American Water Works Association 2005 Annual Conference

Emerging Water Quality Concerns Associated with Integrating Desalinated Seawater into Existing Distribution Systems

Tai J. Tseng, Janel Grebel, Robert C. Cheng, Diem X. Vuong, and Kevin L. Wattier

Long Beach Water Department

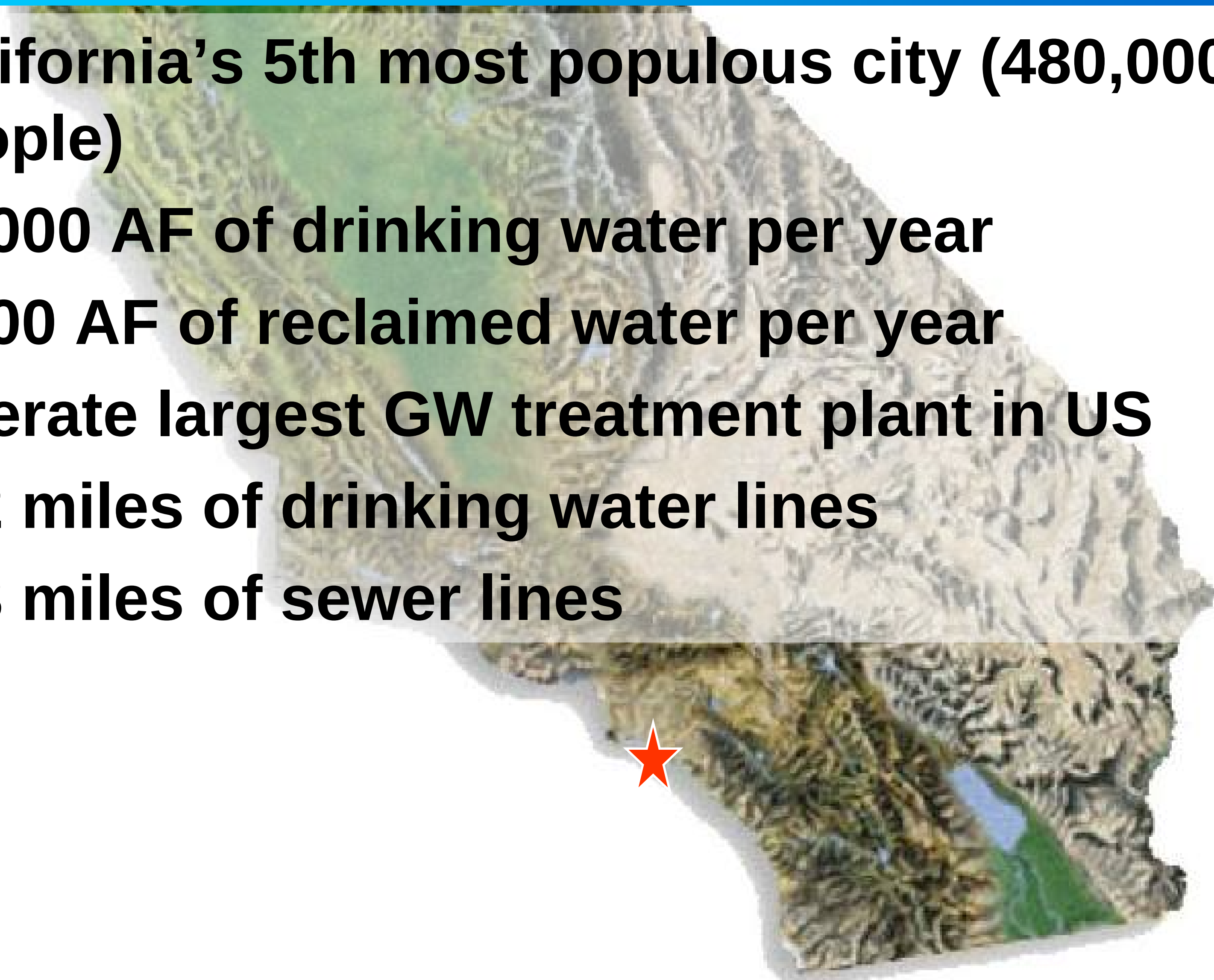
June 14, 2005

Presentation Outline

- Long Beach Overview
- Research Background
- Research Goals
- Results
- Conclusion

Long Beach Water Department

- California's 5th most populous city (480,000 people)
- 70,000 AF of drinking water per year
- 5,500 AF of reclaimed water per year
- Operate largest GW treatment plant in US
- 912 miles of drinking water lines
- 763 miles of sewer lines



