Regional Water Quality Issues:
Algae and Associated Drinking Water Challenges

Workshop – September 2009

A Cooperative Research and Implementation Program
Arizona State University (Tempe, AZ)

Paul Westerhoff
Chao-An Chiu and Marisa Masles

Salt River Project
Central Arizona Project
City of Phoenix
City of Tempe
City of Peoria
City of Chandler
City of Glendale
ASU NSF Water Environment & Technology Center

Agenda

Purpose: Provide a forum to review and discuss on-going regional water quality issues, in particular algae-associated issues.

- **8:30** Refreshments
- **8:45** Introductions
- **9:00** Project overview and Water Quality Trends
- **9:20** Progress towards on-line monitoring
- **9:30** Testing of new algae sensing devices
- **9:45** Break
- **10:00** PPCP/EDC Occurrence in Arizona Waters
- **10:15** DBP Exposure
- **10:25** DBP Control Strategies: Potential I-DBP formation if utilities switch to chloramines
- **10:45** Future directions & discussion

Overview of T&O issues for 2009

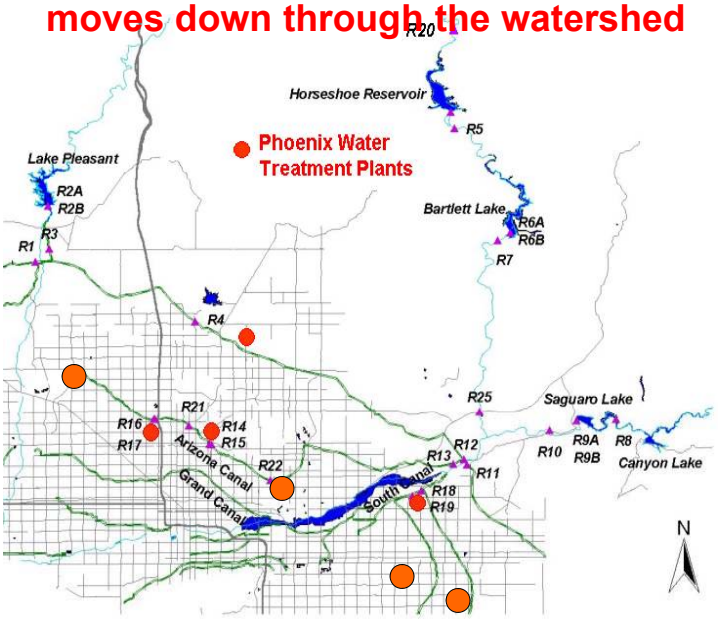
Prof. Westerhoff

What is unique about 2009?

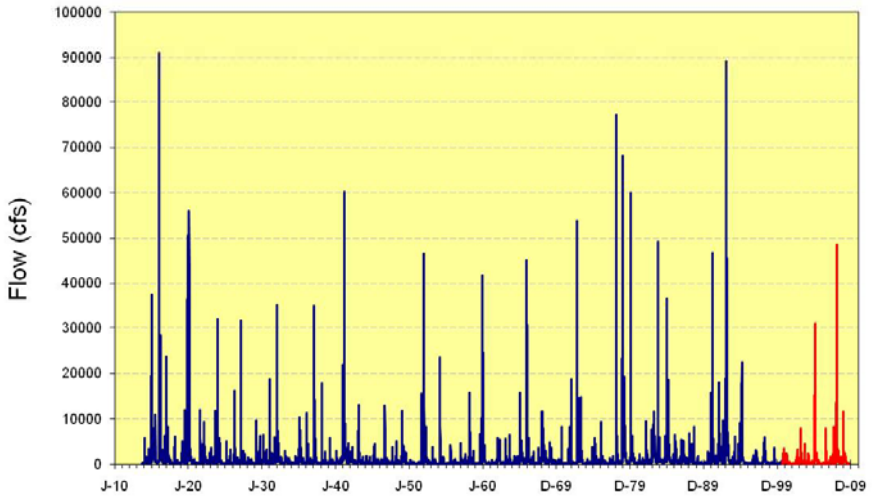
No CAP & very little Groundwater in SRP Canals

Fewer "high-intensity" rainfall events

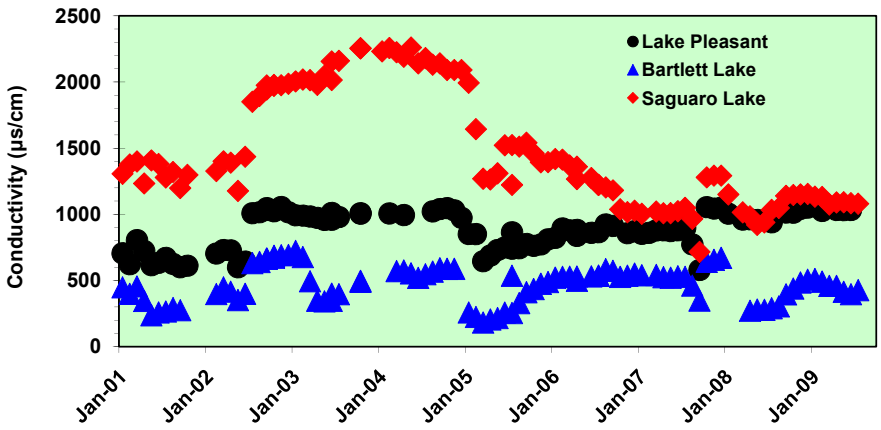
Workshop will present results as water moves down through the watershed



Project is spanning dry-wet years
Salt River Above Roosevelt

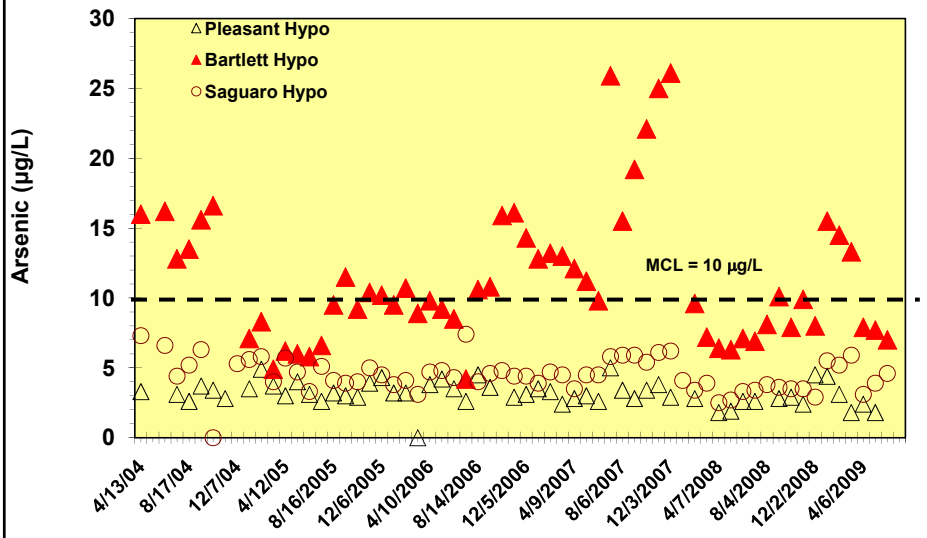


Hydrology Affects Water Quality
(conductance can affect algal dominance)

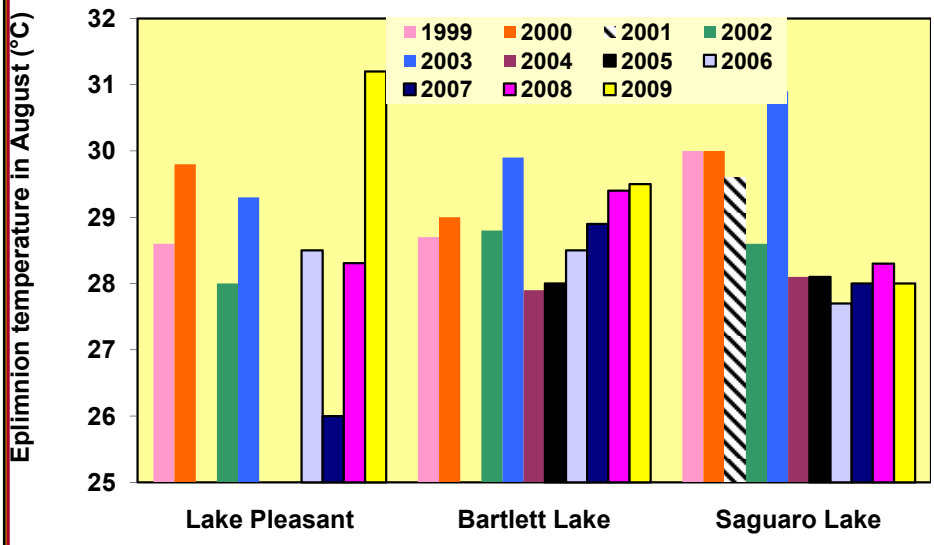


Arsenic

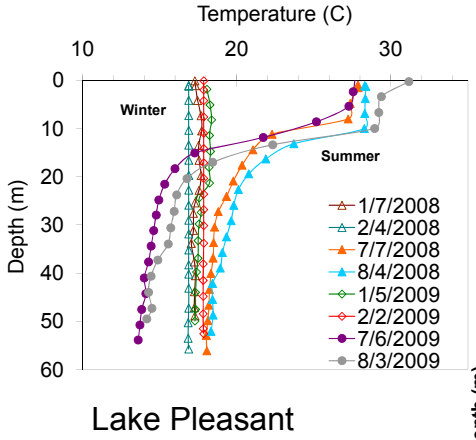
Higher levels in Verde River usually during Winter



