0.75</td>
</tr>
<tr>
<td>10-PC</td>
<td>20.6</td>
<td>7.73</td>
<td>0.30</td>
</tr>
<tr>
<td>12-SW</td>
<td>20.6</td>
<td>7.65</td>
<td>1.10</td>
</tr>
</tbody>
</table>

2. Pour samples from each of the 1-L bottles into the corresponding 60-mL DBP bottles
3. Pack all 20 60-mL sample bottles in ice chest and add frozen blue ice
4. Ship ice chest via overnight carrier to Clemson University
<table>
<thead>
<tr>
<th>Date</th>
<th>source</th>
<th>pH</th>
<th>Conventional Contactor Dose, mg/L</th>
<th>Pipeline Contactor Dose, mg/L</th>
<th>Ozone Dose, mg/L</th>
<th>Conventional Contactor Dose, mg/L</th>
<th>Pipeline Contactor Dose, mg/L</th>
<th>H2O2 Dose, mg/L</th>
<th>Chlorine Dose, 1-hr free Chlorine Residual, mg/L</th>
<th>24-hr total Chlorine Residual, mg/L</th>
<th>N Concentration, mg/L</th>
<th>THMs Formed, ug/L</th>
<th>HAAS Formed, ug/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/4/2008</td>
<td>raw</td>
<td>7.8</td>
<td>1.8</td>
<td>2.5</td>
<td>2</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>0.95</td>
<td>2.06</td>
<td>1.72</td>
<td>3.89</td>
<td>5.0</td>
</tr>
<tr>
<td>6/10/2008</td>
<td>raw</td>
<td>8.1</td>
<td>4</td>
<td>4</td>
<td>0.8</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>0.98</td>
<td>0.96</td>
<td>0.96</td>
<td>0.93</td>
<td>0.94</td>
</tr>
<tr>
<td>7/11/2008</td>
<td>raw</td>
<td>7.7</td>
<td>2.5</td>
<td>2.5</td>
<td>1.3</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>0.55</td>
<td>0.49</td>
<td>0.51</td>
<td>0.51</td>
<td>0.42</td>
</tr>
<tr>
<td>7/22/2008</td>
<td>raw</td>
<td>7.9</td>
<td>2.5</td>
<td>2.5</td>
<td>1.3</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>1.67</td>
<td>1.66</td>
<td>1.67</td>
<td>1.51</td>
<td>1.79</td>
</tr>
<tr>
<td>8/5/2008</td>
<td>settled</td>
<td>6.6</td>
<td>1.5</td>
<td>1.5</td>
<td>0.75</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>2.16</td>
<td>2.46</td>
<td>1.07</td>
<td>1.06</td>
<td>1.42</td>
</tr>
<tr>
<td>9/3/2008</td>
<td>settled</td>
<td>6.7</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2.2</td>
<td>2.2</td>
<td>2.2</td>
<td>1.36</td>
<td>1.78</td>
<td>0.46</td>
<td>0.82</td>
<td>0.70</td>
</tr>
<tr>
<td>9/16/2008</td>
<td>settled</td>
<td>6.8</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3.4</td>
<td>3.4</td>
<td>3.4</td>
<td>1.86</td>
<td>2.32</td>
<td>1.57</td>
<td>1.59</td>
<td>0.19</td>
</tr>
<tr>
<td>9/30/2008</td>
<td>settled</td>
<td>6.7</td>
<td>1.5</td>
<td>1.5</td>
<td>0.75</td>
<td>3.6</td>
<td>3.6</td>
<td>3.6</td>
<td>1.06</td>
<td>2.62</td>
<td>0.14</td>
<td>1.73</td>
<td>0.83</td>
</tr>
<tr>
<td>10/28/2008</td>
<td>raw</td>
<td>7.8</td>
<td>3</td>
<td>3</td>
<td>1.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>0.97</td>
<td>0.95</td>
<td>0.94</td>
<td>0.93</td>
<td>0.78</td>
</tr>
</tbody>
</table>

Simulated Distribution System Testing Results