In-Tank Aeration to Reduce Disinfection Byproducts

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Northern Kentucky Water District Facts

- Service Area 300 sq. mi.
- Population Served 300,000
- Over 80,000 Active Accounts
- 3 Treatment Plants
- Average demand ~29 MGD
- Maximum demand ~ 49 MGD
- 3 Raw Water Intakes
- 20 Storage Tanks
- 16 Pump Stations
- 1,300 Miles of Main

- Campbell County
- Kenton County
- Wholesale to portions of Boone, Grant and Pendleton Counties
Treatment Plants

- Ft. Thomas, 44 MGD
- Memorial Parkway, 10 MGD
- Taylor Mill, 10 MGD
Disinfection Byproducts

- Organics not removed during treatment form byproducts - trihalomethanes (THMs) and haloacetic acids (HAAs)
- Disinfection byproducts regulated under the Disinfection Byproducts Rule
- Stage 2 Rule effective April 1, 2012
  - Locational Running Annual Average (4 quarters)
    - THMs = 80 µg/L
    - HAAs = 60 µg/L
- 8 compliance sites in distribution system
  - Each site must comply with Maximum Contaminant Level (MCL)
Advanced Treatment

- Added granular activated carbon July 2012 at FTTP and MPTP
- TMTP – no GAC
- Finished water TOC target of 1.25 mg/L or less
- 8 contactors at FTTP
- 4 contactors at MPTP
- React each contactor every 12 - 18 months

- Estimated annual reactivation cost $2.3 million for MPTP and FTTP
# Organics and DBPs

## 2013 Finished Water Results

<table>
<thead>
<tr>
<th>Plant</th>
<th>Range of TOC, mg/L</th>
<th>Average TOC, mg/L</th>
<th>Range of THMs, µg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPTP</td>
<td>0.22 – 1.22</td>
<td>0.65</td>
<td>&lt;1 – 23</td>
</tr>
<tr>
<td>FTTP</td>
<td>0.30 – 1.71</td>
<td>0.84</td>
<td>&lt;1 – 30</td>
</tr>
<tr>
<td>TMTP</td>
<td>1.45 – 2.36</td>
<td>1.85</td>
<td>9 - 33</td>
</tr>
</tbody>
</table>
2013 Distribution System Results

**DBPs**  
**LRAA**  
Quarterly

<table>
<thead>
<tr>
<th>HAAs, µg/L</th>
<th>THMs, µg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>13 – 19</td>
<td>17 – 38</td>
</tr>
<tr>
<td>9 – 29</td>
<td>2 - 80</td>
</tr>
</tbody>
</table>
DBP Data Review

- LRAAs well below the MCL
  - GAC and blending FTTP/TMTP effective for meeting DBP Rule
- Goal - keep all quarterly samples below MCLs
- Look for ways to reduce DBP formation in system
- Use a phased approach
  - Reduce detention time
  - Review booster chlorination
  - Enhance tank mixing and aeration
Optimization Strategy

- **Lower Detention Time - Flushing**
  - Installed 11 automated flushing devices
    - Improve chlorine residual
    - Hopefully lower DBPs
  - Conduct routine hydrant flushing

- **Review Booster Chlorination**
  - Boost at 4 locations in the blended FTTP/TMTP system
    - Chlorine no longer boosted at 2 other sites post-GAC
  - Need chlorine to maintain residual - cannot eliminate boosting

- **Enhance Tank Mixing and Aeration**
  - On-going effort
TARGET AREA FOR STUDY FOR THM REMOVAL

8/13 THMs 66 µg/L
8/13 THMs 80 µg/L

BOOSTER CHLORINATION
AUTOMATED FLUSHING
THM Removal Using Aeration

- THMs are volatile organic compounds (VOCs)
- VOCs can separate from solution when exposed to air (Henry’s Law)
- Proven technology
- THM Speciation important
  - Chloroform = most volatile (and most prevalent)
  - Bromoform = least volatile
Types of Aeration Systems