Summary of Annual August Temperatures

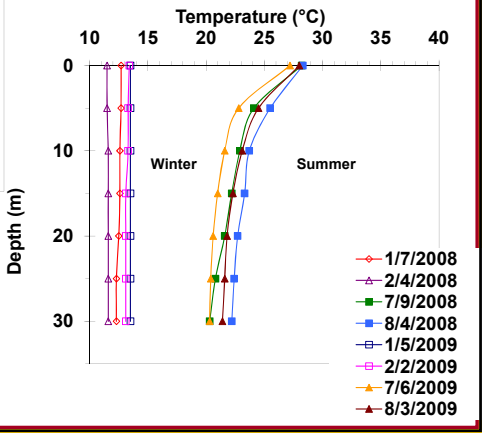


Thermal Stratification of Reservoirs

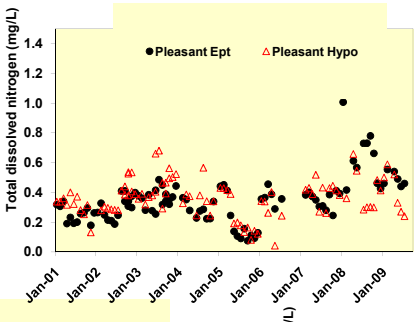


Lake Pleasant

Saguaro Lake

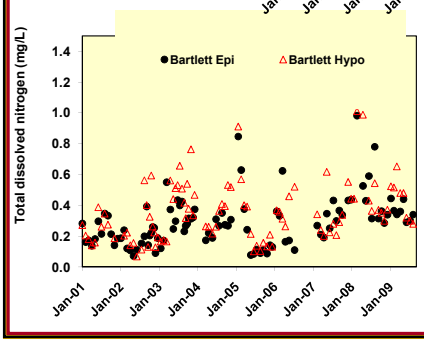


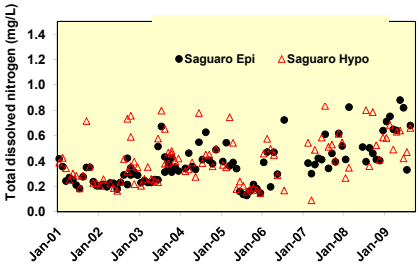
Dissolved Nitrogen Trends in Reservoirs



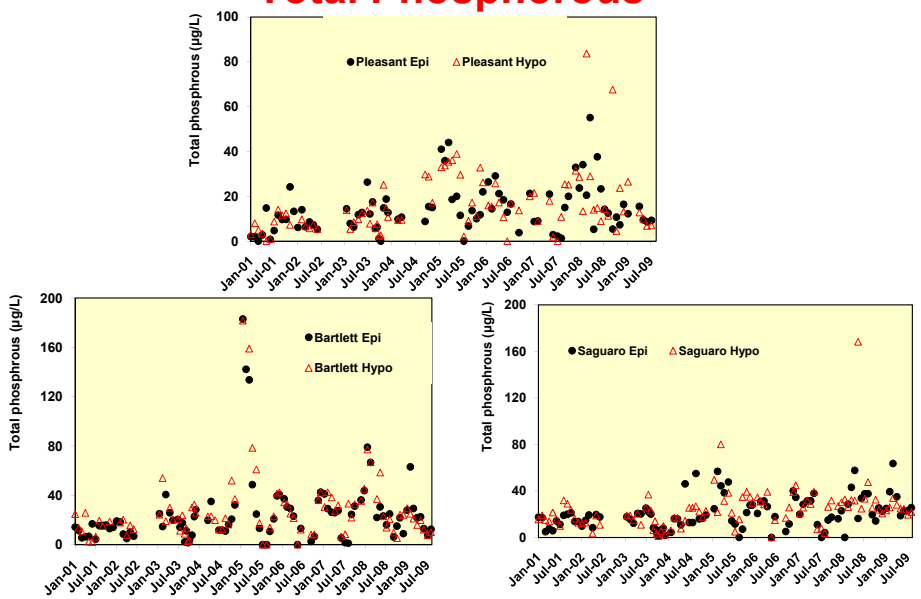
Lowest in Lake Pleasant

Less variable in Saguaro Lake



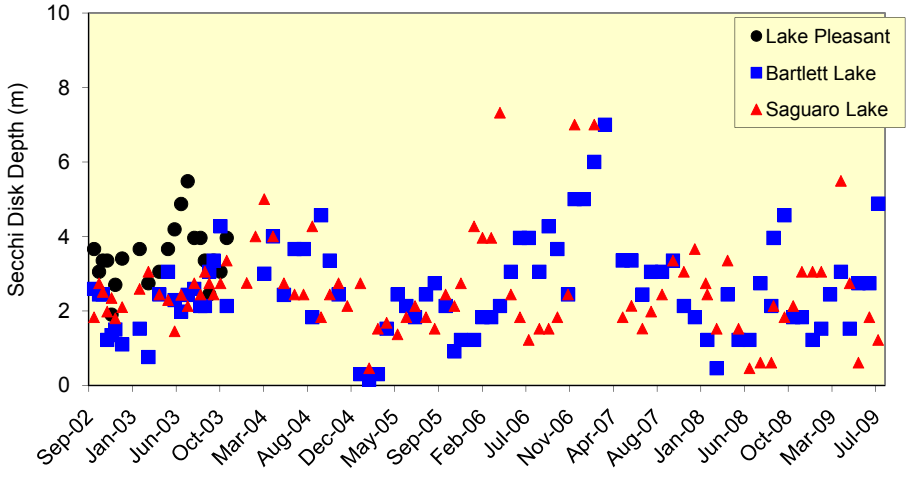


Total Phosphorous

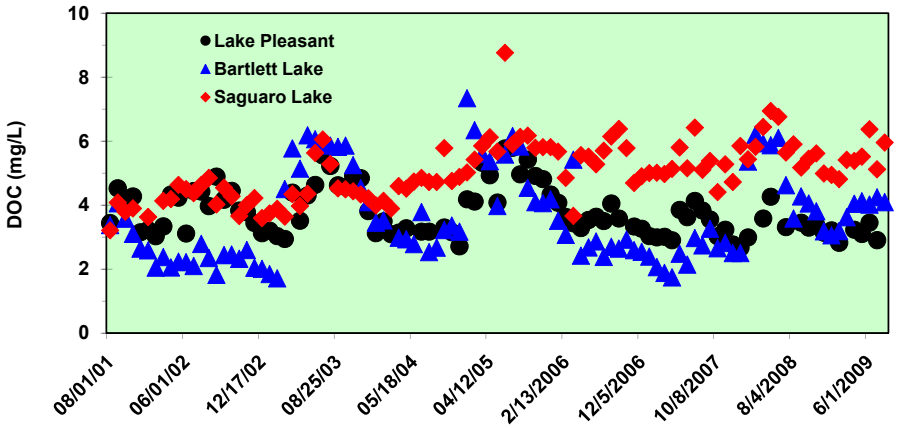


Secchi Disk Depth Influenced by Inorganic Suspended Sediment and/or Organic Biomass

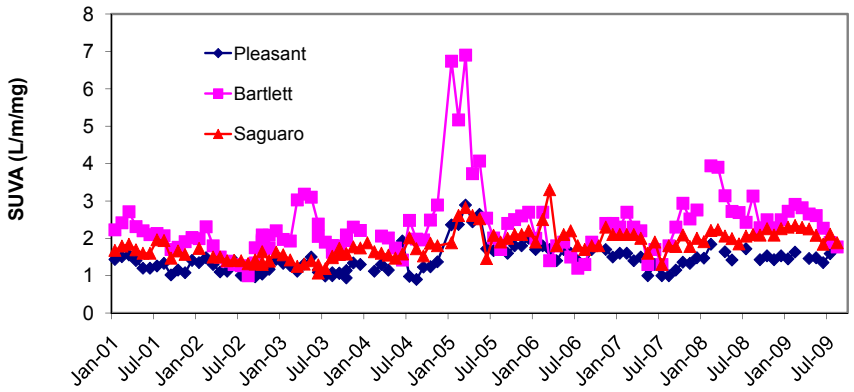
(lowest values in summer for Saguaro Lake)



Up-stream reservoirs attenuate DOC



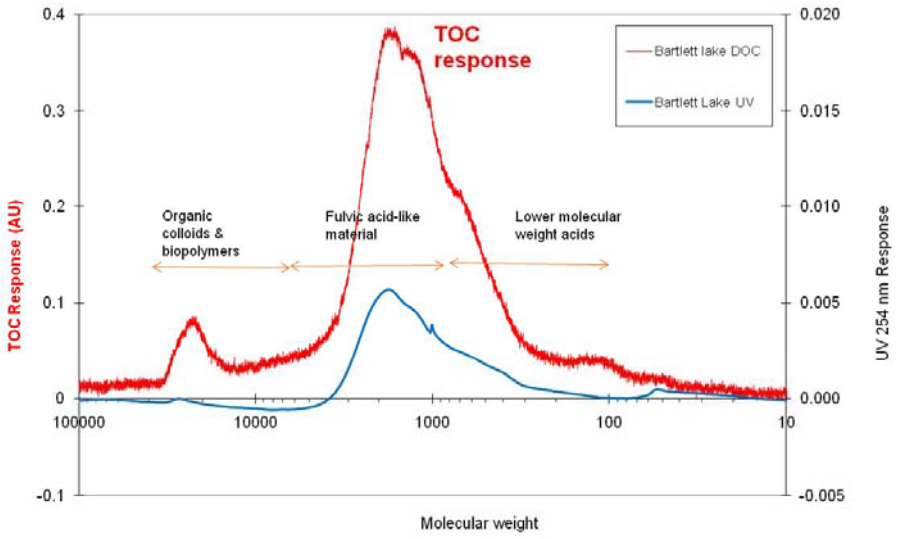
Specific UV Absorbance at 254 nm



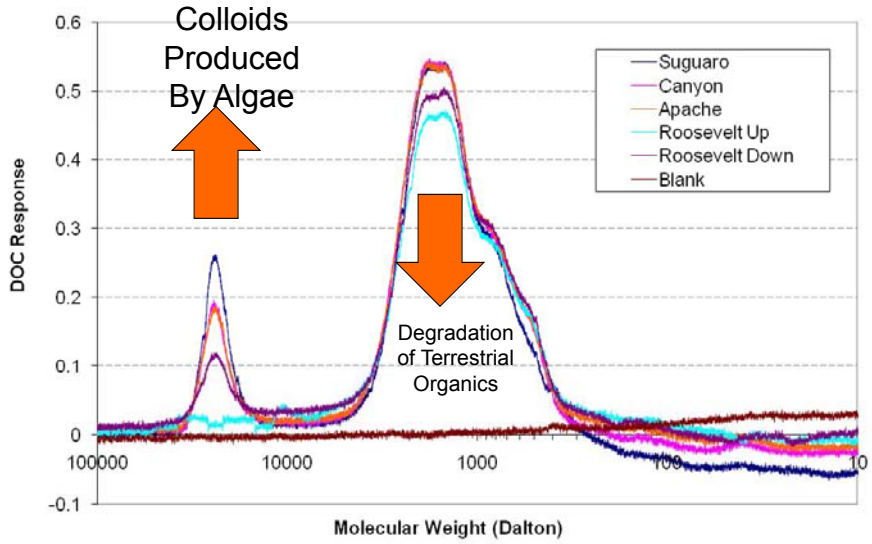
Other Organic Matter Characterization

- **Size Exclusion Chromatography**
  - **Separates organic matter based upon size**
  - **Using a HPLC instrument**
- **Detection**
  - **Total organic carbon**
  - **UV Absorbance**
- **Fingerprints what "size" and "type" of organic carbon is present in reservoirs and removed by different treatment processes**
- *Why Organic matter? Oxidation of TOC forms disinfection by-products*