Future Reliability

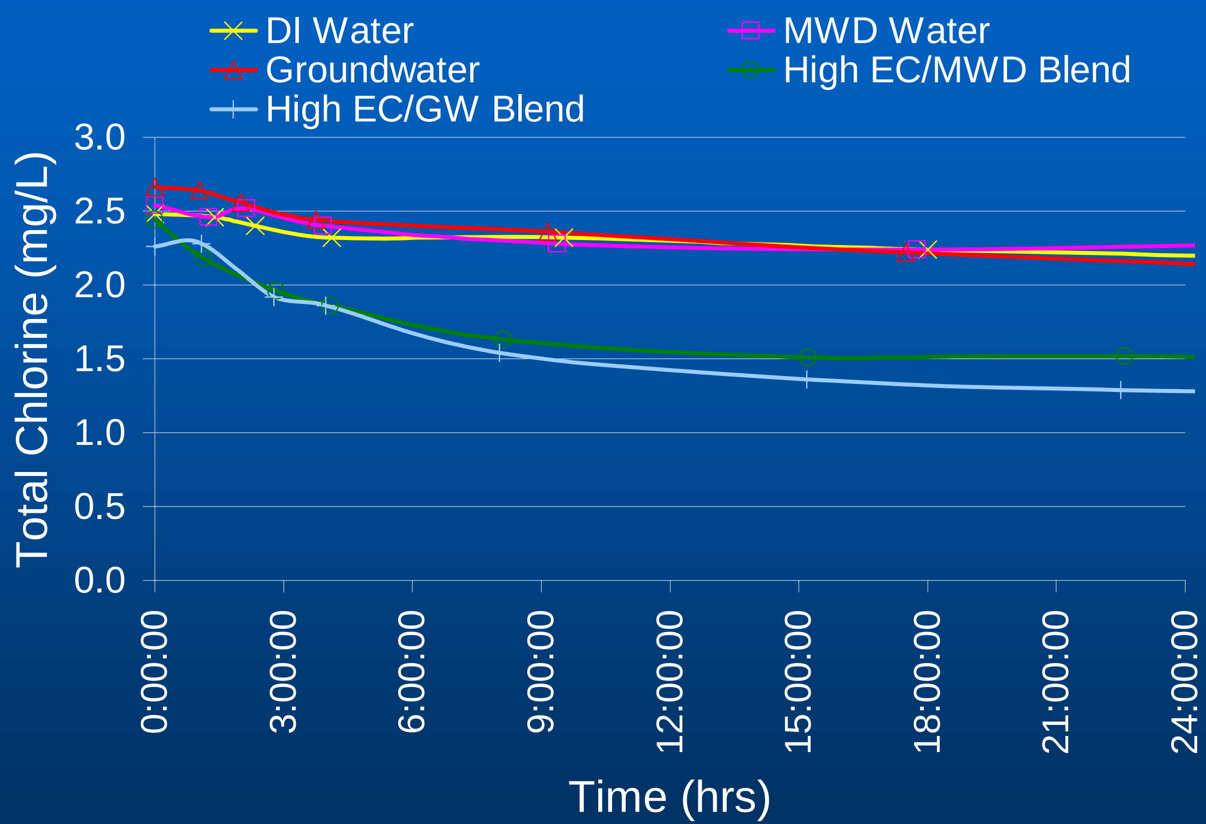
- Very little population growth
- Expansion of recycled water and water conservation
- Seawater desalination necessary ==> supplement City's imported drinking water supply

Water Quality Concerns

	LBWD Tap Water	Desalinated Seawater
TDS	~ 390 mg/L	350 - 150 mg/L
Boron	< 0.2 mg/L	2.0 – 0.3 mg/L
Bromide	0.4 mg/L - ND	1.0 – 0.4 mg/L

Initial Blending Study

- **Initially, want to evaluate SDS DBP formation**
- **Observed rapid decay of residual disinfectant**
- **Isolated bromide as the cause**



Literature Review

Key Equations

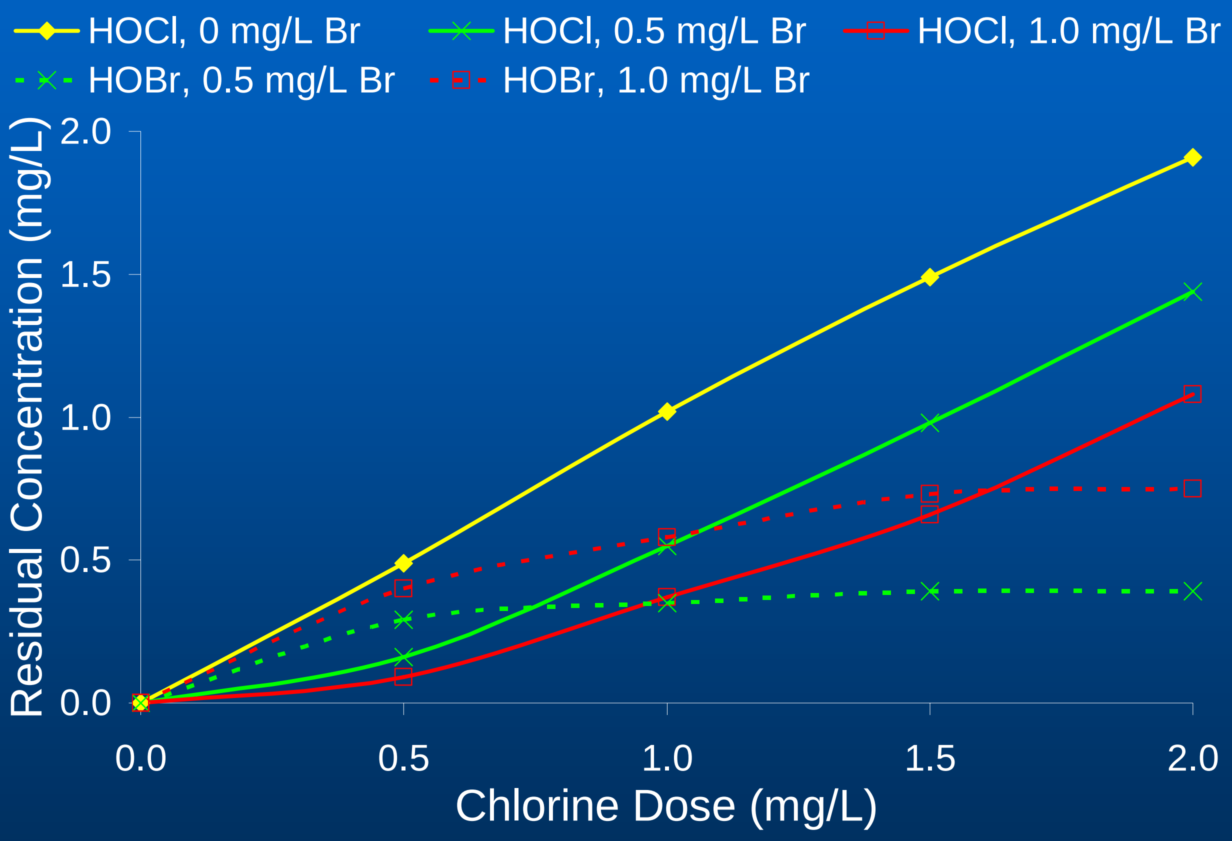
- $Cl_2 + H_2O \rightarrow HOCl + HCl$
- $HOCl + Br^- \rightarrow HOBr + Cl^-$
- $HOCl + NH_3 \rightarrow NH_2Cl + H_2O$
- $HOBr + NH_3 \rightarrow NH_2Br + H_2O$
- $HOBr + NH_2Cl \rightarrow NHBrCl + H_2O$
- $NHBrCl + NH_2Cl \rightarrow N_2 + Br^- + 2\ Cl + 3H^+$

