REGIONAL WATER QUALITY NEWSLETTER

DATE: Report for May 15-16, 2006
Samples Collected on May 18, 2006
From the Phoenix, Tempe, Peoria, CAP, SRP – ASU Regional Water Quality Partnership

http://enpub.fulton.asu.edu/pwest/tasteandodor.htm

DISTRIBUTION: **Phoenix:** Greg Ramon, Robert Leible, Walid Alsmadi, Edna Bienz, Frank Blanco, Nicoleta Buliga, Natasha Bernard, Alice.Brawley-Chesworth, Paul Burchfield, Jennifer Calles, Aimee Conroy, Tom Doyle, Ron Jennings, Francisco Gonzales, Randy Gottler, Keith Greenburg, Mike Gritzuk, Yu Chu Hsu, Maureen Hymel, Ron Jennings,Tom Martin, Shan Miller, Erin Pysell, Paul Mally, Matt Palencia, Chris Rounseville, Raymond Schultz, Bonnie Smith, Jeff Van Hoy, Mike Welch Vic Vanderslice; **SRP**: Gregg Elliott, Brian Moorehead, Rick Prigg: **CAWCD**: Doug Crosby, Patrick Dent, Brian Henning,Tim Kacerek; Steve Rottas;**Tempe**: Tom Hartman; Michael Bershad, Grant Osburn, German McCutheon.; **Scottsdale**: Michelle DeHaan,, B. Vernon; Suzanne Grendahl; **Gilbert:** Antonio Trejo, Bill Taylor; **Glendale**: Tracey Hockett, Usha Iyer, Stephen Rot, Kim Remmel, Tracy Hockett; **Mesa**: Alan Martindale; Charolette Jones; William Hughes; Matt Rexing **Peoria**: John Kerns, Dave Van Fleet, Linda Wahlstrom; **Chandler**: Lori Mccallum, Robert Goff, Victoria Sharp, Jackie Strong, Chris Kincaid, Wendy Chambers; **Tucson**: Michael Dew. **American Water:** Jeff Stuck, Nina Miller **Chaparral City Water Company (CCWC)**: Bob Carlson **Consultants**: G. Masseeh, S. Kommineni (Malcom Pirnie); Warren Swanson (Schmueser Gordon Meyer, Inc., Colorado); Troy Day (CZN); Vance Lee, Bob Ardizzone (Carollo Engineering); Paul Westcott, Applied Biochemists, Shugen Pan, Greeley and Hanson, Larry Baker; **ASU Team**: Mario Esparza, Marisa Masles, Darla Gill, Hu Qiang, Milt Sommerfeld, Tom Dempster, Paul Westerhoff, **EPA**: Marvin Young; **DEQ**, Casey Roberts

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SUMMARY: EVALUATION AND RECOMMENDATIONS

1. MIB and geosmin concentrations remain low throughout the system. Only the upper 10 meters of the water column in Bartlett Lake had detectable MIB.
2. Three WTPs are adding powder activated carbon (PAC) even though taste and odor compounds are not present. Several WTPs noted this is being done to 1) minimize in-plant algae growth without using prechlorination, 2) improve DBP precursor removal.
3. DOC concentrations are ~ 4.5 mg/L throughout the SRP canal system (only 2.5 mg/L in the CAP system). Higher DOC levels produce more DBPs upon chlorination.
4. With minimal runoff this spring to dilute bromide concentrations, there are higher levels of brominated DBPs after chlorination. Remember that BROMIDE is critical in affecting the speciation of DBPs.
5. ASU is investigating a new "green" coagulant that may oxidize DOC and MIB, while also producing a settlable solid. Results next month.
6. A PAC optimization study was conducted this month on 8 different PAC samples. A description of the process is enclosed.

Table 1 Summary of WTP Operations

	Union Hills	24th Street WTP	N.Tempe J.G. Martinez	Deer Valley	Greenway WTP	Val Vista	South Tempe	Chandler WTP
Location	**CAP**	**Arizona Canal System**				**South Canal System**		
PAC Type and Dose		Norit 20B 15-18 ppm	Calgon WPH 9ppm	No	No		PACarb+ 11.5ppm	
Copper Sulfate		No	No	No	No		No	
PreOxidation		No	No	No	1.0ppm Cl2 1.6ppm O3		No	
Alum Dose Alkalinity pH		50 142 6.7-6.8	26 [3] 146 7.4	11.3 95 6.8	12 145 7.7		16.8 104 7.7	
WTP Comments		No complaints	Adding PAC for algae control; preCl2 being avoided to minimize DBPs	No perceived T&O problems			Adding PAC for algae control; preCl2 being avoided to minimize DBPs	
Raw water DOC % DOC removal[2]	2.78 16%	4.53 41%	4.68 25%	4.63 39%	4.68 5%	4.58 38%	4.60 10%	
Process Recommendations								