SEC-TOC (Bartlett Lake)

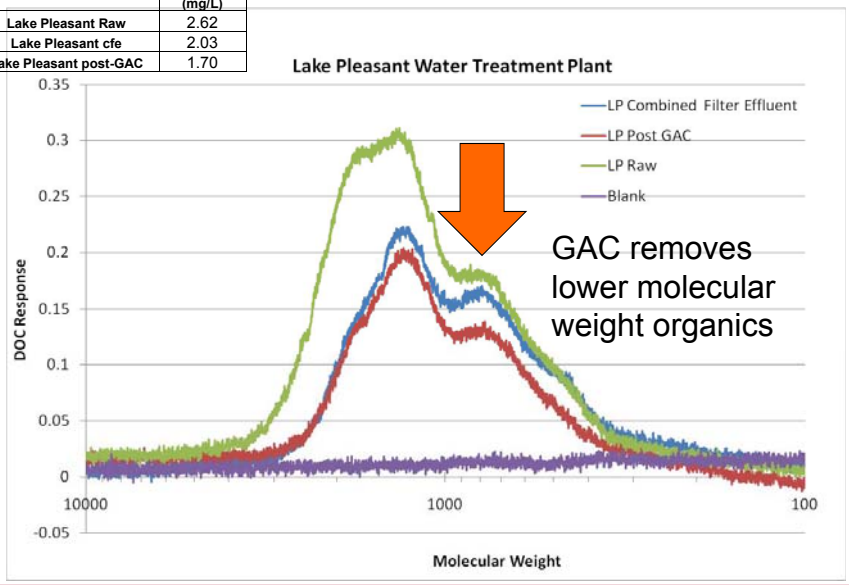


SEC-TOC of Lakes (May 2009)

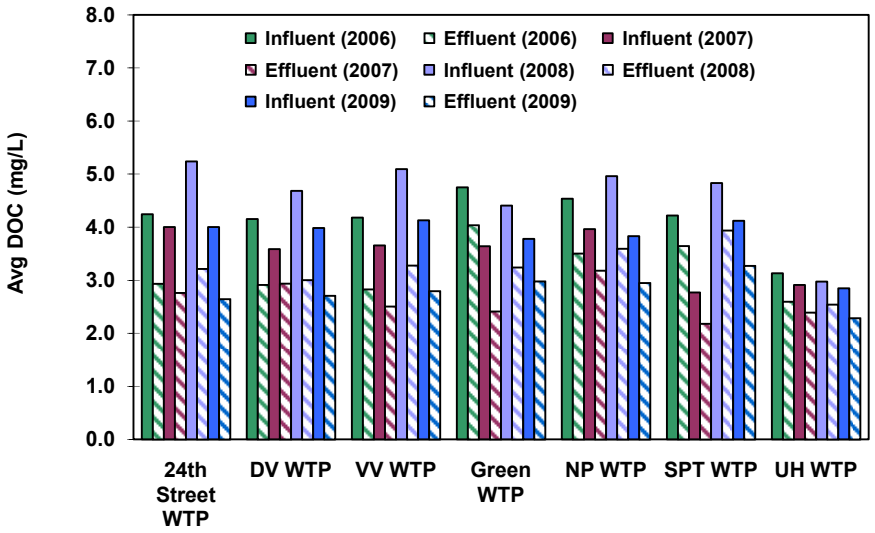


Removal of Different Molecular Weight Organics at LP WTP

	DOC (mg/L)
Lake Pleasant Raw	2.62
Lake Pleasant cfe	2.03
Lake Pleasant post-GAC	1.70



DOC Removal by WTP

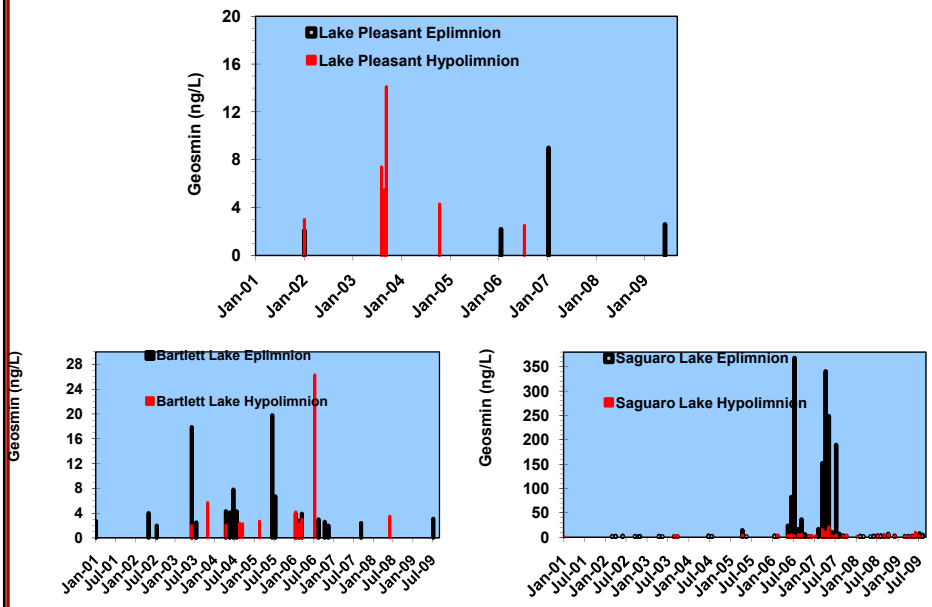


MIB & Geosmin NOW

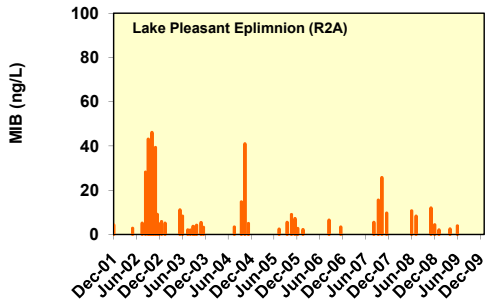
Table 3 - Canal Sampling – Aug 31, 2009

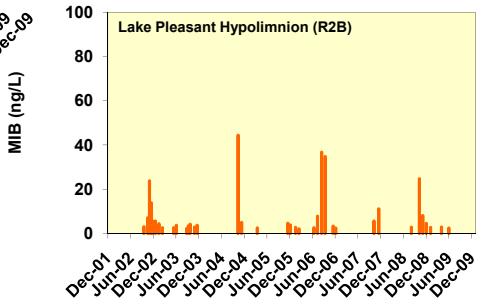
System	Sample Description	MIB (ng/L)	Geosmin (ng/L)	Cyclocitral (ng/L)
CAP	Waddell Canal	<2.0	<2.0	<2.0
	Union Hills Inlet	4.0	<2.0	<2.0
	CAP Canal at Cross-connect			
AZ Canal	Salt River @ Blue Pt Bridge	7.9	2.7	<2.0
	Verde River @ Beeline	6.7	3.7	<2.0
	AZ Canal above CAP Cross-connect	8.7	3.9	<2.0
	AZ Canal below CAP Cross-connect	8.7	3.9	<2.0
	AZ Canal at Highway 87	8.6	5.5	<2.0
	AZ Canal at Pima Rd.	8.5	9.5	<2.0
	AZ Canal at 56th St.	8.0	10.2	<2.0
	AZ Canal - Inlet to 24th Street WTP	7.1	9.7	<2.0
	AZ Canal - Central Avenue	6.9	10.2	<2.0
	AZ Canal - Inlet to Deer Valley WTP	6.9	9.5	<2.0
	AZ Canal - Inlet to Glendale WTP	7.5	12.7	<2.0
South and Tempe Canals	South Canal below CAP Cross-connect	8.7	3.4	<2.0
	South Canal at Val Vista WTP	8.1	3.7	<2.0
	Head of the Tempe Canal	6.8	4.0	<2.0
	Tempe Canal - Inlet to Tempe's South Plant	5.6	2.3	<2.0