Research Goals

- Chlorination Chemistry
  - Bromide effect on chlorination
  - Bromide effect on breakpoint
  - Bromide effect on disinfectant residual
- SDS DBP formation
  - Three scenarios

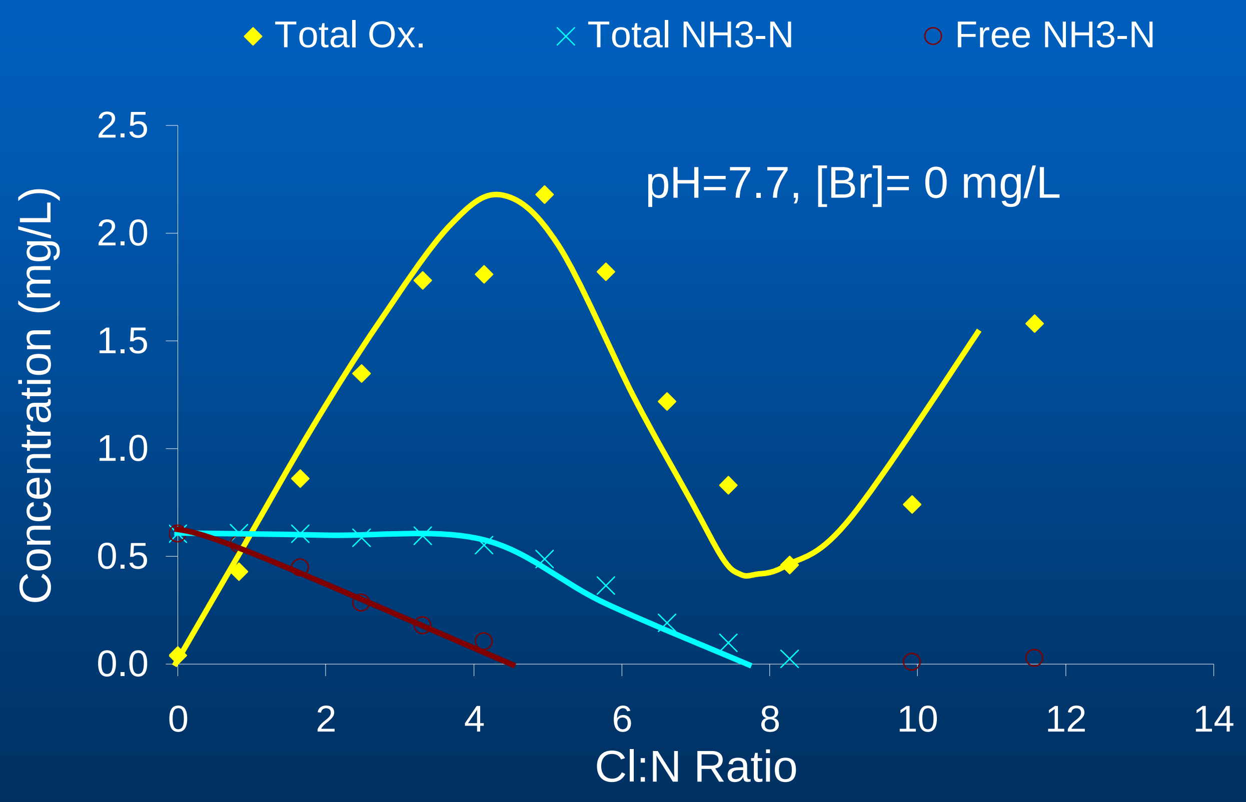
Chlorination

- DPD vs. DPD Glycine