[1] **Ferric chloride instead of alum**
[2] Calculated based upon influent and filtered water DOC
[3] Also adding 3.4 ppm Clariflox C358 floc aid

MONITORING RESULTS

Table 2 - Water Treatment Plants – May 15, 2006

Sample Description	MIB (ng/L)	Geosmin (ng/L)	Cyclocitral (ng/L)
24th Street WTP Inlet	<2.0	<2.0	<2.0
24th Street WTP Treated	<2.0	<2.0	<2.0
Deer Valley Inlet	<2.0	2.4	<2.0
Deer Valley WTP Treated	<2.0	<2.0	<2.0
Val Vista Inlet	<2.0	2.5	<2.0
Val Vista WTP Treated –East	<2.0	<2.0	<2.0
Val Vista WTP Treated -West	<2.0	<2.0	<2.0
Union Hills Inlet	<2.0	<2.0	<2.0
Union Hills Treated	<2.0	<2.0	<2.0
Tempe North Inlet	<2.0	2.3	<2.0
Tempe North Plant Treated	<2.0	<2.0	<2.0
Tempe South WTP	<2.0	2.9	<2.0
Tempe South Plant Treated	<2.0	<2.0	<2.0
Chandler WTP Inlet	<2.0	<2.0	<2.0
Chandler WTP Treated	<2.0	<2.0	<2.0
Greenway WTP Inlet	<2.0	<2.0	<2.0
Greenway WTP Treated	<2.0	<2.0	<2.0

Table 3 - Canal Sampling – May 15, 2006

System	Sample Description	MIB (ng/L)	Geosmin (ng/L)	Cyclocitral (ng/L)
CAP	Waddell Canal	<2.0	<2.0	<2.0
	Union Hills Inlet	<2.0	<2.0	<2.0
	CAP Canal at Cross-connect	<2.0	2.4	<2.0
AZ Canal	Salt River @ Blue Pt Bridge	<2.0	<2.0	<2.0
	Verde River @ Beeline	<2.0	<2.0	<2.0
	AZ Canal above CAP Cross-connect	<2.0	<2.0	<2.0
	AZ Canal below CAP Cross-connect	<2.0	<2.0	<2.0
	AZ Canal at Highway 87	<2.0	2.9	<2.0
	AZ Canal at Pima Rd.	<2.0	2.7	<2.0
	AZ Canal at 56th St.	<2.0	2.2	<2.0
	AZ Canal - Inlet to 24th Street WTP	<2.0	<2.0	<2.0
	AZ Canal - Central Avenue	<2.0	2.4	<2.0
	AZ Canal - Inlet to Deer Valley WTP	<2.0	2.4	<2.0
	AZ Canal - Inlet to Greenway WTP	<2.0	<2.0	<2.0
South and Tempe Canals	South Canal below CAP Cross-connect	<2.0	<2.0	<2.0
	South Canal at Val Vista WTP	<2.0	2.5	<2.0
	Head of the Tempe Canal	<2.0	<2.0	<2.0
	Tempe Canal - Inlet to Tempe's South Plant	<2.0	2.9	<2.0
	Chandler WTP – Inlet	<2.0	<2.0	<2.0

Table 4 - Reservoir Samples – May 15, 2006

Sample Description	Location	MIB (ng/L)	Geosmin (ng/L)	Cyclocitral (ng/L)
Lake Pleasant	Eplimnion	<2.0	<2.0	<2.0
Lake Pleasant	Hypolimnio	<2.0	<2.0	<2.0
Verde River @ Beeline		<2.0	<2.0	<2.0
Bartlett Reservoir	Epilimnion	9.4	<2.0	<2.0
Bartlett Reservoir	Epi-near dock	8.4	<2.0	<2.0
Bartlett Reservoir	Hypolimnio	<2.0	<2.0	<2.0
Salt River @ BluePt Bridge		<2.0	<2.0	<2.0
Saguaro Lake	Epilimnion	<2.0	23.7	<2.0
Saguaro Lake	Epi - Duplicate	<2.0	23.7	<2.0
Saguaro Lake	Epi-near doc	<2.0	24.7	<2.0
Saguaro Lake	Hypolimnio	<2.0	4.3	<2.0
Verde River at Tangle		<2.0	2.2	<2.0
Havasu		<2.0	<2.0	<2.0

Table 5 - SRP/CAP OPERATIONS
Values in cfs, for May 15, 2006

System	SRP Diversions	CAP
Arizona Canal	696	108
South Canal	826	0
Pumping	87	0
Total	1609	108

SRP is releasing water from both Verde and Salt River Systems. Salt River release from Saguaro Lake: 1388 cfs; Verde River release from Bartlett Lake: 133 cfs. Horseshoe Lake is at 0% capacity.

