Smart Distribution Systems:
Bringing Storage Tanks To The 21st Century
Outline / Agenda

1\textsuperscript{st} - Intro – Who am I & Why am here? (5 min)

2\textsuperscript{nd} – Cost Effective Technologies (20 min)
   a) Mixing – Water quality + Case Studies
   c) Chem-Feed – Alternative to manual boosting
   b) Aeration – TTHM removal + Case Studies

3\textsuperscript{rd} – Q& A (5 min)
Goal:

Everyone learns something new.
Focus on Tanks

90% $$$ Of Proactive Spending Is In Treatment!

Only 10% $ Of Proactive Spending is In Distribution... However Water Spends +90% Of Its Time Here!
Why Mix Water Tanks?

2 Main Reasons...

#1: Water Age / Water Quality

#2: RISK MANAGEMENT
#1: Water Age / Water Quality

Simple Reason

The longer it stays stratified...
- The worse it tastes
- The less accurate samples are
- The more residual abnormalities occur
#2: RISK MANAGEMENT

More Complex!

If your samples aren't accurate...
- What if you miss something?
- Is nitrification coming?
- Is there bio film eating residual?
- Is there coliform or other issues breading?
#2: RISK MANAGEMENT
Mixing Technologies

Nozzles
“Passive”

Draft Tube
“Active”

Active Mixer
“Active”

Timeline showing when solutions became available...
Case Study: Spanaway WA
Motive: Water Quality
Spanaway, WA – 127 ft standpipe

Condensation was visible up to approximately 24 feet above ground. But top of water was around 110 feet...

Almost 800KG of questionable water quality!
Temperature Results

Spanaway Tank 2 - Temp Baseline

- Top Chlorine residual ~ 0.05ppm
- Bottom Chlorine residual ~ 0.65ppm
- Bottom Chlorine residual ~ 0.75ppm
- Approx 10°C stratification
- Top Chlorine residual ~ 0.0ppm
Spanaway WA – Standpipe 46’ x 127’ 1.5MG

Spanaway Water Temperature data - 46 x 127 ft tall standpipe

Mixer Off

~60 hours to blend to this point

~24 hours to blend to this point

~155 hours to blend to this point

Mixer On

~24 hours to blend to this point

~60 hours to blend to this point

~155 hours to blend to this point

20 ft of cold water is added to the tank here

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Case Study: Old Town Maine
Motives: Risk & Water Quality
Sweat line on both tanks

Tank 1 (PAX mixer)

Tank 2 (no mixer)

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Tank 1 (PAX mixer)

- Warmer headspace
- Thicker ice ring and lots of scraping
- Thinner ice on N side

Tank 2 (no mixer)

42°F

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Tank Skin Temperatures

Pocket of warm water at tank bottom (no mixer)
No damage to tank, structure or facility. Its all about velocity!
Spring Thaw – 3/25/09

How quickly can you eliminate destruction & potential failure? Again... Manage Risk!

Tank #1 – Mixed

Tank #2 – not mixed
It's not all risk management... there are tools that make your crew more effective!

Reservoir Control Systems!
Residual Loss in Tanks

Calcs dictate disinfection rate here... at the plant

Range of residual levels in system
Residual Loss in Tanks

Depending on water age, possible to have nearly ZERO residual here.

Range of residual levels in system
Residual Loss in Tanks

Operators may boost here

Which only increases DBPs here, for very little gain in the end & waste chem

Range of residual levels in system
Residual Loss in Tanks

Manually boost? Is that working?
Residual Loss in Tanks

What if you could reliably boost here???

And… reduce DBPs here?

Range of residual levels in system
Residual Loss in Tanks

And... reduce DBPs here?

And... reduce chem feed here?

What if you could reliably boost here???

Range of residual levels in system

Maintaining Healthy Residual
Residual Loss in Tanks

And... reduce DBPs here?

What if you could reliably boost here???

And... reduce chem feed here?

Smart Reservoir Control Systems
- Automated Water Quality samples / monitoring of tanks
- Automated dosing (chlorine or chloramine) based on samples
- Automated reports / control to operations

Work smarter, not harder!
RCS Installation layout
Secured Site Install: Chloraminated System, CA
Tank Residual Chlorine Concentration
Before & After RCS Added

- RCS off
- RCS start-up and tuning
- RCS on (set-point = 3.3)
Summary: Automated Residual Control and Stage 2 Compliance

- Active monitoring and boosting of disinfectant levels
- Reduces range of residual levels in system
  - Allows you to lower absolute levels = lower DBP production
- Rapid, targeted improvement in water quality
- Save on labor & chemicals
- Eliminate “disinfectant” slugs & corrosion!
In-Tank Aeration for THMs?
Aeration to remove THMs is not new...

Table 1. Simulated Aquarium Test
Aeration reduced THMs 85 percent in Soleta Irrigation District’s aquarium test.

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Sample Location</th>
<th>THM Result</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/25/2006</td>
<td>10:10</td>
<td>Aquarium before aeration</td>
<td>151 µg/L</td>
<td>-85%</td>
</tr>
<tr>
<td>10/25/2006</td>
<td>12:55</td>
<td>Aquarium after aeration</td>
<td>23.2 µg/L</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Full-Scale Storage Tank Test
Aeration at SSWA’s Gregory Hill Storage Tank reduced THMs 70 percent.