- HOBr and HOCl co-exists
- HOBr is dominant



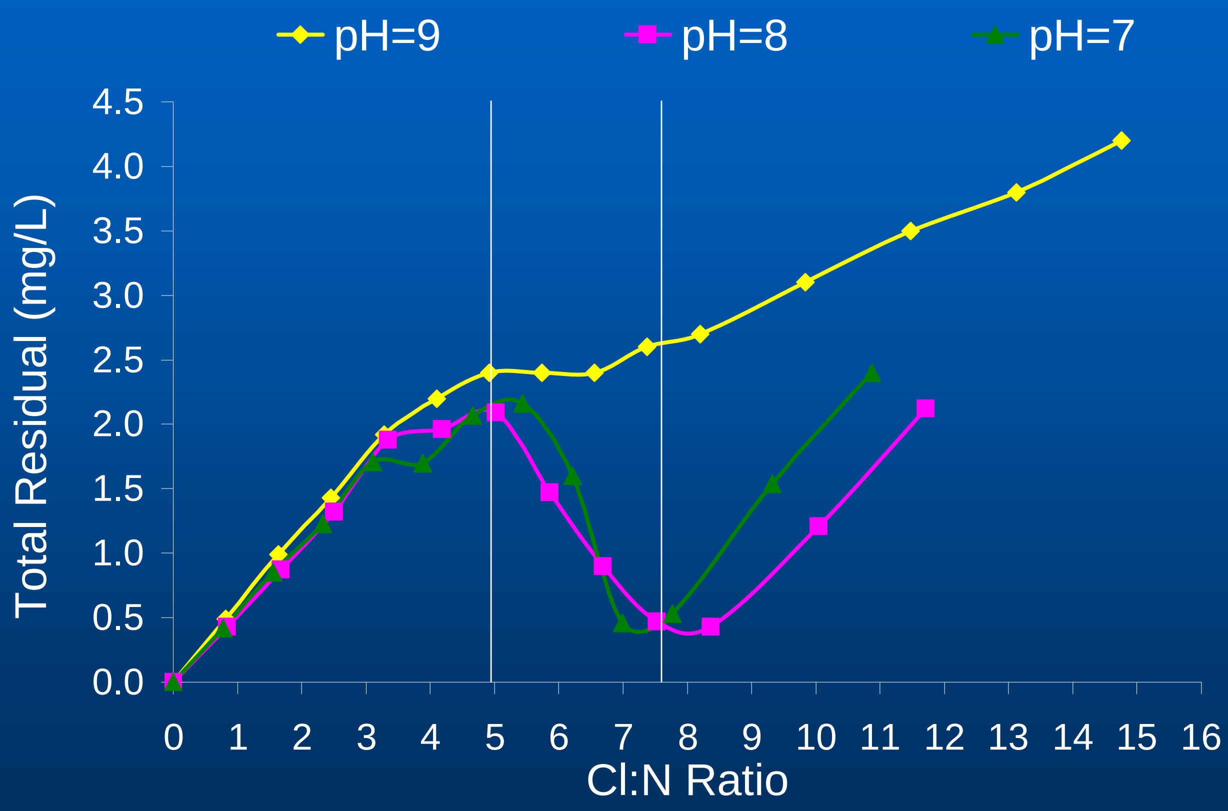
Chlorination

- **Classic breakpoint chemistry**



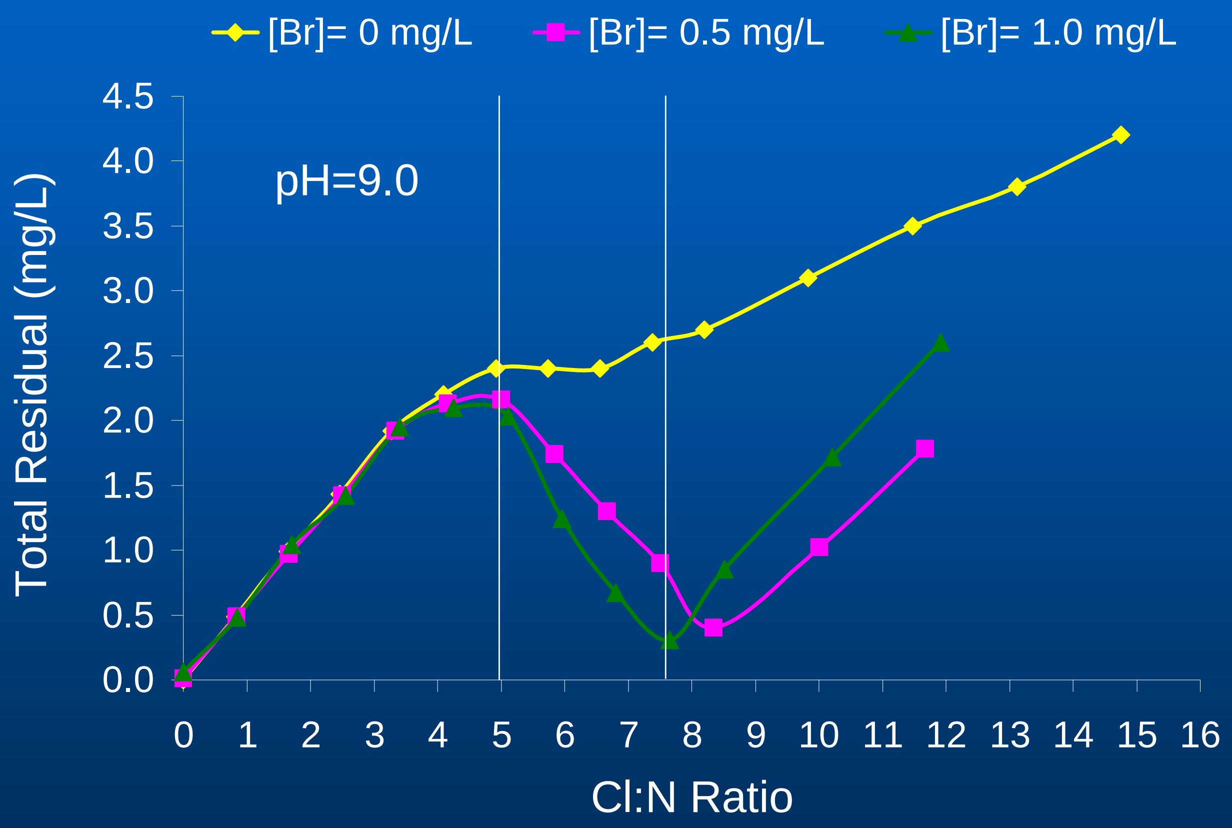
Chlorination

- **Breakpoint chlorination controlled by NHCl2 formation**