5/12/2006

WADDELL RELEASE SCHEDULE

		% Flow	Date	Time
Current Waddell Releases	2100 cfs	89%	05/12/06	12:00
Current Pass-Thru Flow	250 cfs	11%	05/12/06	12:00
New Waddell Releases	1600 cfs	67%	05/13/06	00:00
New Pass-Thru Flow	790 cfs	33%	05/13/06	00:00
New Waddell Releases	0 cfs	0%	05/13/06	08:00
New Pass-Thru Flow	2200 cfs	100%	05/13/06	08:00

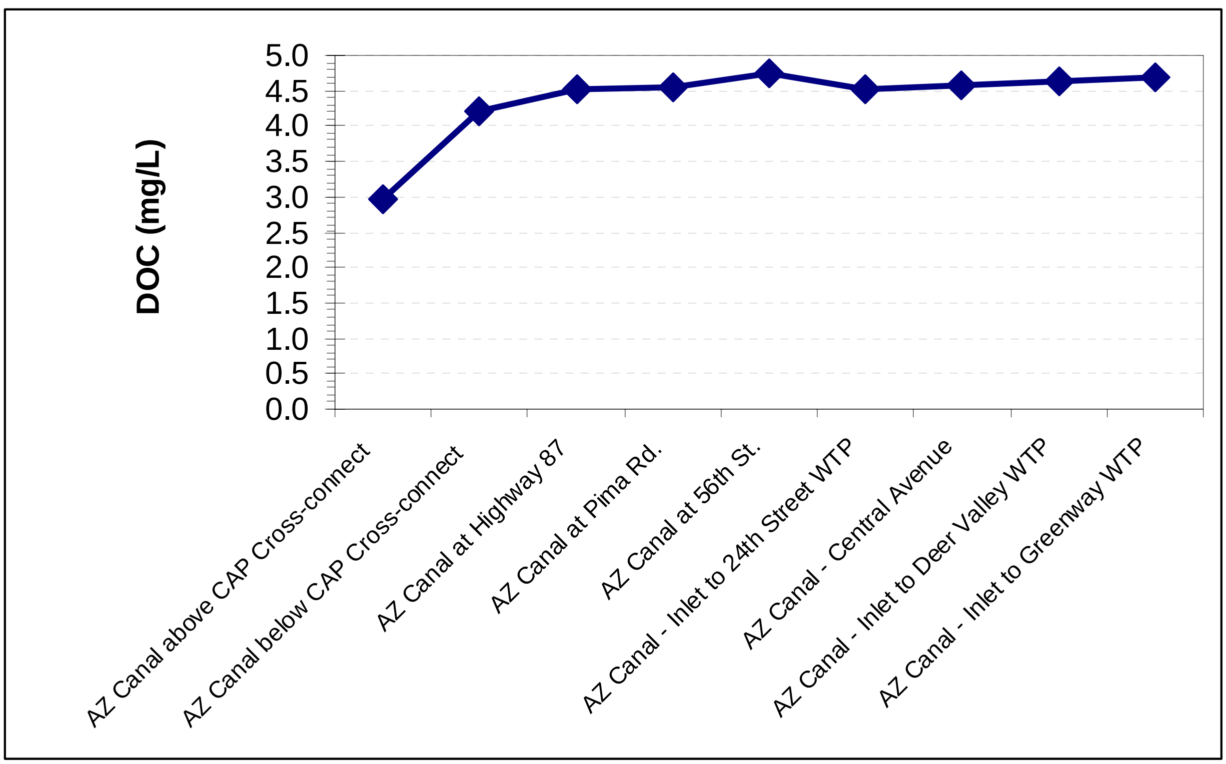
Watershed Organic Matter Levels

Sample Description	Location	DOC (mg/L)	SUVA	TDN (mg/L)
Lake Pleasant	Eplimnion	3.53	1.7	0.289
Lake Pleasant	Hypolimnion	3.90	1.6	0.042
Verde River @ Beeline	River	1.75	2.7	0.106
Bartlett Reservoir	Epilimnion	2.68	1.9	0.172
Bartlett Reservoir	Hypolimnion	3.25	2.2	0.459
Salt River @ BluePt Bridge	River	4.73	2.5	0.180
Saguaro Lake	Epilimnion	5.51	2.1	0.297
Saguaro Lake	Epi - Duplicate	5.41	2.2	0.350
Saguaro Lake	Hypolimnion	4.95	2.3	0.287
Verde River at Tangle		1.12	2.4	0.151
Havasu		2.67	1.5	0.456

* TDN = total dissolved nitrogen (mgN/L)

Organic Matter in Canals

CAP Canal DOC (2.8 mg/L) is lower than SRP water coming from the Salt and Verde River system. But less than 15% of the flow in the Arizona Canal is CAP water currently. DOC of the South Canal is 4.6 mg/L.