Geosmin Data

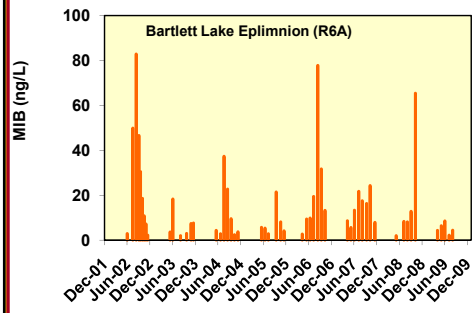


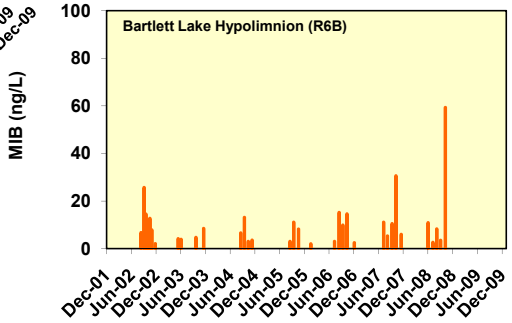
MIB Data – Lake Pleasant



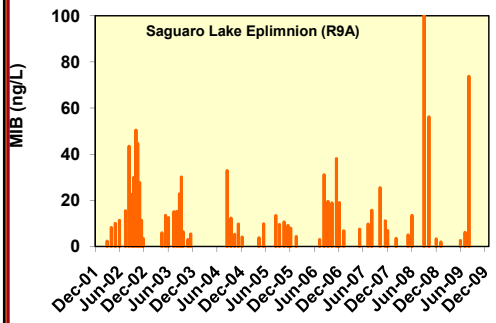


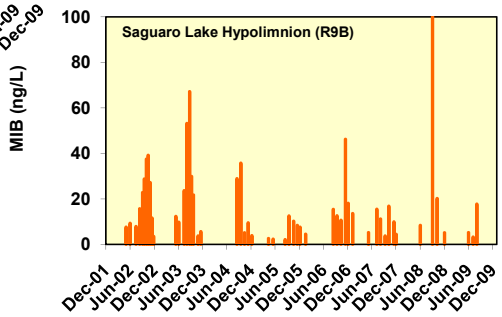
MIB Data – Bartlett Lake



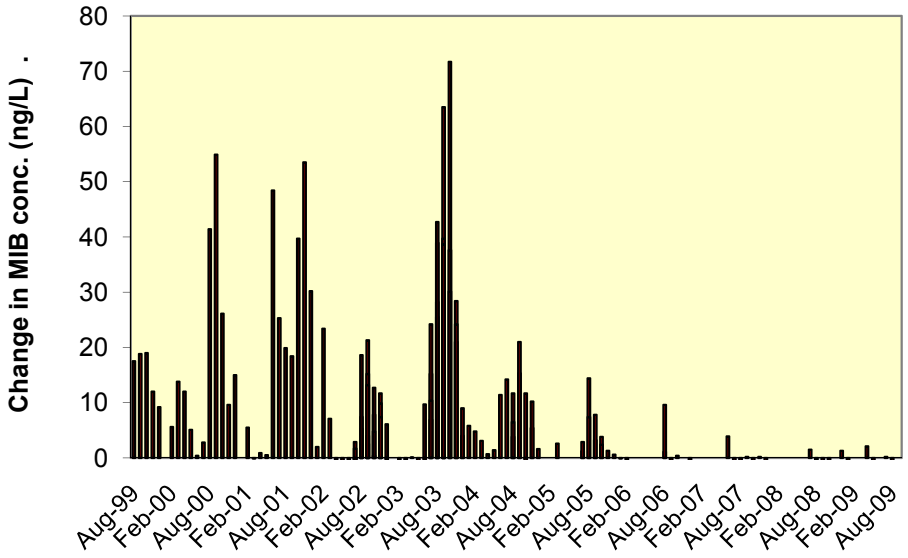


MIB Data – Saguaro Lake

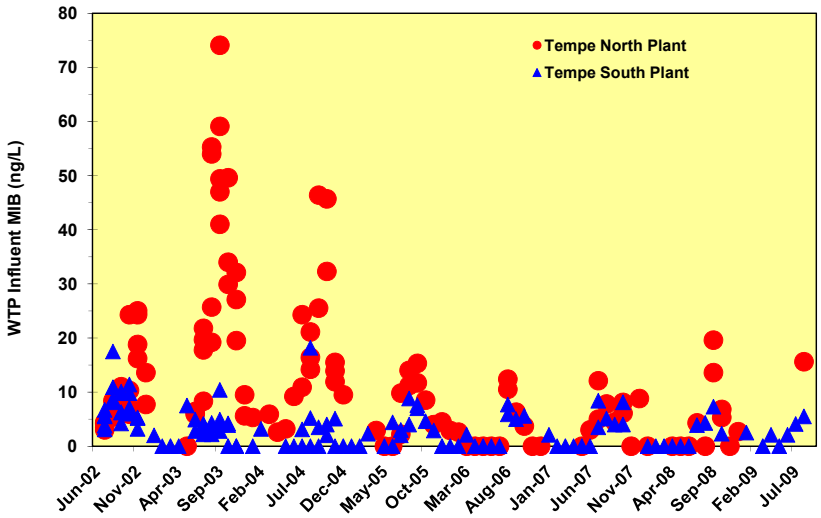




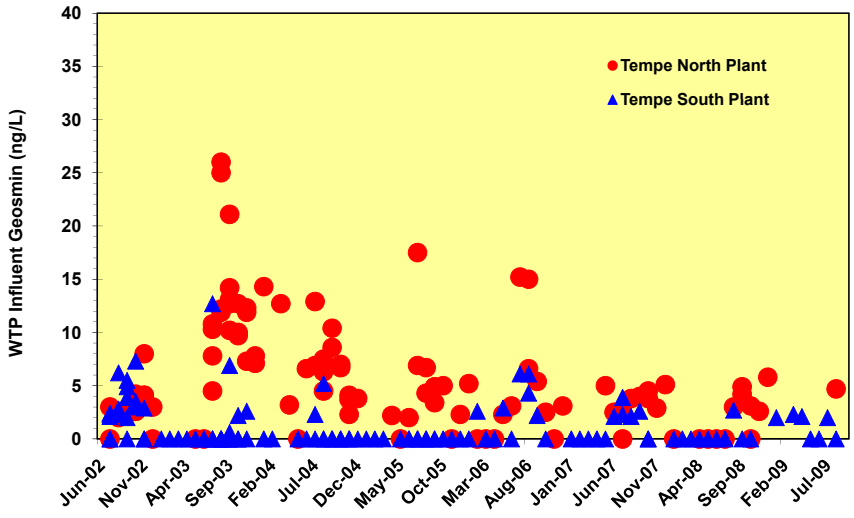
MIB Growth in AZ canal from below X-Con to DV Inlet



MIB levels higher in AZ Canal system compared against South Canal system



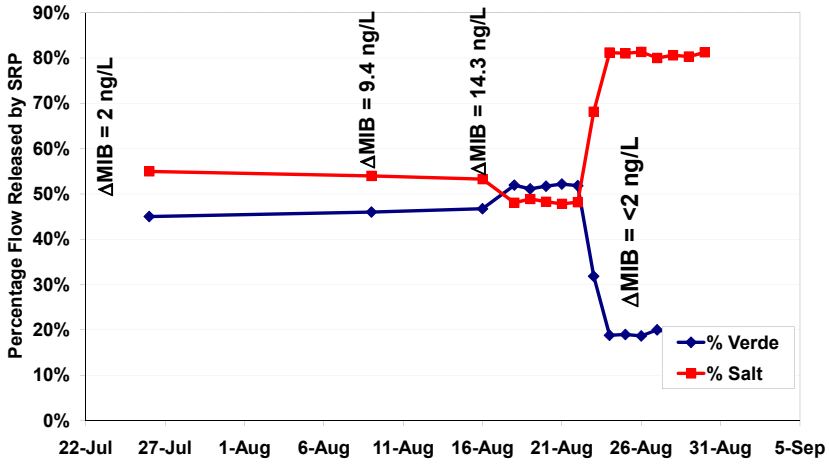
Geosmin is lower in Recent Years



Why does MIB and Geosmin levels differ so much year to year?

- In reservoirs:
  - Function of temperature & nutrients
  - Function of reservoir operations
- In Canals:
  - We hypothesize it is a function of changing water quality that "stresses" algae attached to canal walls
  - We hope to support this hypothesis this fall as SRP changes over from Salt River to Verde River water

SRP Change in River Release affected MIB Production in the canals – suggests conductance effect (2005)



MIB & Geosmin Removal in WTPs

Table 2 - Water Treatment Plants – Aug 31, 2009

Sample Description	MIB (ng/L)	Geosmin (ng/L)	Cyclocitral (ng/L)
24th Street WTP Inlet	7.1	9.7	<2.0
24th Street WTP Treated	*4.1*	*2.7*	*<2.0*
Deer Valley Inlet	6.9	9.5	<2.0
Deer Valley WTP Treated	*7.6*	*9.9*	*<2.0*
Val Vista Inlet	8.1	3.7	<2.0
Val Vista WTP Treated –East	*5.0*	*<2.0*	*<2.0*
Val Vista WTP Treated -West	*6.0*	*<2.0*	*<2.0*
Union Hills Inlet	4.0	<2.0	<2.0
Union Hills Treated	*4.0*	*<2.0*	*<2.0*
Tempe North Inlet	8.2	10.9	<2.0
Tempe North Plant Treated	*5.4*	*4.3*	*<2.0*
Tempe South WTP	5.6	2.3	<2.0
Tempe South Plant Treated	*3.0*	*<2.0*	*<2.0*
Greenway WTP Inlet	<2.0	<2.0	<2.0
Greenway WTP Treated	*<2.0*	*<2.0*	*<2.0*
Glendale WTP Inlet	7.5	12.7	<2.0
Glendale WTP Treated	*<2.0*	*<2.0*	*<2.0*
Glendale WTP Treated (Lab)			

Summary

- Organic matter is transformed in the reservoirs by algal processes
- Algae release colloidal organic matter & earthy-musty T&O compounds
- Bacteria, photolysis, and sorption remove terrestrial organic matter in the reservoirs
- MIB and geosmin levels in canals this & last week have a sum near 10 ng/L (threshold)

Real-Time Water Quality Stations

Maureen Hymel/City of Phoenix
Gregg Elliott/SRP

YSI sonde in SRP canals

- Temperature
- pH
- Conductivity
- Turbidity
- Dissolved O2
- Blue-green algae
- Chlorophyll

WTPs upstream source water YSI sensor

Val Vista WTP Intake

WTPs: HACH probes installed at raw water intake

- pH, temperature, conductivity, nitrate, turbidity, UV 254

Early Warning of Algae Induced Taste and Odor

Susanne Neuer
School of Life Sciences
Arizona State University

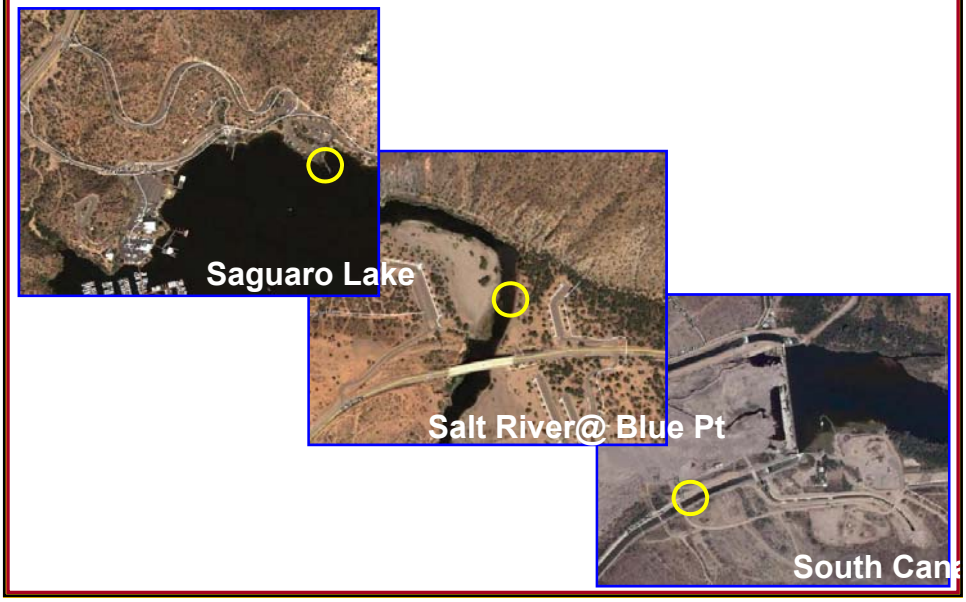
Technology Investigation

- AWWA (Water Research Foundation) sponsored project.
- Intended to test the potential of new technology to identify the presence of taste and odor causing organisms and provide early warning.
- Runs from July 2009 until December 2009.
- Neuer Lab sampling and analyzing Salt River water with additional sample input and assistance from the Westerhoff Lab

Digital Analysis

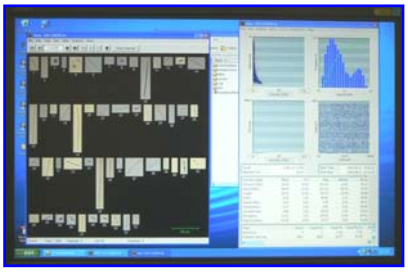
- Flow cytometry combined with digital imaging and software parameter analysis.
- New methodology being compared with existing microscopy methods.