- **Raising the pH will slow the breakpoint process**



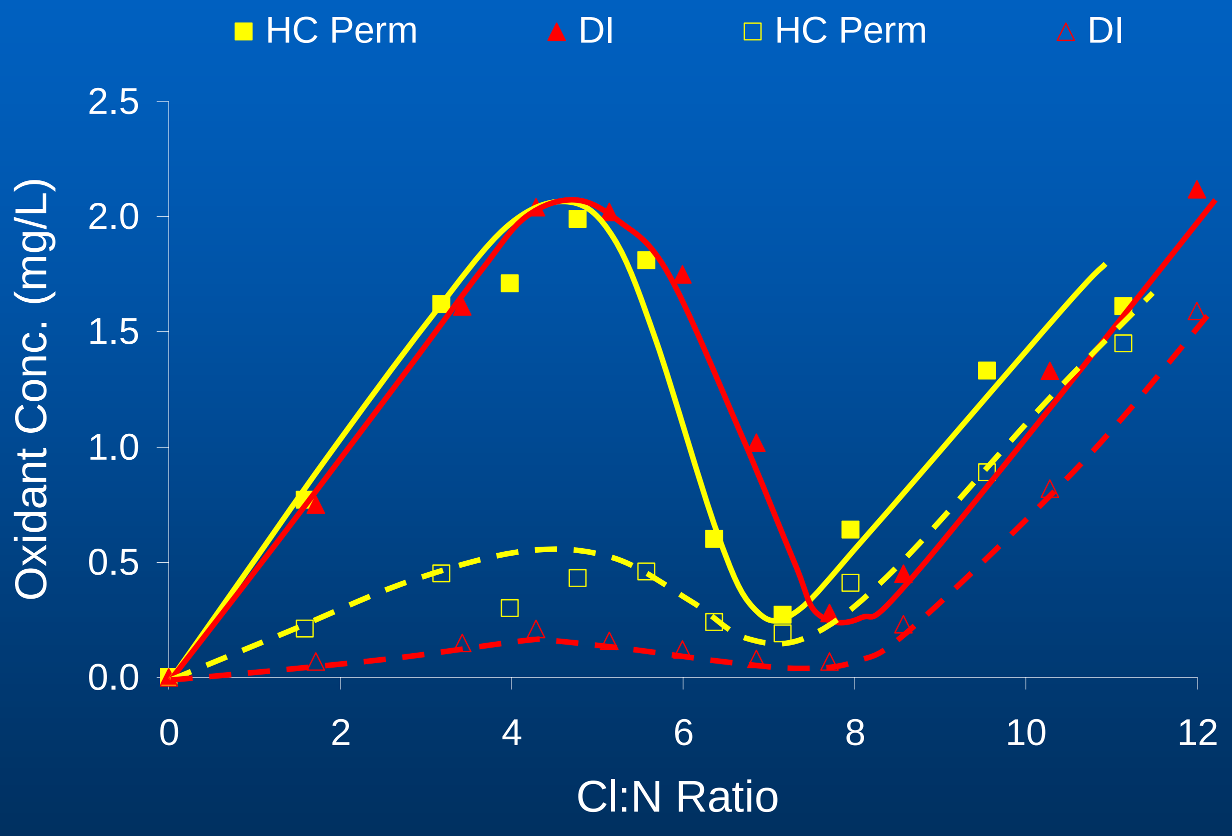
Chlorination

- **pH adjustment in the presence of bromide did not slow the breakpoint process at the pH tested**
- **Raising the pH may be inadequate**