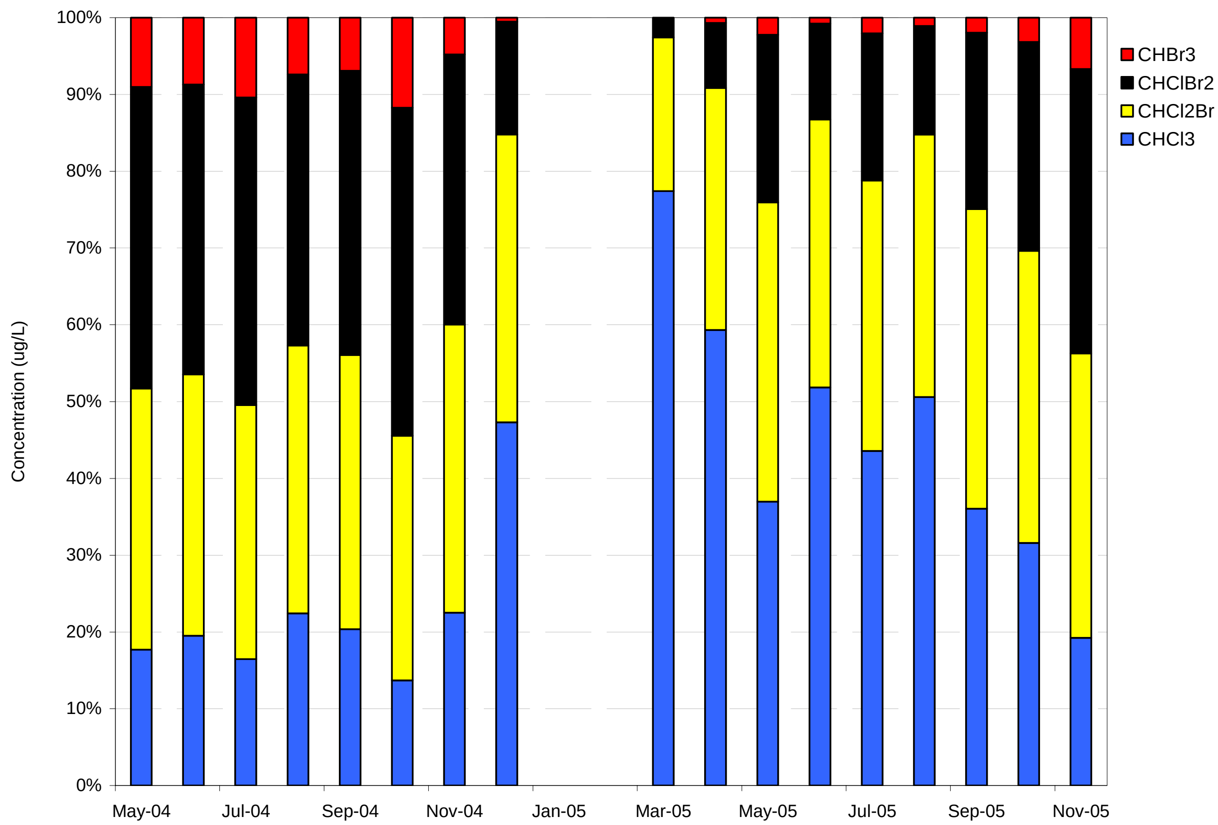


Organic Matter Removal at Individual Water Treatment Plants

Sample Description	DOC (mg/L)	UV254 (1/cm)	SUVA	TDN (mg/L)
24th Street WTP Inlet	**4.53**	**0.1044**	**2.3**	**0.199**
24th Street WTP Treated	**2.67**	**0.0362**	**1.4**	**0.071**
Deer Valley Inlet	**4.63**	**0.1053**	**2.3**	**0.178**
Deer Valley WTP Treated	**2.81**	**0.0408**	**1.5**	**0.167**
Val Vista Inlet	**4.58**	**0.1162**	**2.5**	**0.035**
Val Vista WTP Treated –East	**2.83**	**0.0464**	**1.6**	**0.137**
Val Vista WTP Treated -West	**2.52**	**0.0368**	**1.5**	**0.141**
Union Hills Inlet	**2.78**	**0.0371**	**1.3**	**0.433**
Union Hills Treated	**2.34**	**0.0199**	**0.9**	**0.394**
Tempe North Inlet	**4.68**	**0.1028**	**2.2**	**0.248**
Tempe North Plant Treated	**3.53**	**0.0614**	**1.7**	**0.157**
Tempe South WTP	**4.60**	**0.1087**	**2.4**	**0.243**