Sampling Sites



FlowCAM® System

- Fluid Imaging Technologies Inc.
- Processes samples by drawing water through a laser monitored flow chamber.
- Auto-imaging of cells as they pass through flow cell with a digital camera
- Visualspreadsheet™ software processes and categorizes using filters and libraries (based on multiple parameters, custom-build)



FlowCAM® System

FlowCAM Unit

Particle images

Peristaltic pump

Imaging chamber

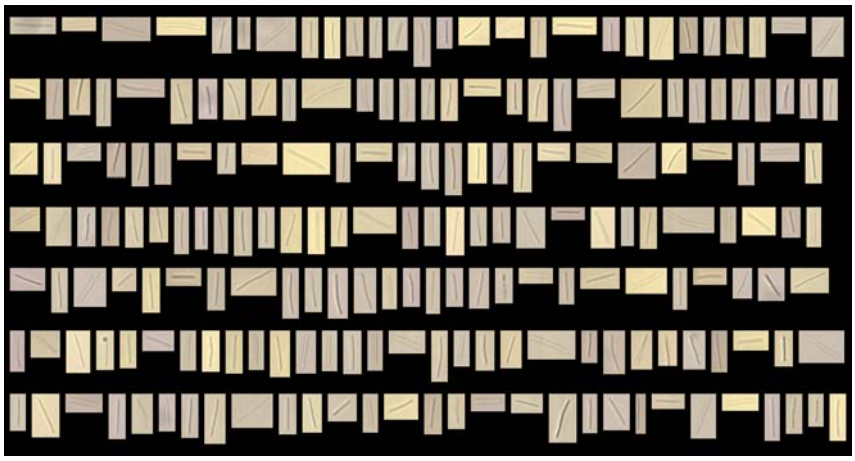
Local MIB/Geosmin and T&O causing algae

Table 2.8. Known taste and odor causing organisms observed in phytoplankton.

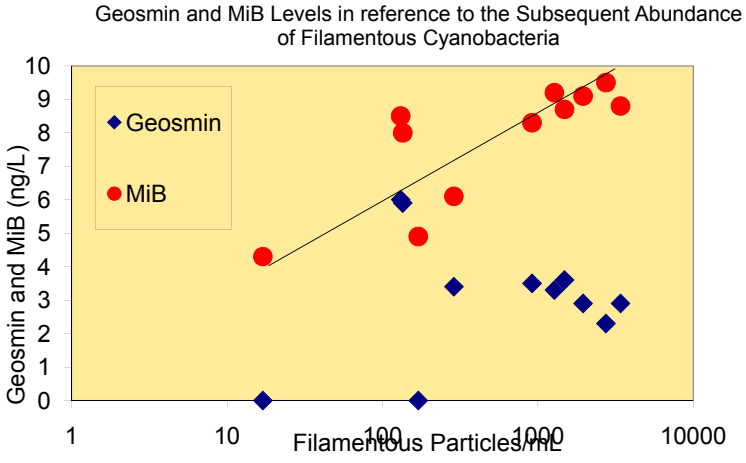
MIB Producers	Associated with Other Tastes & Odors	
Anabaena	*Anabaena*	*Mallomonas*
Oscillatoria	*Asterionella*	*Pandorina*
Phormidium	*Ceratium*	*Peridinium*
Pseudanabaena	*Chara*	*Staurastrum*
	Chlamydomonas	*Synedra*
Geosmin Producers	*Diatoma*	*Synura*
Anabaena	*Dinobryon*	*Tabellaria*
Oscillatoria	*Gomphosphaeria*	

Sommerfeld, Westerhoff, Baker 2002

Flow Cam Panel of cells under "Filamentous cyanobacteria" (Filter)



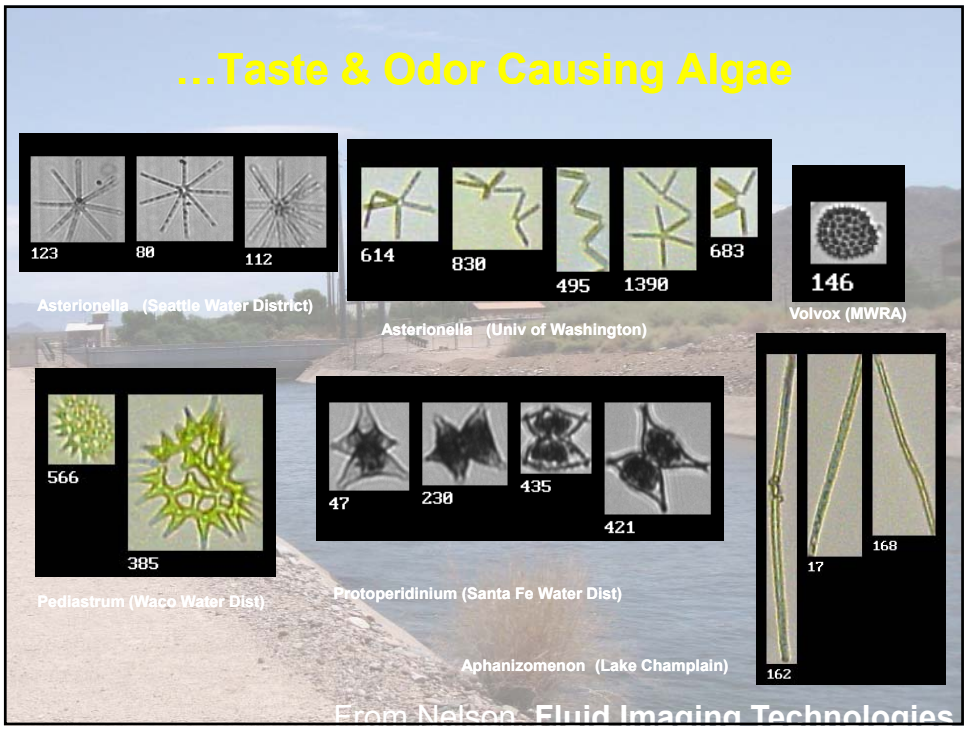
Early results: Correlation of filamentous particles with MIB and Geosmin levels



MIB/Geosmin data courtesy of Westerhoff's lab

Acknowledgements

- Funding: Water Research Foundation (www.waterresearchfoundation.org).
- Equipment: Fluid Imaging Technologies Inc (www.fluidimaging.com).
- Tyler Sawyer, Becky Mestek: Running of samples on FlowCam
- Paul Westerhoff's group for data on Geosmin and MIB concentrations



SHORT BREAK

PPCP/EDC Occurrence in Arizona Waters

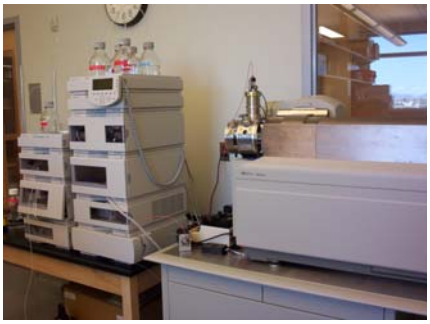
Chao-An Chiu

Target compounds

Compounds name	Function	Ionization mode	Compounds name	Function	Ionization mode
Acetaminophen	NSAID	ESI +	Naproxen	NSAID	ESI -
Caffeine	stimulant	ESI +	Oxybenzone	Sunscreens	ESI +
Carbamazepine	anticonvulsant	ESI +	Pentoxifylline	antiplatelet drug	ESI +
Cotinine	metabolite of nicotine	ESI +	Primidone	Anticonvulsant	ESI +
DEET	insect repellent	ESI +	Sucralose	artificial sweetener	ESI -
Diazepam	anxiolytic	ESI +	Sulfamethoxazole	antibiotic	ESI +
Diclofenac	NSAID	ESI -	TBBA	flame retardant	ESI -
Dilantin	antiepileptic	ESI -	Triclosan	antibiotic	ESI -
Erythromycin	antibiotic	ESI +	Trimethoprim	antibiotic	ESI +
Fluoxetine	antidepressant	ESI +	Estradiol	sex hormone	APCI
Hydrocodone	narcotic analgesic	ESI +	Ethinyl Estradiol	estrogen	APCI
Ibuprofen	NSAID	ESI -	Progesterone	steroid hormone	APCI
Meprobamate	anxiolytic	ESI +	Testosterone	steroid hormone	APCI

Analytical Scheme

- Filtration using 0.75µm (GF/F) filter paper.
- Solid Phase extraction (Oasis HLB) @ ASU
- Analysis at ADHS (LC/MS/MS)
- Isotope spiking for recovery correction
- Quality control – Lab blank, field blank and duplication.



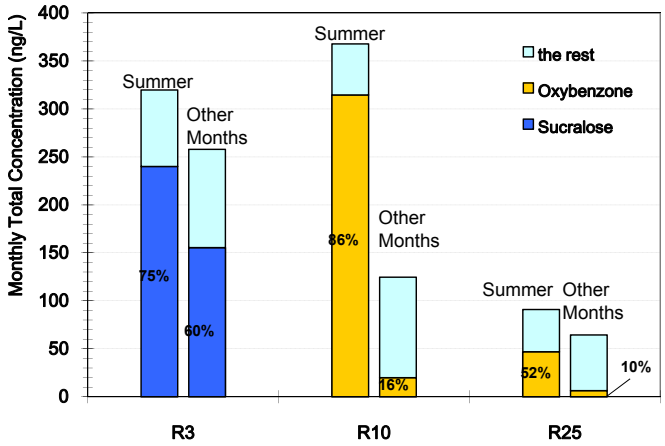
Arizona Potential EDC/PPCP Sources

- Colorado River
- Wastewater discharges into rivers and groundwater
- Houseboats & direct contact (recreation)

Surface Waters

- CAP Canal, Salt River, and Verde River
  - > 90% samples were measured with PPCP/EDC presented.
  - Progesterone was not detected in any of them.
  - Concentrations were low (less than 50 ng/L).
  - Oxybenzone and sucralose exceeded 300 ng/L during this investigation.
  - 15/26 compounds were prevalent (>50% occurrences).
  - Caffeine, DEET, Sucralose and oxybenzone were detected in most compounds (>90% occurrences)