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Sample Location</th>
<th>THM Result</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/5/2007</td>
<td>11:00</td>
<td>Tank before aeration</td>
<td>120 µg/L</td>
<td>-70%</td>
</tr>
<tr>
<td>1/15/2007</td>
<td>10:20</td>
<td>Tank after aeration</td>
<td>36.4 µg/L</td>
<td></td>
</tr>
</tbody>
</table>

Aeration has been PROVEN to work

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Aeration - starts with evaporation
At equilibrium, a ratio in THM concentration between the air and the water. That ratio is the Henry’s Law constant.
Some aeration happens all by itself…

Diffusional barrier

Poor mixing prevents THMs below the surface from escaping

Evaporation stops
Mixing enhances aeration

But you need **STRONG** mixing
Spray aeration
Evaporation from droplets
Aeration in splash zone
However **Accurate** THM modeling is!

- Water sprayed at the top of the tank to strip DBPs into air
- Spray efficiency model
- Example of model output
Pilot study: Cal American, Monterey, CA

- Ryan Ranch Tank: 0.5MG, 72’ dia., 16’ h – end of line, low turnover
- THM levels average 140 \( \mu g/L \) in tank, max 50 \( \mu g/L \) rest of dist. system
- Three quarters of elevated levels, to avoid violation (RAA < 80 \( \mu g/L \)), sample needs to be just around 50 \( \mu g/L \) in Q3-2011
- Estimate w/o intervention: 140 ug/l
- Low Cl – periodic dosing onsite

- Cal American allows for only 2 violations across ALL their systems
- American Water corporate engineering had proposed a sprayer aeration system ($350K)
- Limited power at tank
The TRS goals and design

Goals
- Lower Cl demand
  - Eliminate stratification
  - Clean tank
- Remove THMs
  - Aeration
  - Goal: 60% reduction
- Use as little power as possible

Design
- Wash-out
- Chemical clean
- 1 PWM-400 mixer
- 1 PAX Powervent fan
TRS installation: Chemical cleaning
TRS Installation: Interior coatings repair
TRS Installation: PAX PowerVent Installation
TRS Installation: Mixer Installation
Initial results of Q3 compliance test

Post-TRS
Q3 Sample result = 49.2 µg/L

RAA = 79.3 µg/L  (the MCL is 80...)
Have the low THM levels remained?

Summer 2010 average = 141.5 ug/L

TRS activated 6/22/2011

Return to Ryan Ranch water

Δ = 90.0 ug/L or 63% year-to-year reduction

Summer 2011 average = 51.5 ug/L
Case Study: Stanly County, NC
Motives: Aerate TTHMs
Stanly County, NC

- Millingport Tank: 200,000 G, Pedisphere – very low turnover
- Received 20 day old water from City of Albemarle
- THM levels average 78 μg/l – highs of 112 μg/l
- Tried a type of active mixing in 2008 – no effect on water quality or THMs
- Tank cleaned several times – no improvement
Stanly County, NC
Millingport
The combination of small tank and low T/O makes for high TRS effectiveness
The TRS goals and design

Goals
• Remove THMs
  – Goal: 60% reduction

Design
• 4-nozzle sprayer system
• 1 PAX Powervent fan
  – NEPTUNE models suggested >90% THM reduction…

No MIXER?
Accurate modeling allows the correct configuration & most efficient design. Why pay for something that isn’t needed?
After operation of the TRS
<table>
<thead>
<tr>
<th>CONT. CODE</th>
<th>CONTAMINANT</th>
<th>METHOD CODE</th>
<th>REQUIRED REPORTING LIMIT (R.R.L)</th>
<th>QUANTIFIED RESULTS</th>
<th>ALLOWABLE LIMIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>2941</td>
<td>Chloroform</td>
<td>502.2</td>
<td>0.001 mg/L</td>
<td>&lt;0.001 mg/L</td>
<td>0.100 mg/L</td>
</tr>
<tr>
<td>2942</td>
<td>Bromoform</td>
<td>502.2</td>
<td>0.001 mg/L</td>
<td>&lt;0.001 mg/L</td>
<td>0.080 mg/L</td>
</tr>
<tr>
<td>2943</td>
<td>Bromodichloromethane</td>
<td>502.2</td>
<td>0.001 mg/L</td>
<td>&lt;0.001 mg/L</td>
<td>0.080 mg/L</td>
</tr>
<tr>
<td>2944</td>
<td>Chlorodibromomethane</td>
<td>502.2</td>
<td>0.001 mg/L</td>
<td>&lt;0.001 mg/L</td>
<td>0.080 mg/L</td>
</tr>
<tr>
<td>2950</td>
<td>Total Trihalomethanes</td>
<td>502.2</td>
<td>0.0010 mg/L</td>
<td>&lt;0.0010 mg/L</td>
<td>0.080 mg/L</td>
</tr>
</tbody>
</table>

100% THM removal
Further out in the distribution system…
To summarize today's talk

1. Mixing can: Improve water & minimize Risk  
   a) mixer strength is crucial!
2. Automated Residual Feed  
   a) Reduces labor  
   b) Reduces chem costs  
   c) Reduces Risk (nitrification, DBPs)
3. Aeration is not new  
   a) can be accurately modeled (% removal upfront)  
   b) reduced trial and error costs
Questions?

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