- **Diffused Air**
  - Ground storage tank
  - Energy costs
  - Maintenance

- **Surface**
  - Similar to lagoon aerator
  - Energy costs
  - Tank modifications
Types of Aeration Systems

- **Spray**
  - Most common
  - Lower cost
  - Elevated tank
Spray Aeration

- Commercial or custom engineered
- Custom engineered:
  - Pump and piping - recycle
  - Spray nozzles
- Effective
  - Air-to-Water Ratio
- Design considerations
  - Head space above water
  - Droplet size and configuration
  - Recycle rate
  - Ventilation
  - Pipe Material (clogging)
  - Loss of chlorine
Site Selection Considerations

- **What is the best distribution system location?**
  - Water may bypass tank
  - Are there sufficient THMs already formed to remove in tank?
    - Clearwell may not have enough THMs to be worthwhile

- **Is the tank suitable for installing equipment?**
  - Ground storage easier than elevated tank
  - Power needs to be available
  - Is there a way to get equipment inside the tank?

- **Monitoring**
  - How will performance be monitored?
SELECTED INDEPENDENCE TANK FOR STUDY
Independence Tank

- 1 million gallon capacity
- Source = FTTP/TMTP Blend
- Demand ≈ 2 MGD
- Influences 2 THM compliance sites
- 3 drain/fill cycles daily
- 450,000 gallon per day turnover
- ~20% flows through tank
- Booster chlorine up and downstream
Recycle pump at base of tank

Piping to tank bowl
In-Tank THM Monitoring Results

• Installed on-line THM analyzer August 2013
• Records THM reading every 4 hours
• Continuous web-based access to data
• THMs 50 to 70 µg/L in summer and fall
  o Chloroform 60% of THM
• Compared lab data to on-line data
NKWD Lab Results vs. On-Line Analyzer

TTHM Concentration (ug/L)

Date


Lab Total
AMS Total
Modeling Results

• Modeling variables:
  o Different spray angles – no effect
  o Varying droplet diameter – minimal effect
  o Nozzle height above water (1 to 10 ft) – minimal effect
  o Recycle flow rate (up to 350 gpm)

• Most significant factor on THM removal is rate of recycle
Aeration Modeling

<table>
<thead>
<tr>
<th>Recycle Rate, gpm</th>
<th>Percent THM Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>100</td>
<td>20</td>
</tr>
<tr>
<td>175</td>
<td>30</td>
</tr>
<tr>
<td>250</td>
<td>40</td>
</tr>
<tr>
<td>350</td>
<td>45</td>
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</tbody>
</table>

Expect 30% removal = 15 to 20 μg/L reduction in THMs at tank.

![Graph showing THM concentration over time for different recycle rates](image)

Selected for design
Final Design

Pump:
• 10 HP
• 175 gpm, 110 feet TDH
• Required electrical upgrade

Piping:
• 200 feet of 3 inch, Schedule 80 PVC
• Pressure Gauges
• Strainer
• Ball Valve

Nozzles:
• Three Bete TF Model Spray Nozzles (20 psi)
• Mounted on 8-ft long arms
Performance and Construction Cost

Estimated materials  $14,000
Electrical service    $15,000
Contract labor       $  8,000
Total Construction   $37,000

THM Analyzer         $65,000
Lessons Learned

• Conduct site visits to see installed systems and learn what works, what doesn’t work
  o Don’t use galvanized pipe – nozzles clogged
  o Need way to ensure system is functioning properly
    • Gauges and analyzers
• Project requires plan review and approval from Kentucky Division of Water
• Piping more challenging to install than expected
• On-line monitor needs a heated space in winter
Next Steps

- Clean any accumulated sediment from Independence Tank
- Install recirculation pump, piping, and nozzles
- Monitor THMs and chlorine residuals at tank
- Continue to optimize in-plant treatment and GAC reactivation schedule
  - On-line THM analyzer in system helpful for operations
- Determine if a mixing and/or an aeration system should be installed in other tanks
Acknowledgements

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Questions

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