Tempe South Plant Treated	**4.15**	**0.0621**	**1.5**	**0.133**
Greenway WTP Inlet	**4.68**	**0.1050**	**2.2**	**0.226**
Greenway WTP Treated	**4.47**	**0.0492**	**1.1**	**0.277**

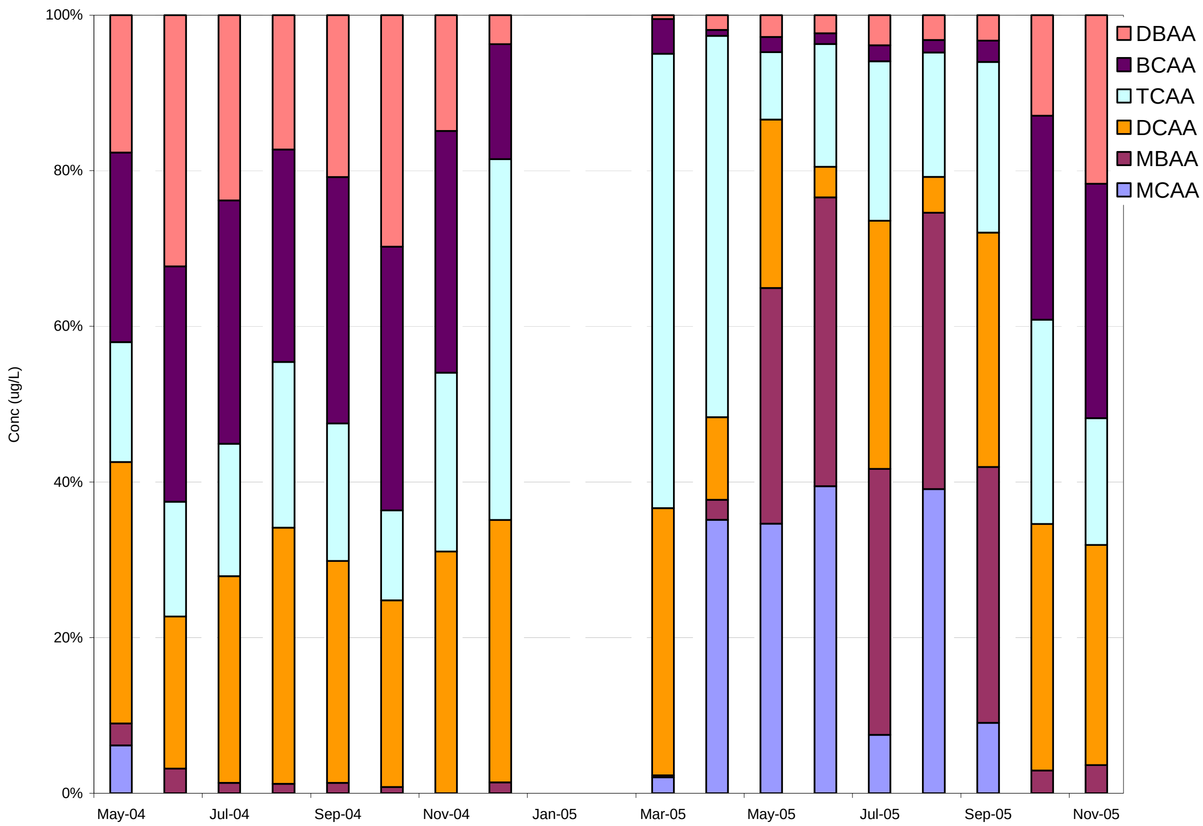
DBPs for 2005

Continuing the theme from last month. Here is data for a different WTP in 2004-2005. Winter rains in January 2005 increased DOC and decreased bromide. As a result more chlorinated trihalomethanes formed (i.e., decreased percentage of brominated THMs). Bromide is naturally occurring in the salt deposits and springs along the Salt and Verde Rivers. Therefore bromide concentrations actually are higher during baseflow (no storm or snow-melt runoff) periods. Throughout 2005 a steady decrease in chloroform (CHCl3) is observed, with increasing percentages of brominated DBPs. Brominated DBPs are generally considered to be a higher potential health effect than chlorinated species.