Chlorination

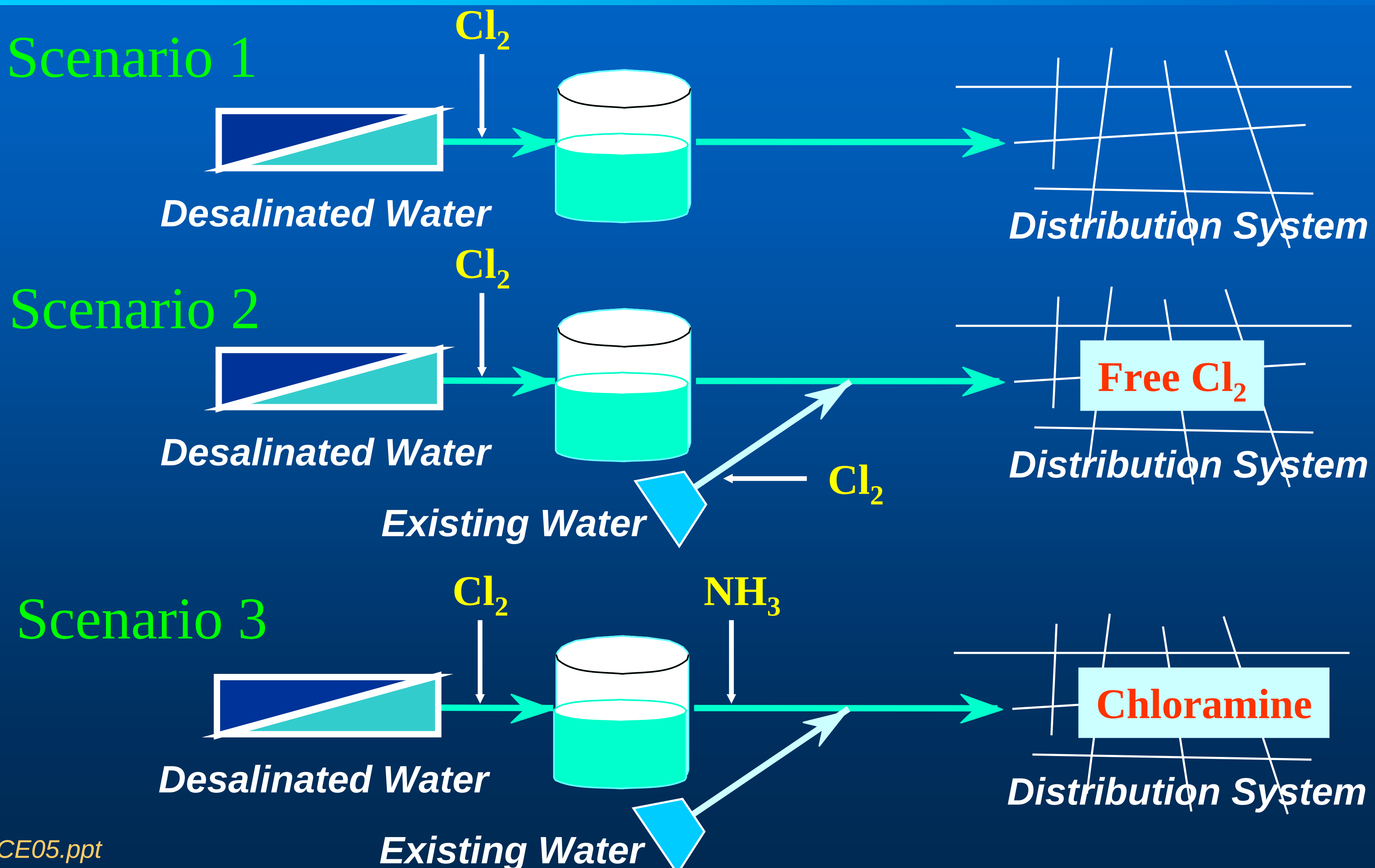
- Strong oxidants are detected in the presence of ammonia
- Suspect bromamines
- Bromamines may react with other chemicals to induced demand-decay



Chlorination Summary

- HOBr co-exists with HOCl, where HOBr is preferential
- Raising the pH can slow breakpoint but waters with bromide is less affected at the pH tested
- At 5:1 Cl:NH3-N ratio, strong oxidants are detected when Br is present. This strong oxidant may catalyze decomposition

