The Search for Good Mixing & Water Quality

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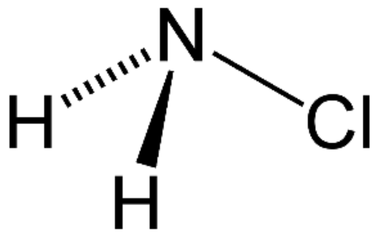
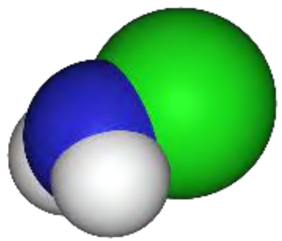
Chloramines are used in about a third of municipal water systems, provide longer protection in distribution systems, and are less prone to encourage DBP formation

$$NH_3 + OCl^- \leftrightarrow NH_2Cl + HO^-$$





Monochloramine is formed by the reaction of chlorine and ammonia with a chlorine atom substituting for one of the three ammonia hydrogen atoms

There are three "chloramine" variants – only one of which is desirable in a water system

This reaction is reversible – under certain conditions, products can decompose into reactants

(1) $H0Cl + NH_3 \leftrightarrow NH_2Cl + H_20$ — monochloramine

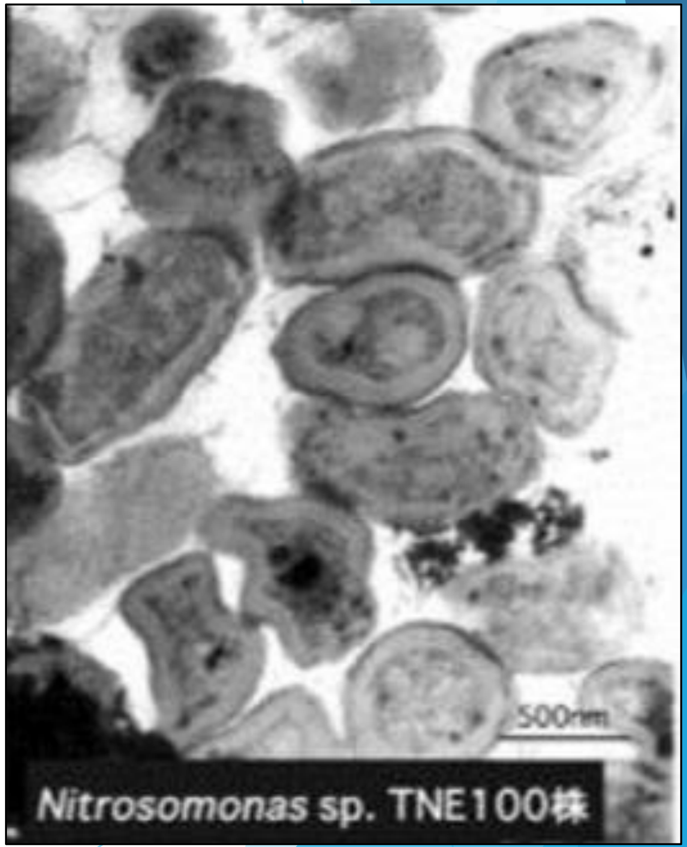
(2) $H0Cl + NH_2Cl \leftrightarrow NHCl_2 + H_20$ — dichloramine

(3) $H0Cl + NHCl_2 \leftrightarrow NCl_3 + H_20$ — trichloramine

Only monochloramine is considered a suitable disinfectant

Chloramine usage has been problematic due to difficulty in accurately controlling ammonia and chlorine dosage in a dynamic distribution system

- Introduction of ammonia can lead to nitrification as it is a nutrient to AOB's
- Over-chlorination can create chloramine variants which lead to taste and odor problems in drinking water (dichloramine and trichloramine)
- Low residual levels can also lead to costly mitigation efforts such as:
  - Chlorine burns
  - Line flushing
  - Tank dumping
  - Hydraulic acrobatics



Ammonia Oxidizing Bacteria (AOB)