On the next page a similar plot is shown for 6 haloacetic acid species (HAA). There are actually nine HAA species, although only 5 are regulated and 6 commonly measured. The other 3 non-measured HAAs are mixed bromine-chlorine-HAAs and tribromo acetic acid. After the January 2005 rains trichloroacetic acid (TCAA) increased due to low bromide content of the water. As that bromide concentrations increased in the water supply during 2005the HAA speciation returned to levels comparable with March 2004, before the rains.

A key to understanding and controlling DBPs includes both BROMIDE and DISSOLVED ORGANIC CARBON.


100%
80%
60%
40%
20%
0%
Conc (ug/L)
May-04
Jul-04
Sep-04
Nov-04
Jan-05
Mar-05
May-05
Jul-05
Sep-05
Nov-05
DBAA
BCAA
TCAA
DCAA
MBAA
MCAA

Powder Activated Carbon Screening

ASU screened eight (8) powder activated carbon (PAC) samples for their ability to remove MIB and geosmin, with the intent that the City of --------- may base the selection of a PAC supplier upon this data. This was a blind testing study; codes (1 through 8) were used to designate each PAC brand. ASU takes no legal responsibility for the City of --------- decisions for a PAC supplier. Below is the testing and evaluation protocol, test findings, and results. Overall, PAC brands "4" and "8" had the two lowest Index values and comparable MIB & geosmin removal. Overall, PAC "4" would be the top ranked brand.

TESTING PROTOCOL

Water Source. Water was collected from the Arizona Canal at Pima Road on May 2, 2006. The water was filtered (Whatman GF/F) and DOC measured. MIB and geosmin were simultaneous spiked into the water for final concentrations of 89±8 and 91±6 ng/L, respectively.

PAC Batch Experiments. Activated carbon adsorption studies with MIB and geosmin were conducted in the laboratory with commercially available brands of PAC. PAC samples were obtained from a single batch from manufacturers in amounts sufficient to run all experiments. A total of eight different PAC types were tested. This was a blind testing study; codes (1 through 8) were used to designate each PAC brand. Two PAC doses (15 and 25 ppm) were used. A PAC slurry of each PAC sample was prepared at a concentration of 1000 mg PAC/L in nano-pure water; the slurry was mixed and allowed to hydrate for 24 hours at room temperature. Amber glass vials (40 ml) were used for treatments and were continuously shaken. The duration of shaking was based upon the average hydraulic residence time of PAC in the pre-sedimentation basins plus flocculation basins (a contact time of 6 hours was used). Activated carbon was removed from the samples by syringe filtering with a 0.2 µm nylon membrane filter (Acrodisc® 25 mm syringe filter with 0.2 µm nylon membrane, Pall Corporation, Ann Arbor, MI). Control treatments containing MIB and geosmin, but no PAC, were shaken and filtered in a similar manner as the samples containing PAC. Experiments were conducted at room temperature. All experiments were conducted in at least duplicate.

Measurement of MIB and Geosmin. MIB and geosmin were measured using Solid-Phase Microextraction/Gas Chromatography Mass Spectroscopy (SPME-GC/MS) (Watson et al., 2000; Lloyd et al., 1998). Twenty-five ml of sample is added to a 40 ml septum capped vial that contains 8 gm desiccated sodium chloride and a magnetic stir bar. An internal standard (10 ng/L IPMP, Aldrich Chemical Co., Milwaukee, WI) is added through the septum and the vial is placed in a water bath on a magnetic stir plate heated to 50 ± 1.5 ^{0}C. A SPME fiber (Supelco # 57348 U) is introduced into the head space gas through the septum and the sample is stirred for 30 minutes. The fiber is removed from the vial and inserted into the gas chromatograph injector at 250 ^{0}C for 5 minutes. The fiber was then retracted into the holder, removed from the GC inlet and reused for the next sample. Compounds are eluted from the column gas chromatograph to a mass spectrometer set for selective ion storage (selective *m/z* values: MIB = 95, geosmin = 112 and IPMP = 124, 136). Calibration curves are generated using MIB and geosmin standards (mixture standard: Supelco # 47525 U). Method detection limit for SPME is 2 ng/L. An MIB internal standard was run in triplicate, and had excellent reproducibility: 27.5±0.8 ng/L.