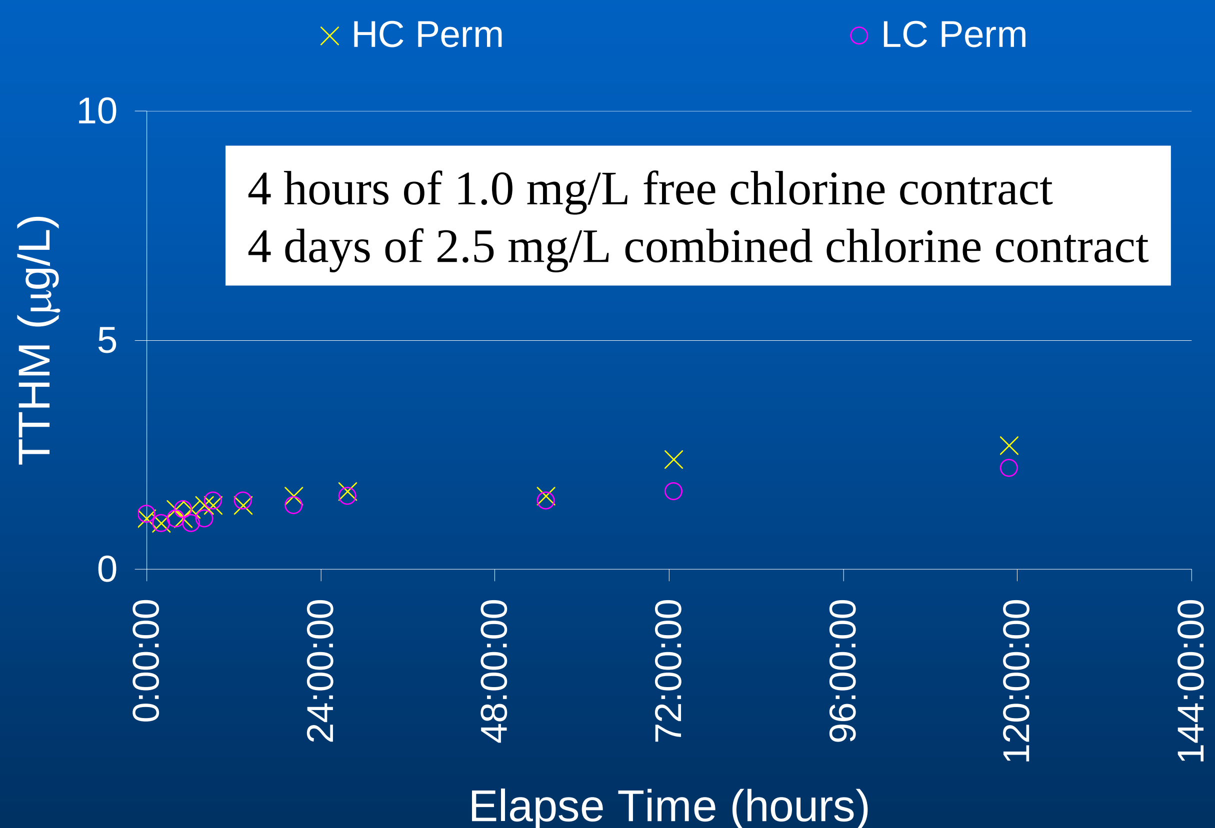
SDS



Scenario 1
Cl_2
Desalinated Water
Distribution System
Scenario 2
Cl_2
Desalinated Water
Existing Water
Cl_2
Free Cl_2
Distribution System
Scenario 3
Cl_2
NH_3
Desalinated Water
Existing Water
Chloramine
Distribution System

SDS

- **Scenario 1**
  - **High bromide did not affect significantly affect TTHM formation**
  - **TTHM < 5 µg/L**
  - **Low DBP due to absence of TOC**



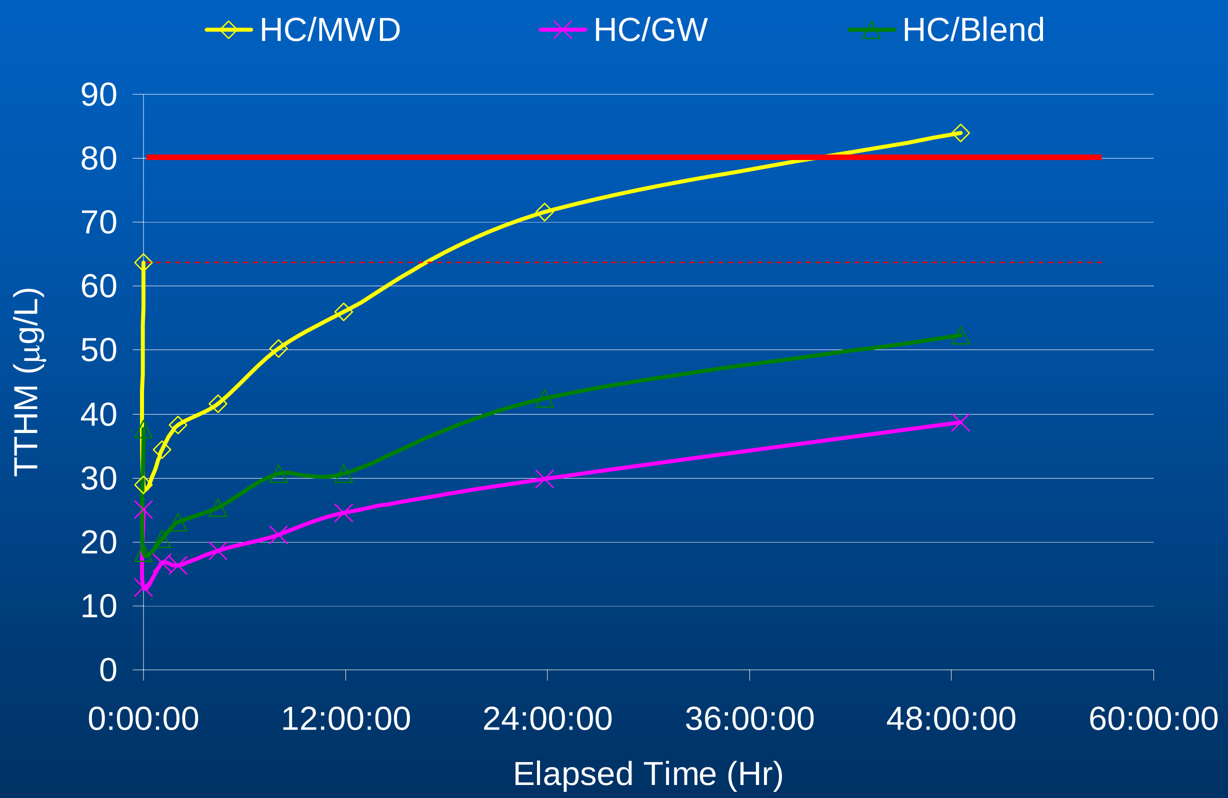
SDS

- 3 Blends
  - 50/50 - HC Permeate / MWD Water
  - 50/50 – HC Permeate / LBWD GW
  - 50/50 – HC Permeate / Blend of GW and MWD