In a distribution system, chloramine levels are challenged by a number of factors:

- Temperature stratification in tanks
- Chemical stratification in tanks
- Multiple water source compatibility
  - Surface, ground, purchased
- Distribution pipeline conditions
  - Unlined cast iron, biofilm buildup
- Water aging in tanks and pipelines

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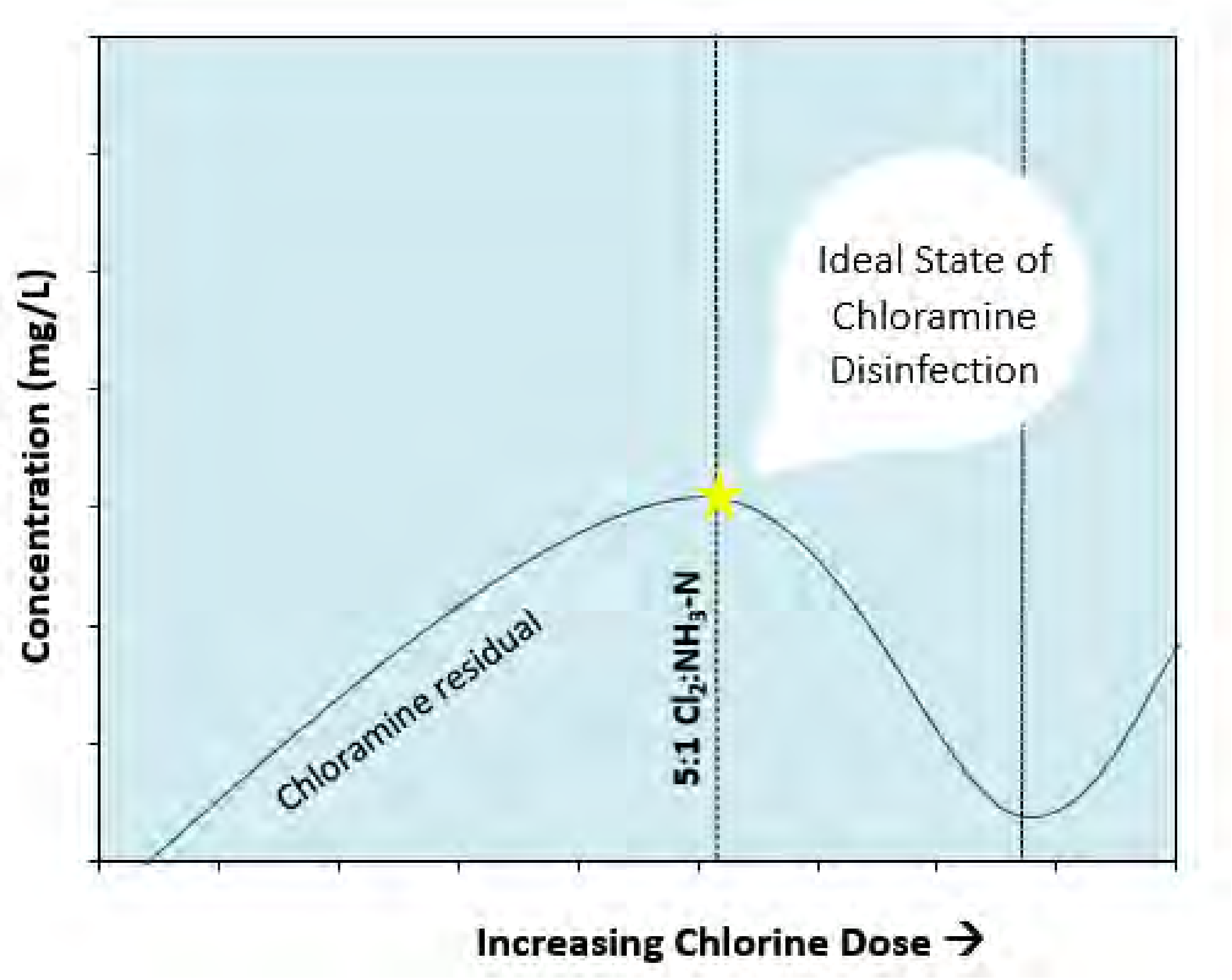
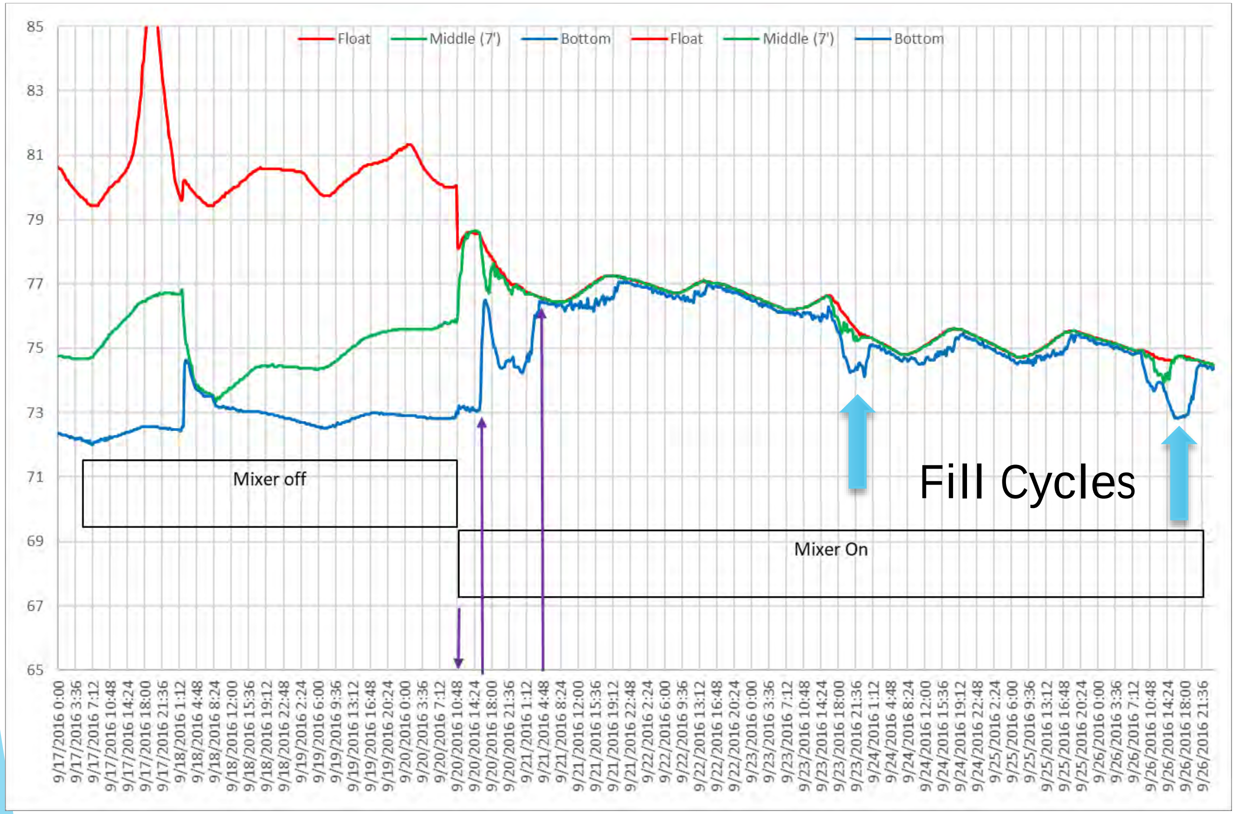
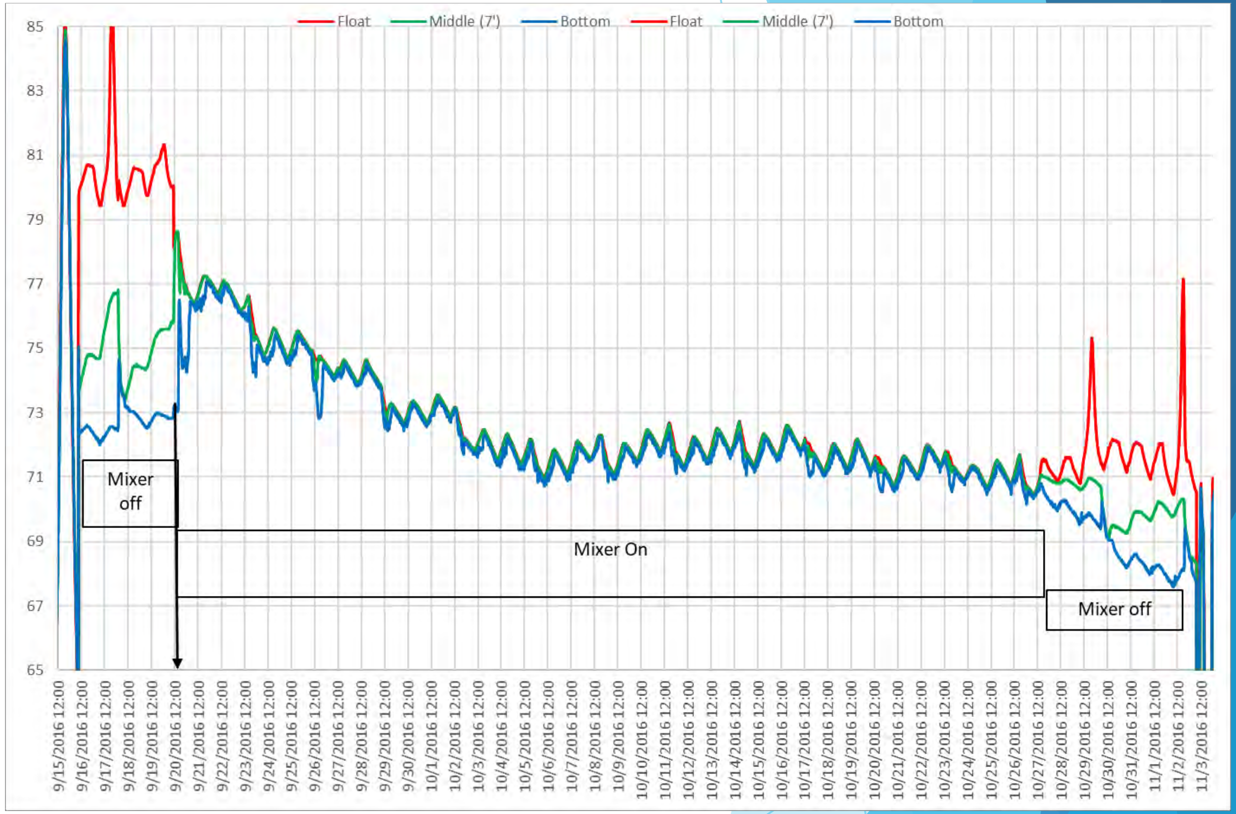
- Changes in constituent ratios over time (Chlorine & Ammonia)