Seasonal effect on PPCP in surface waters



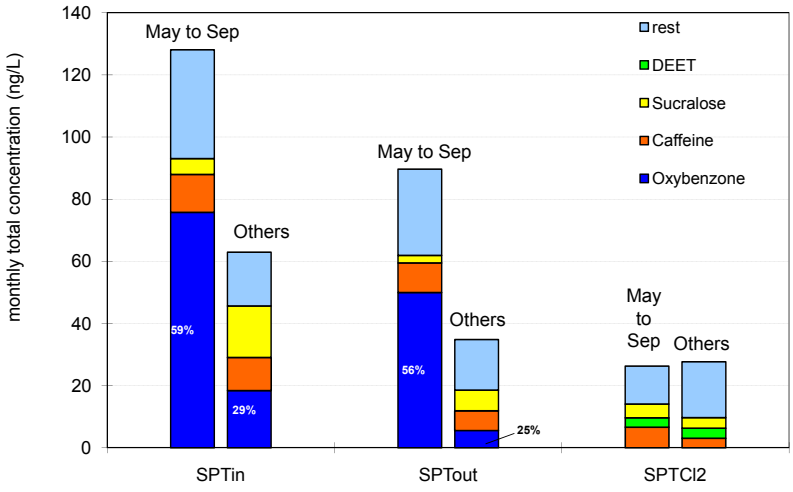
Water Treatment Plant

- **Local WTP**
  - **Only Caffeine, DEET, Sucralose and oxybenzone were detected >10 ng/L in some WTP influent samples.**
  - **11/26 compounds remained in finished water (1~5 ng/L)**
  - **Chlorination shows further oxidation on some compounds, especially oxybenzone.**

Removal efficiency in WTP

(Uint: ng/L)	Raw Water	Sedimentation	Disinfection	% Removal
Acetaminophen	2	2	2	<1%
Caffeine	10	7	5	52%
Cotinine	1	1	1	<1%
DEET	6	3	3	46%
Oxybenzone	43	25	0	100%
Sucralose	10	4	4	61%
Sulfamethoxazole	1	1	0	79%
TBBA	1	1	0	17%
Trimethoprim	1	0	0	27%

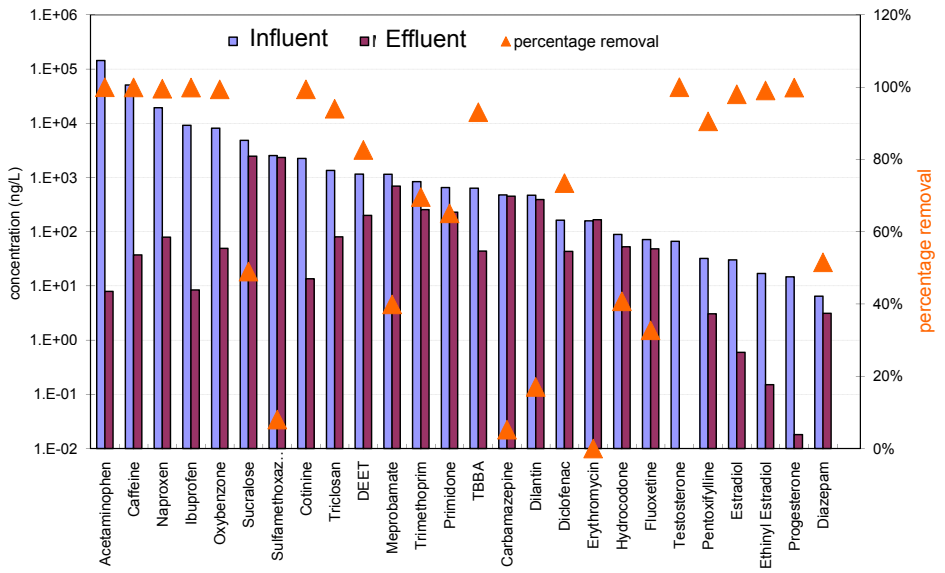
Seasonal effect on PPCP/EDC in drinking water



Wastewater Treatment Plant

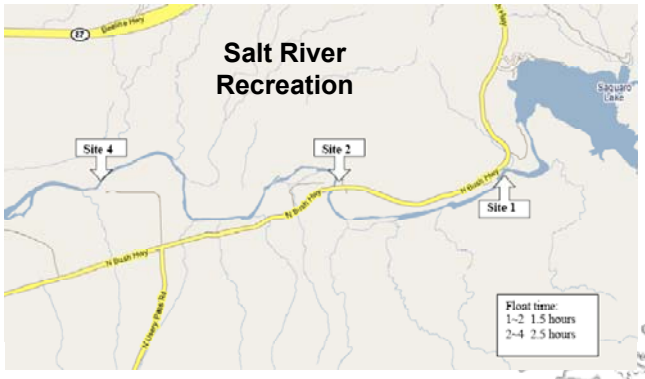
- 12 out of 26 compounds were detected >1 µg/L; acetaminophen, caffeine, ibuprofen, and naproxen were >10 µg/L.
- caffeine, DEET, oxybenzone, ibuprofen, meprobamate, and triclosan show increasing trend in raw wastewater during summer.
- Removal efficiency of PPCP/EDC is not necessarily K_{ow} correlated in Mesa WWTP.

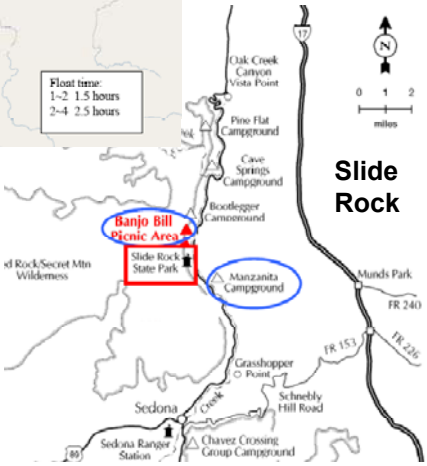
WWTP removal efficiency of PPCP/EDC

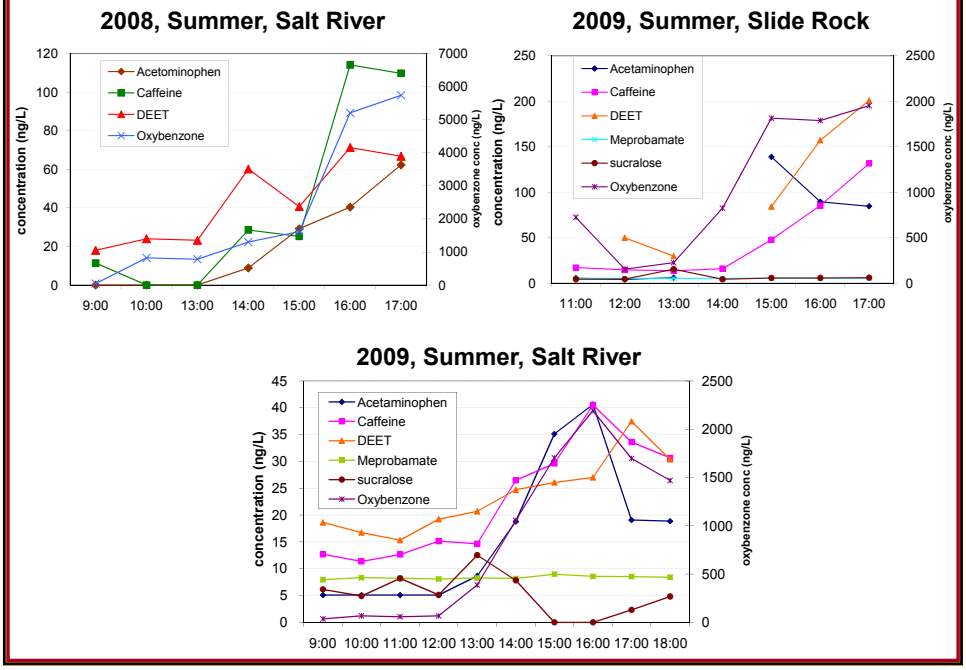


Water Recreation Area

- **Salt River and Slide Rock recreation area**
  - **Samples were collected hourly in one day during summer**
  - **Caffeine, DEET, and acetaminophen increased along time (up to 120 ng/L)**
  - **Oxybenzone was detected >1 µg/L**
  - **Most of the sources for these detected PPCPs are from skin-applied products (sunscreen, insect repellent) rather than oral-applied drugs.**

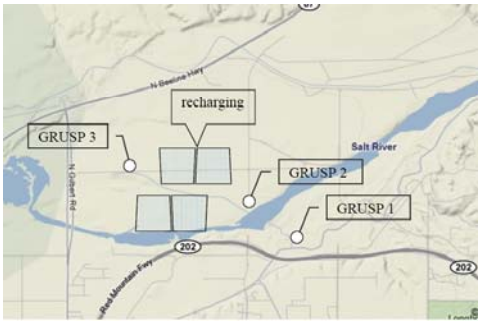






GRUSP Measuring Wells

- 13 out of 26 compounds were detected in three measuring wells.
- Most of the detected concentrations are low (< 5 ng/L)
- Acetaminophen, caffeine, DEET, Sulfamethoxazole, Sucralose, and Erythromycin were constantly present in ground water system.
- Sulfamethoxazole was detected up to 200 ng/L in MW#3.



PPCP/EDC occurrence in Phoenix water supply area

- PPCP/EDC existing in surface water system might increase health risk for drinking water management.
- Water recreation and lakes from upstream could be important sources of these PPCP/EDC present in canal system of Phoenix area.
- Seasonal effect on different surface waters might influence raw water quality of WTP during source water switch by SRP.
- Tracking the occurrences and fate of these PPCP/EDC in drinking water system is important for water management of metropolitan Phoenix.

Disinfection By-Products

Summary of Gordon Conference on DBP Formation & Exposure

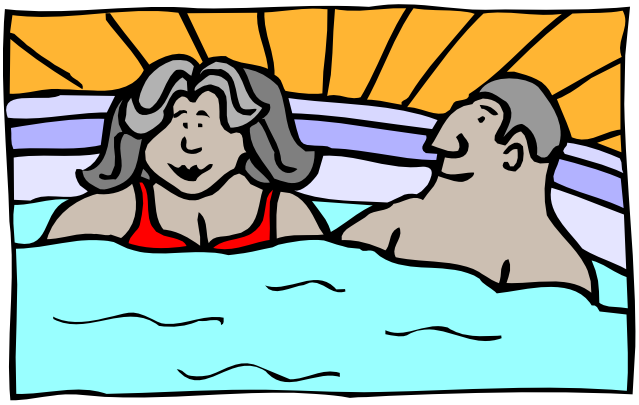
Emerging DBPs

- N-DBPs and I-DBPs are more genotoxic and cytotoxic than most C-DBPs
- EPA 4-Lab study
  - Huge investment to study mixtures of DBPs
  - DBP concentrations were ~ 100x typical drinking water studies
  - Rat studies showed some reproductive effects and effects on dental malclusions (power of study was limited)
  - Provides framework for future exposure studies
  - EPA researcher convinced DBPs cause cancer
- Strong need exists for better epidemiological studies

Major Focus on *EXPOSURE*

- Where do we become exposed to DBPs?
- THMs:
  - Dermal exposure – bathing, swimming
  - Inhalation – bathing, swimming, dish washing
  - Ingestion – drinking water
- Dermal exposure and inhalation are connected with volatility of DBPs
- Ingestion – DBPs go through kidney
- Dermal and inhalation – DBPs go directly into blood stream

Challenge for EPA:
How to study dermal DBP exposure?
Put a rat in a hot-tub?