Water Type	TOC	$CHCl_3$	BDCM	DBCM	$CHBr_3$	TTHM
	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L
HC Permeate	0.22	0.84	0.31	0.00	0.00	1.15
MWD Water	2.62	25.15	23.06	13.63	1.86	63.70
LBWD GW	0.99	9.37	7.95	6.16	1.65	25.12
Blend GW/MWD	1.65	14.64	12.85	8.51	1.71	37.71

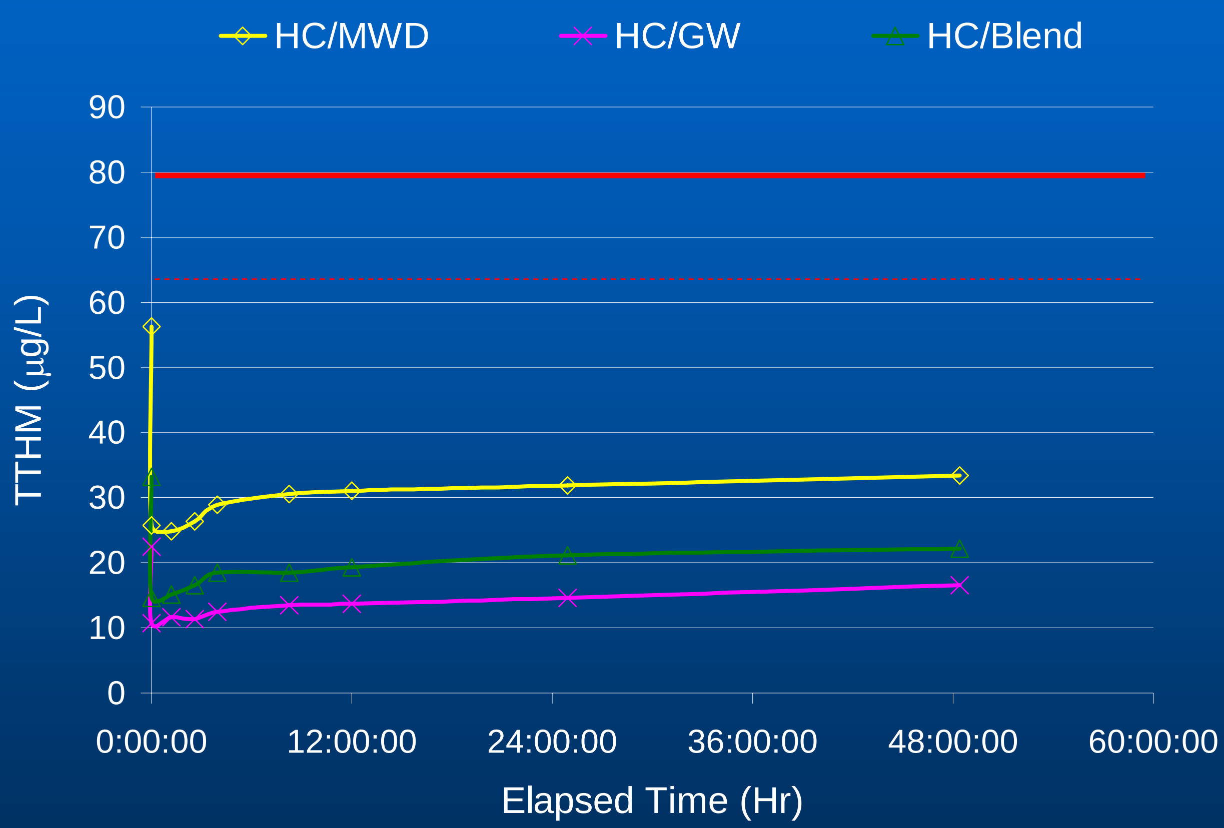
SDS

- **Scenario 2**
  - **Initial effect is dilution of DBPs**
  - **Reformation of TTHMs occurs**
  - **Depending on blend, TTHM levels may exceed MCL**



SDS

- **Scenario 3**
  - **Initial dilution of TTHMs**
  - **Reformation not as significant**



SDS

- **Reformation is primarily bromoform**

Disinfection Type	Water Type	$CHCl_3$	BDCM	DBCM	$CHBr_3$
Free Chlorine	HC / MWD	-52%	-39%	10%	2213%
	HC / GW	-44%	-27%	41%	1052%
	HC / Blend	-47%	-33%	29%	1363%
Chloramines	HC / MWD	-59%	-49%	-35%	299%
	HC / GW	-50%	-43%	-28%	171%
	HC / Blend	-56%	-42%	-31%	233%

SDS Summary

- Minimal TTHM formation in 100% desal water due to absence of TOC
- Initially, introduction of desal water will dilute TTHM levels but reformation will occur, most of which is bromoform
- Residual disinfectant selection is contingent on existing system water quality

Conclusions

- Presence of bromide will result in formation of brominated oxidants
- Presence of bromamines results in residual instability
- Raising the pH may not be sufficient in controlling decay and may be limited in utility

Conclusions

- Need to establish a low Br- standard in permeate
- TTHMs should not be a problem, but need to consider blend ratios and existing system water quality
- Additional work is needed to devise a comprehensive strategy to control residual decay

Acknowledgements

Questions