Chloramine Breakpoint Curve: Know where you are on the curve



Temperature & Chemical stratification in tanks:

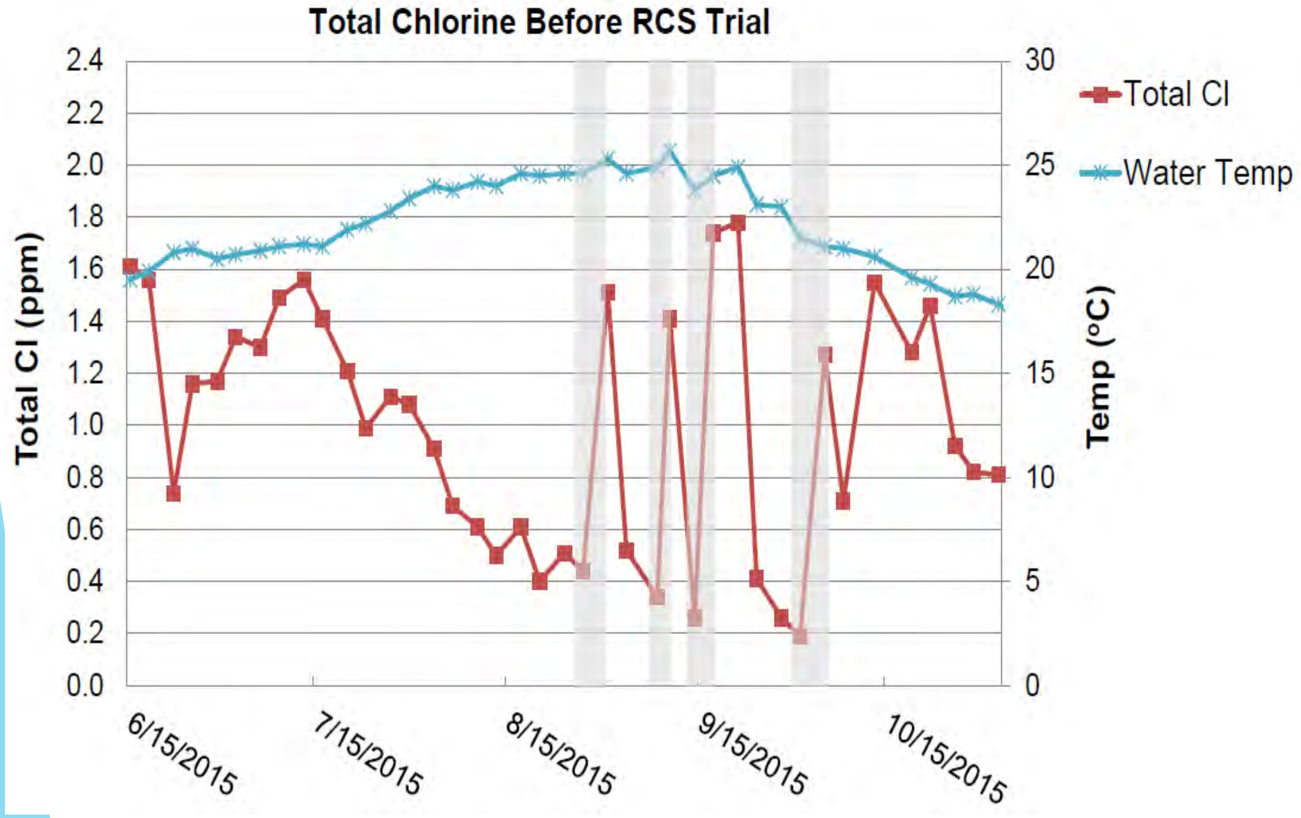


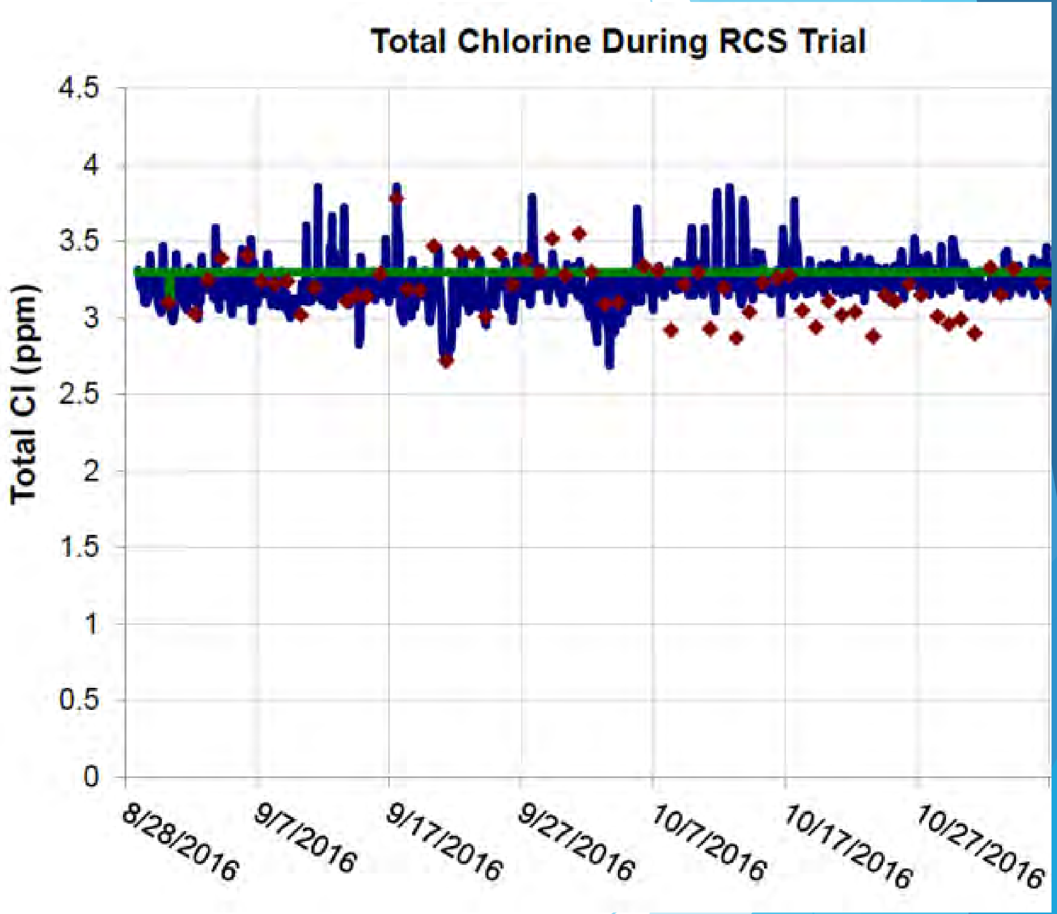


Properly sized active tank mixing eliminates tank stratification

Effective disinfectant residual control completely eliminates the threat of nitrification

<u>Before</u>: August-October (4) tank nitrification events as water temperature remained high





<u>After</u>: August-October next year with residual control - steady 3.3ppm residual through "nitrification season"

Multiple water source compatibility:

Surface water sources

- Have warmer water temperatures during summer
- Varying water quality

Ground water sources

- Have constant cooler water temperatures
- More constant water quality

Purchased water sources

- Can be highly variable water quality
- Completely dependent upon the supplier of the water

Distribution pipeline conditions:

- Unlined cast iron pipes
  - Create chlorine demand
  - Provide a perfect environment for biofilm growth
  - Inhibit flushing efforts due to decreased ID
- Oversized water mains
  - Creates horizontal storage tankage
  - Increases water age - aids in residual loss
  - Decreases water velocities - allows biofilm growth
  - Could inhibit flushing efforts due to large flow required for scouring velocities
- Distribution systems with limited pipe replacement programs

Water aging in tanks and pipelines

- Storage tanks were designed for:
  - Hydraulic pressure for the system
  - Fire suppression requirement
  - Future development - 15 to 30 years
  - Emergency reserve
- Storage tanks were NOT designed for:
  - Water quality
  - Rapid turnover
  - Minimizing water age
- Examples:
  - Standpipes vs. elevated storage
  - Small operating ranges for water levels in order to maintain pressure
  - Common inlet/outlet pipes
  - Large unused volumes of water

Conclusions

- Powerful & continuous mixing is key to make informed process decisions
- Knowing your tank's hydraulics helps understand the problem
- In-tank chemical dosing allows for continuous water quality adjustment

Tank Cl_2 residual taken June 13th, 2017

- Ambient air temp 95°F
- Inlet CL_2 ≈ 1.5 mg/L

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