Swimming Pools were major DBP Exposure points

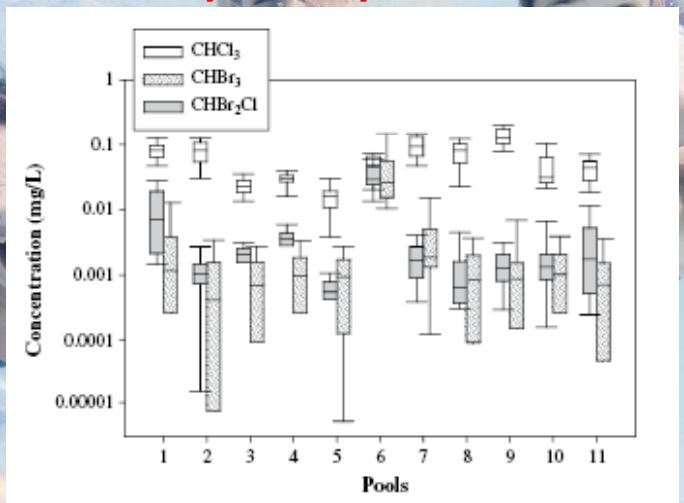


Fig. 4 – Chloroform, bromoform, and dibromochloro-methane concentration ranges (log scale).

Pools Contain Free Chlorine

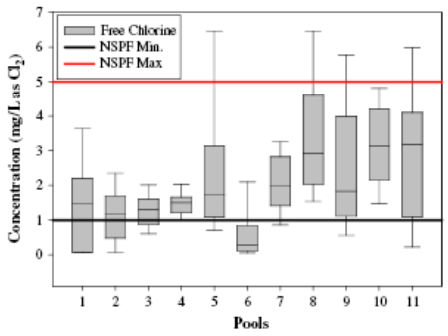


Fig. 1 – Free available chlorine (FAC) concentration ranges as measured by DPD (linear scale). The recommended FAC range for swimming pools, as defined by the National Swimming Pool Foundation (NSPF), are included for reference.

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Chloramines Form as Chlorine Reacts with …

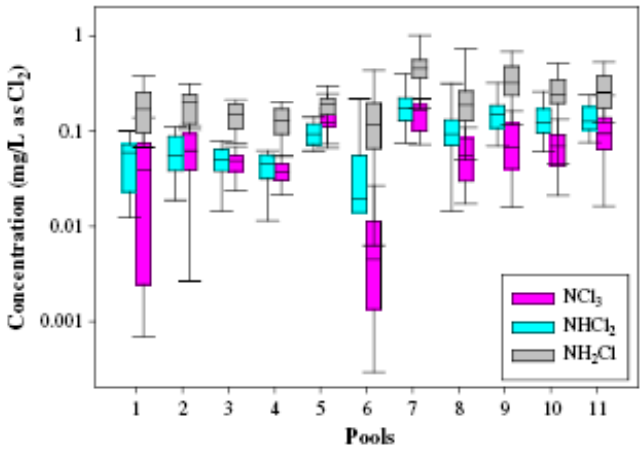

Fig. 2 – Mono- (NH_2Cl), di- ($NHCl_2$), and trichloramine (NCl_3) concentration ranges as measured by MIMS (log scale).

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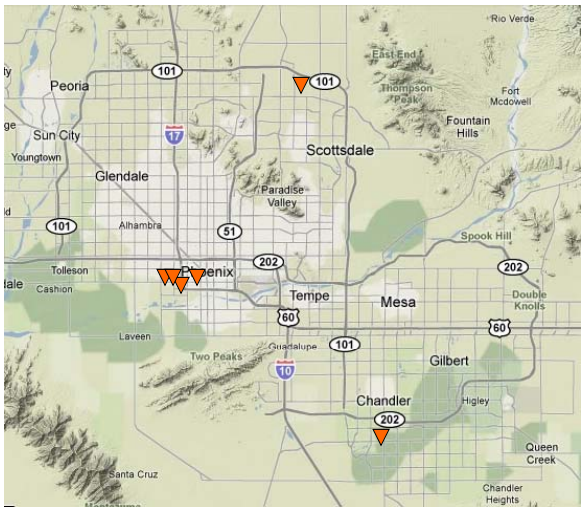
Arizona Pool Samples

- Most work done with indoor pools
- We samples outdoor pools in Arizona



THM in swimming pool & Tap water

Sample name	Time	Concentration (ug/L) $CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	Total THM
Jacelyn Pool	**9:00pm**	**41**	**0.0**	**0.0**	**0.0**	**41**
Jacelyn Pool Duplicate		40	0.0	0.0	0.0	40
PKW Pool	**7:30am**	**69**	**0.0**	**0.0**	**0.0**	**69**
PKW Pool Duplicate		63	0.0	0.0	0.0	64
PKW Pool + 50ppb spk		132	40.6	51.0	40.3	264
Darryl Pool	**8:30am**	**214**	**2.4**	**0.0**	**0.0**	**217**
ASU Pool	**10:00am**	**24**	**5.1**	**0.0**	**0.0**	**30**
ASU Pool Duplicate		22	4.9	0.0	0.0	27
ASU Pool + 50ppb spk		113	49.5	58.1	44.8	266
CC Pool	**9:00am**	**57**	**0.0**	**0.0**	**0.0**	**57**
MM Pool	**6:30am**	**157**	**0.0**	**0.0**	**0.0**	**158**
Jun Pool	**8:30am**	**70**	**0.0**	**0.0**	**0.0**	**70**
PKW Tap	**7:30am**	**66**	**23.0**	**22.4**	**2.8**	**115**
MM Tap	**6:30am**	**10**	**6.7**	**22.2**	**28.6**	**68**
ASU Lab Tap	**10:00am**	**78**	**26.8**	**19.6**	**0.7**	**125**
50ppb QC		**91**	**43.9**	**61.4**	**49.8**	**246**

TTHM MCL in drinking water = 80 µg/L, USEPA

DBP Control Strategies: Potential I-DBP Problems if Utilities Switch to Chloramination Practices

Darryl B. Jones and Tanju Karanfil

Water Research Foundation
Project #4063

Disinfection By-products

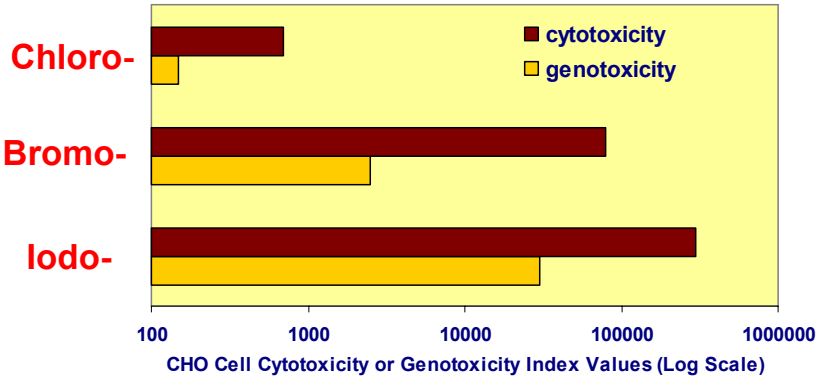
- **Disinfection by-products (DBPs) are formed from reactions of oxidants with natural organic matter.**
- **The majority of DBPs are halogenated organics.**

(chlorine) **Bromide** **Iodide**

Oxidants + NOM → DBPs

Hua and Reckhow (2007)

Halogenated DBP Toxicity

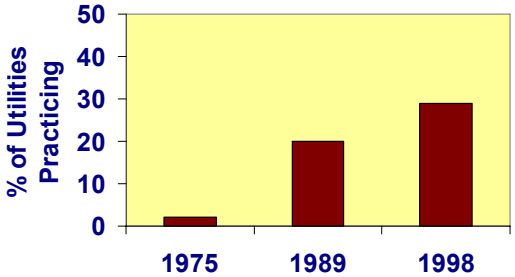


(Adapted from Plewa et al. 2008)

Why Switch to Chloramines?

- More stable disinfectant residual in distribution systems
- Much lower formation of THMs and HAAs

DBPs	MCLs
THMs	80 µg/L
HAAs	60 µg/L
Bromate	10 µg/L
Chlorite	1.0 mg/L



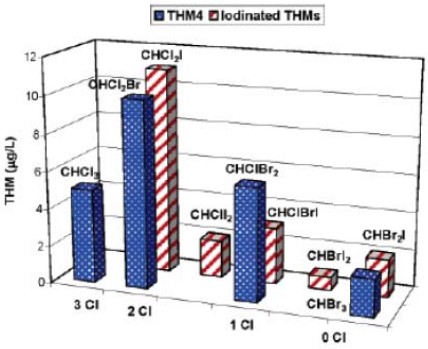
(adapted from McGuire 2006)

Iodo-Trihalomethanes

- According to a nationwide occurrence study, plants that added chlorine and ammonia simultaneously to form monochloramine formed the most I-THMs.
- I-THMs were 81% of THMs (by mass) at one plant.