RESULTS

The fraction remaining of MIB and geosmin was determined from experimental results. The fraction remaining is defined as C/C_0, where C is the MIB or geosmin concentration (ng/L) after contact with the PAC and C_0 is the initial MIB or geosmin concentration (ng/L). The PAC brands (1 through 8) were ranked from best performing (lowest C/C_0 x100%) to worst performing (highest C/C_0 x100%) for MIB or geosmin removal (Figure 1). The values indicated in the bar charts are the average of at least two separate PAC tests, and the error bar one standard deviation.

At a PAC dose of 15 ppm the percentage of MIB remaining ranged from 28% to 60%. At a PAC dose of 25 ppm more MIB was removed than at 15 ppm, and lower percentage remaining values were observed (Figure 1). At a PAC dose of 25 ppm the percentage of MIB remaining ranged from <1% to 14%, with the top three performing PAC brands having essentially equivalent MIB removal capability. Geosmin was removed more effectively than MIB (Figure 1). The percentage of geosmin remaining ranged from 6% to 27% at 15 ppm of PAC. The PAC brand with the highest MIB removal ($1-C/C_0$) also had the best geosmin removal.

INTERPRETATION OF RESULTS

After completion of the blind laboratory PAC performance testing, the City of --------- provided unit cost data on each PAC. The unit costs provided are presented in Table 2. Based upon the PAC test performance for removing MIB or geosmin and the provided PAC unit costs, an Index Value was calculated. The Index Value was computed as follows:

Index Value = [Fraction Compound Remaining]x[PAC Unit Cost] Equation 1

In principle, the PAC brand with the lowest Index Value represents the most cost effective brand of PAC. For example, a lower PAC dose could offset a higher PAC price.

Table 1 – PAC Unit Costs Based Upon Equation 1 and MIB Remaining

PAC Brand	PAC Unit Cost
1	$1300
2	$1180
3	$750
4	$1050
5	$646
6	$902
7	$946
8	$968

Index values for each PAC brand at two PAC doses (15 and 25 ppm) for MIB and geosmin are graphically illustrated in Figure 2. Because of very high geosmin removal (>99%) for some PAC types at 25 ppm PAC dose, these Index values are not presented. For both MIB and geosmin at both PAC doses, PAC Brands 4 and 8 had the lowest Index Values.