THMs (4)

$CHCl_3$
$CHCl_2Br$
$CHClBr_2$
$CHBr_3$



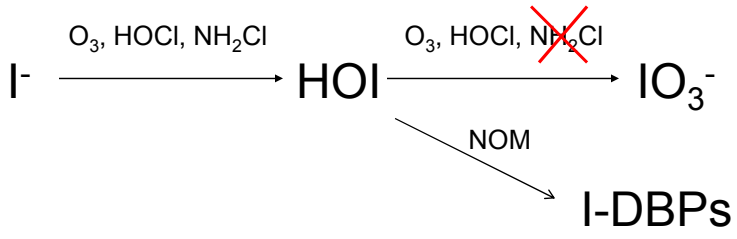
I-THMs (6)

$CHCl_2I$
$CHClI_2$
$CHBrClI$
$CHBr_2I$
$CHBrI_2$
CHI_3

Krasner et al. 2006

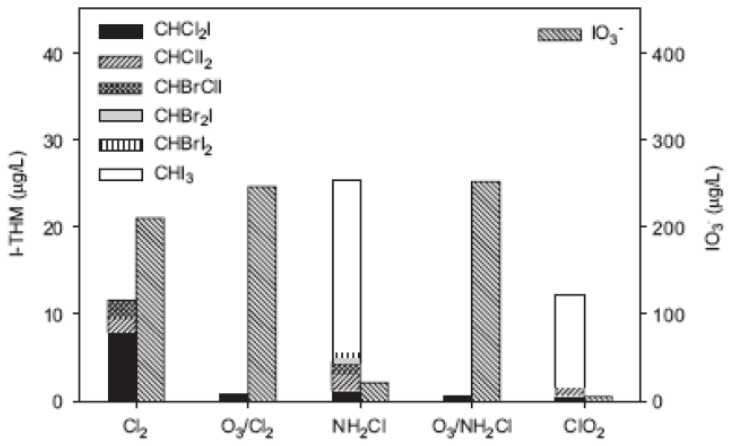
The Stability of HOI

- NH_2Cl cannot further oxidize HOI to IO_3^-.
- Ozone (O_3) and chlorine (Cl_2) oxidize HOI to IO_3^-.



Bichsel and Von Gunten (1999)

I-THM Formation from Oxidation



Hua and Reckhow (2007)

Br^-: 95 µg/L, I^-: 200 µg/L

Water Research Foundation Project #4063

- **Examine I-THM formation from preformed monochloramine and prechlorination followed by ammonia addition (chloramines)**
- **Representative Br^-/I^- ratio and concentrations (µg/L / µg/L)**
  - **ambient**
  - **50/5 or 100/10**
  - **200/20**
  - **800/80**

Source Waters	Br^- (µg/L)	I^- (µg/L)
Low	24	0.4
High	1120	104
Median	109	10.3
Avg. Ratio	13	

(Richardson et al. 2008)

Uniform Formation Conditions (UFC)

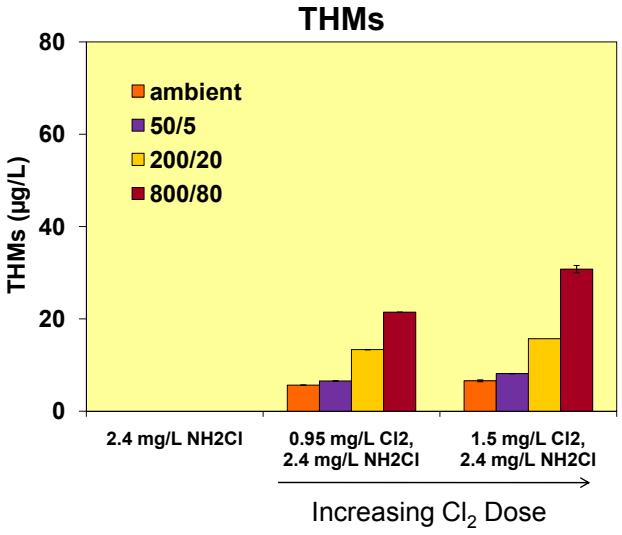
- **Preformed monochloramine:**
  - **NH_2Cl dose to achieve approximately 2.0 mg/L residual after 24 hours**
- **Prechlorination followed by ammonia**
  - **Chlorine residual of 0.5 mg/L or 1.0 mg/L after contact times of 5 and 20 minutes**
  - **Ammonia addition to form UFC dose of NH_2Cl.**

Water characteristics (after conventional treatment)

DOC (mg/L)	1.2
$SUVA_{254}$ (L/mg-m)	1.8
Br^- (µg/L)	28
I^- (µg/L)	5

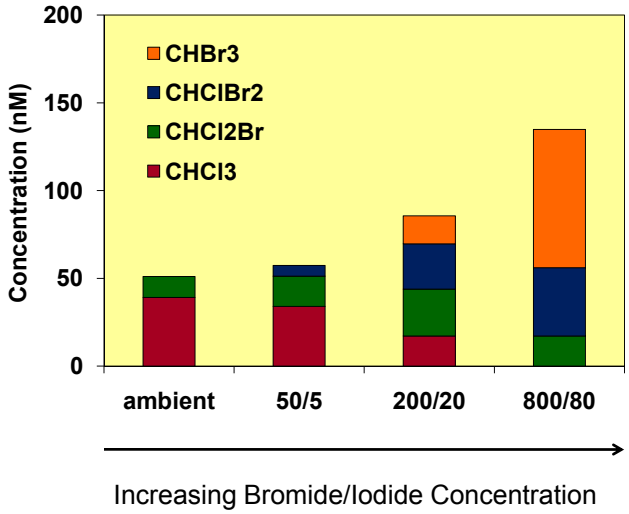
Preformed versus Prechlorination

0 and 5 minute free chlorine contact time



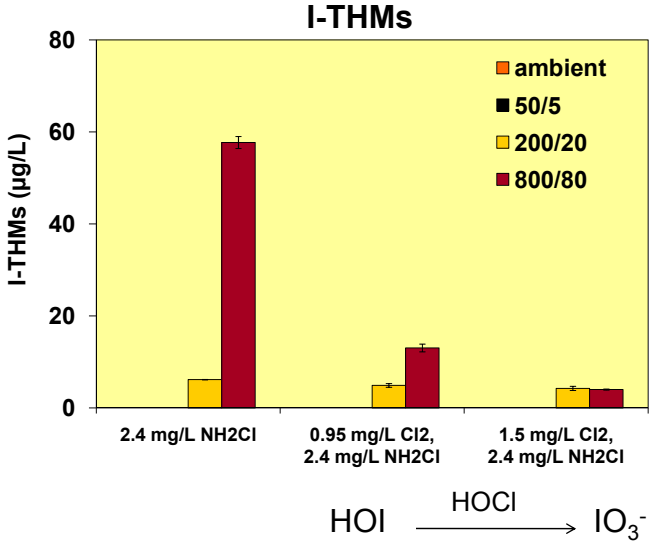
THM speciation

5 minute free chlorine contact time (1.5 mg/L)



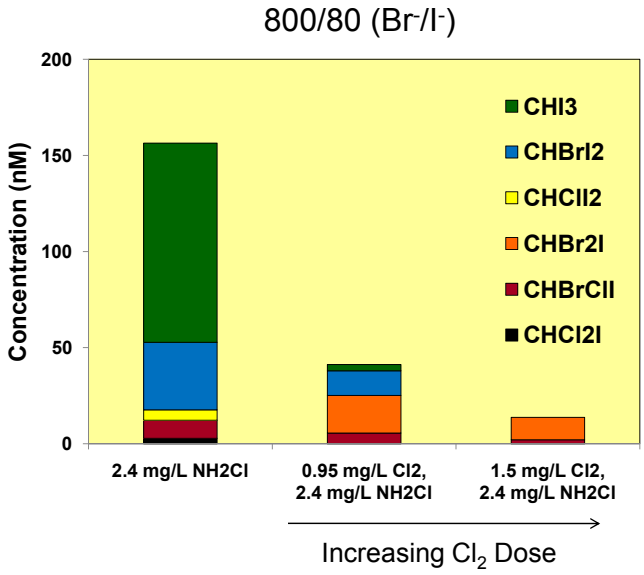
Preformed versus Prechlorination

0 and 5 minute free chlorine contact time



$HOI \xrightarrow{HOCl} IO_3^-$

I-THM speciation



Conclusions and Recommendations

- I-THM formation may be an issue for plants practicing the simultaneous addition of chlorine and ammonia (simulated by preformed NH_2Cl).
- Small doses and short chlorine contact time will usually minimize I-THM formation, especially iodoform (CHI_3), without resulting in excessive THMs.
- If a utility switches to chloramination practices, chlorine should be added prior to ammonia in the plant rather than adding ammonia first.

Discussion??

- Future Directions
  - What would you like to see more data on?
  - Economic models for DBP precursors from different source waters for SRP
  - In-situ regeneration of GAC systems
  - Changes in SEC-TOC during water treatment

Recovery of Method

	R3	R10	R25	SPTin	SPTout	SPTCl2	MESAin	MESAeff	MESAUV
Acetaminophen	34%	27%	34%	33%	31%	27%	14%	16%	18%
Caffeine	72%	48%	63%	66%	62%	61%	59%	33%	32%
Carbamazepine	77%	49%	70%	80%	79%	75%	54%	49%	51%
Cotinine	77%	49%	70%	80%	79%	75%	54%	49%	51%
DEET	77%	49%	70%	80%	79%	75%	54%	49%	51%
Diazepam	77%	49%	70%	80%	79%	75%	54%	49%	51%
Diclofenac	77%	49%	70%	80%	79%	75%	54%	49%	51%
Dilantin	36%	17%	32%	26%	27%	29%	23%	14%	18%
Erythromycin	72%	48%	63%	66%	62%	61%	59%	33%	32%
Fluoxetine	34%	27%	34%	33%	31%	27%	14%	16%	18%
Hydrocodone	77%	49%	70%	80%	79%	75%	54%	49%	51%
Ibuprofen	77%	49%	70%	80%	79%	75%	54%	49%	51%
Meprobamate	77%	49%	70%	80%	79%	75%	54%	49%	51%
Naproxen	36%	17%	32%	26%	27%	29%	23%	14%	18%
Oxybenzone	34%	27%	34%	33%	31%	27%	14%	16%	18%
Pentoxifylline	72%	48%	63%	66%	62%	61%	59%	33%	32%
Primidone	77%	49%	70%	80%	79%	75%	54%	49%	51%

Quality control – Lab blank & Field blank

(Unit: ng/L)	Adj M	Adj SD	M+2SD
Acetaminophen	0.2	0.3	0.9
Caffeine	1.0	1.0	3.0
Carbamazepine	0.1	0.3	0.7
Cotinine	0.1	0.1	0.3
DEET	1.1	1.0	3.0
Diazepam	0.1	0.2	0.5
Diclofenac	0.4	0.5	1.3
Dilantin	0.7	1.1	2.8
Erythromycin	0.1	0.3	0.7
Fluoxetine	0.3	0.4	1.1
Hydrocodone	0.5	0.8	2.0
Ibuprofen	0.6	1.0	2.6
Meprobamate	0.2	0.3	0.8
Naproxen	0.2	0.5	1.3
Oxybenzone	2.0	1.3	4.6
Pentoxifylline	0.2	0.5	1.1
Primidone	0.1	0.2	0.6
Sucralose	0.4	0.7	1.7
Sulfamethoxazole	0.3	0.7	1.7
TBBA	0.5	0.9	2.4
Triclosan	1.0	1.0	3.0
Trimethoprim	0.1	0.4	0.8