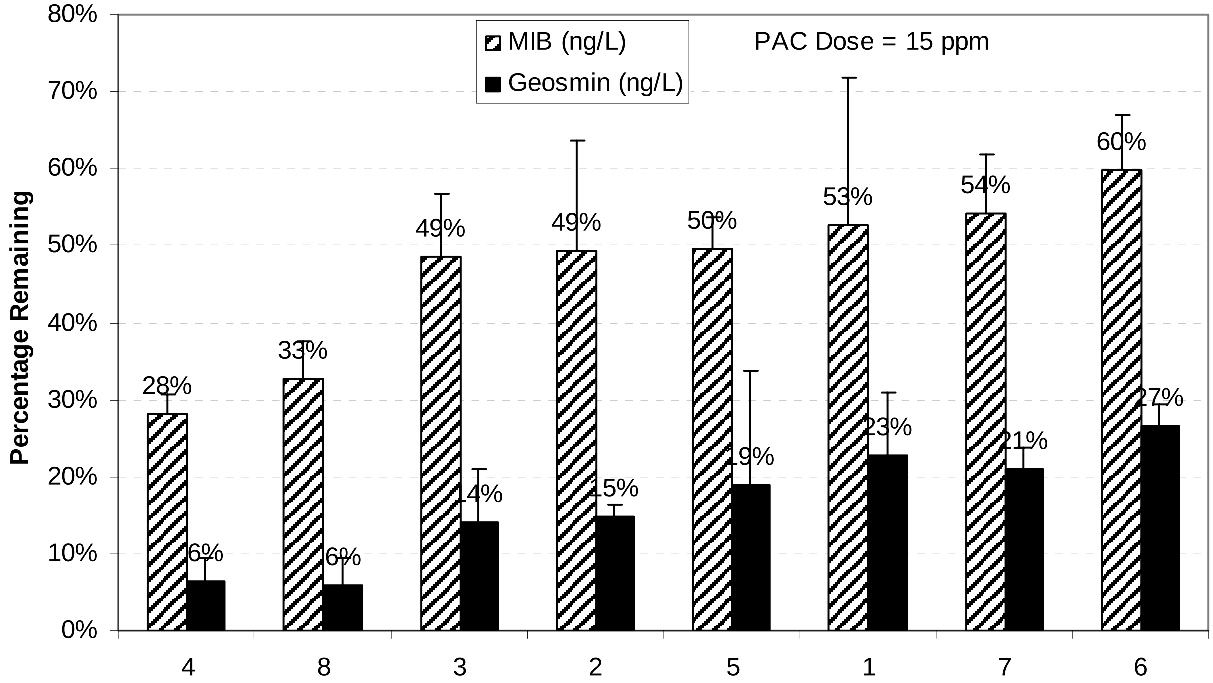
RECOMMENDATION

Based upon the batch PAC tests, PAC brands "4" and "8" had the among the highest MIB removal efficiency (lowest percentage remaining). These two PACs had the lowest Index Values also. Brand "5" has a low Index value because of its cheap price, ranking third overall. However, because of the limited PAC feed capabilities at most of the --------- WTPs (less than 15 ppm PAC dose commonly used), it is not recommended. Overall, PAC brands "4" and "8" had the two lowest Index values and comparable MIB & geosmin removal. Overall, PAC "4" would be the top ranked brand.

The City may also want to consider the following issues in final selection of a PAC supplier:

- Availability of product
- Product handling issues
- Size and settling characteristics of the PAC

Figure 1 – Summary of Percentage MIB and Geosmin Remaining after PAC doses of 15 and 25 ppm (6 hour contact time)



MIB (ng/L)
Geosmin (ng/L)
PAC Dose = 15 ppm
Percentage Remaining
80%
70%
60%
50%
40%
30%
20%
10%
0%
28%
6%
33%
6%
49%
14%
49%
15%
50%
19%
53%
23%
54%
21%
60%
27%
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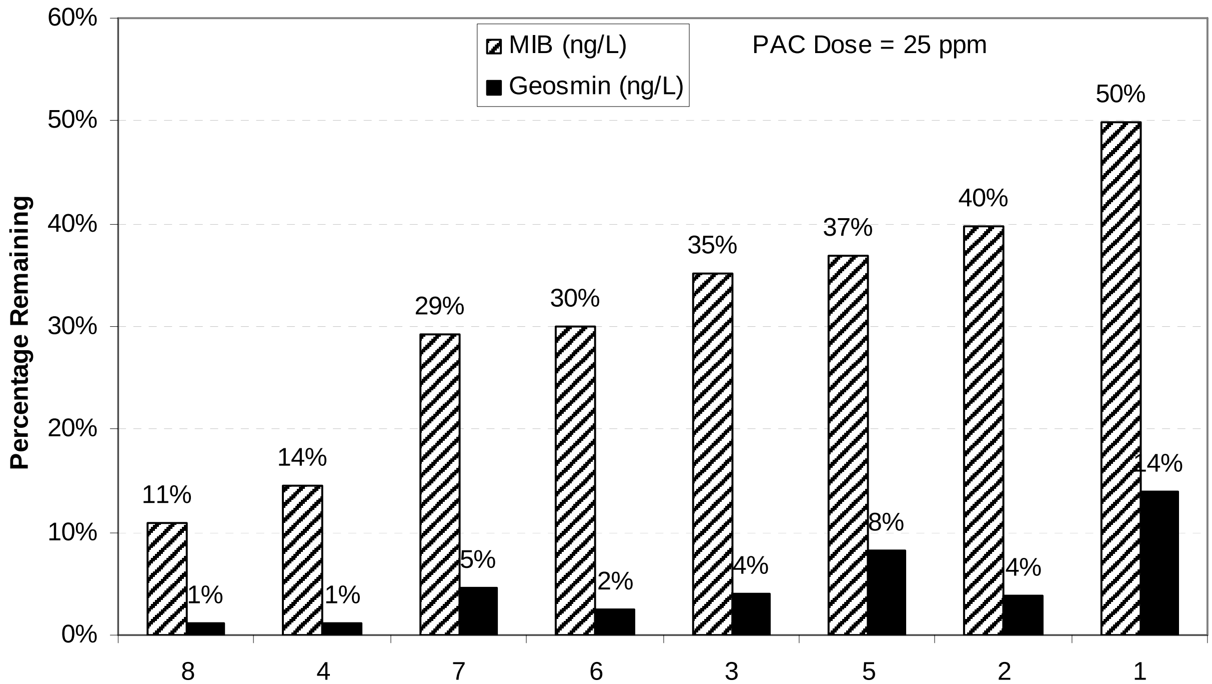
6



MIB (ng/L)
Geosmin (ng/L)
PAC Dose = 25 ppm
Percentage Remaining
60%
50%
40%
30%
20%
10%
0%
11%
1%
14%
1%
29%
5%
30%
2%
35%
4%
37%
8%
40%
4%
50%
14%
8
4
7
6
3
5
2
1

Figure 3 – Summary of Index Values