

**TRIHALOMETHANE SPECIATION AND THE RELATIONSHIP TO  
ELEVATED TOTAL DISSOLVED SOLID CONCENTRATIONS AFFECTING  
DRINKING WATER QUALITY AT SYSTEMS UTILIZING THE  
MONONGAHELA RIVER AS A PRIMARY SOURCE DURING THE 3<sup>RD</sup> AND  
4<sup>TH</sup> QUARTERS OF 2008**

**EXECUTIVE SUMMARY**

In September 2008, a collaborative distribution field event, with representatives from the Environmental Protection Agency (EPA), the Pennsylvania Department of Environmental Protection (DEP) and the Allegheny County Health Department (ACHD) was conducted at a surface water treatment facility located on the Ohio River. During this field event, sample analysis results for Disinfection By-Products (DBPs) showed a high percentage of the DBPs being formed were brominated DBPs, which pose a greater health risk than chlorinated DBPs. A raw water sample indicated that the source water bromide concentration was 170 ug/L. Bromide in fresh water is typically found in areas influenced by saltwater intrusion or another bromide source (well drilling brines, industrial chemicals and agricultural chemicals).

In October 2008, unusually high levels of sulfate and Total Dissolved Solids (TDS) were detected at points along the Monongahela River, beginning at the West Virginia border to the confluence with the Youghigheny River and were impacting surface water supplies in that same area. Sulfates and TDS are naturally occurring substances that are found in minerals, soil and rocks. Sulfates and TDS may also be discharged to surface water sources through mine drainage, gas well drilling or sewage treatment plants. In addition, several systems on the Monongahela River, which feeds the Ohio River, have recently experienced elevated THMs, as shown by their compliance monitoring results.

The presence of bromide and subsequent formation of brominated DBPs increases overall DBP concentrations, specifically trihalomethanes (THMs). Although bromide may not create additional THMs on a molecular level, it does create brominated analogues, which have higher molecular weights and increase the overall concentration on a weight to volume basis (i.e. mg/L). The concentration of regulated haloacetic acids (HAAs) may decrease, since other non-regulated species, which are brominated, will most likely increase in concentration, while the regulated species decrease in concentration.

Overall, the systems that were used in this study have TTHM concentrations that are impacted by bromide in the source water at various times during the year. In some cases the TTHM concentration that was comprised of mostly brominated species produced the highest historical TTHM value. In conjunction, the systems on the Monongahela River appear to have been impacted directly by the source of the TDS and sulfate, which is most likely also a source of bromide. Elevated concentrations of bromide, as well as TDS and sulfates, may also have been impacted by low river flows during the 3<sup>rd</sup> and 4<sup>th</sup> quarters 2008, compared to historical seasonal flows. Without source water bromide sample results it is difficult to make a direct correlation between the TDS and sulfate event and the elevated brominated THM species. However, based on the speciation there appears to be a strong correlation between THM formation and elevated source water bromide concentrations in the Monongahela River.

The water systems on the Allegheny and Ohio Rivers have a more historical and seasonal cycle of brominated THM formation. As with the Monongahela, the source of the bromide contributing to the seasonal increases in brominated THMs is unknown; although, there appears to be a correlation between low seasonal flows and increased brominated THM formation. During the 3<sup>rd</sup> and 4<sup>th</sup> quarter 2008, the drinking water systems on the Ohio River may have been impacted by the same source of bromide as the systems on the Monongahela River, since it feeds into the Ohio River.

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**BACKGROUND**

In September 2008, a collaborative distribution field event, with representatives from the Environmental Protection Agency (EPA), the Pennsylvania Department of Environmental Protection (DEP) and the Allegheny County Health Department (ACHD) was conducted at a surface water treatment facility located on the Ohio River. During this field event, sample analysis results for Disinfection By-Products (DBPs) showed a high percentage of the DBPs being formed were brominated DBPs, which pose a greater health risk than chlorinated DBPs. A raw water sample indicated that the source water bromide concentration was 170 ug/L. Bromide in fresh water is typically found in areas influenced by saltwater intrusion or another bromide source (well drilling brines, industrial chemicals and agricultural chemicals).

In October 2008, unusually high levels of sulfate and Total Dissolved Solids (TDS) were detected at points along the Monongahela River, beginning at the West Virginia border to the confluence with the Youghigheny River and were impacting surface water supplies in that same area. Sulfates and TDS are naturally occurring substances that are found in minerals, soil and rocks. Sulfates and TDS may also be discharged to surface water sources through mine drainage, gas well drilling or sewage treatment plants. In addition, several systems on the Monongahela River, which feeds the Ohio River, have recently experienced elevated THMs, as shown by their compliance monitoring results.

The presence of bromide and subsequent formation of brominated DBPs increases overall DBP concentrations, specifically trihalomethanes (THMs). Although bromide may not create additional THMs on a molecular level, it does create brominated analogues, which have higher molecular weights and increase the overall concentration on a weight to volume basis (i.e. mg/L). The concentration of regulated haloacetic acids (HAAs) may decrease, since other non-regulated species, which are brominated, will most likely increase in concentration, while the regulated species decrease in concentration.

This report will summarize specific THM results from drinking water systems treating surface water from the Ohio River and Monongahela and Allegheny Rivers, which combine to form the Ohio River. The purpose is to compare THM results, on a species level, to determine if there has been a recent increase in brominated species that may be related to the sudden increase in TDS and Sulfates. Source water bromide results are not available, so this report will be relying on THM speciation to determine if source water bromide had an impact on DBP formation.

## OVERVIEW

DBPs have been a focus of the drinking water industry since their presence in finished drinking water first appeared in published reports in 1974.<sup>1</sup> Since that time, EPA has promulgated a THM rule (1979) and the Stage 1 (1998) and Stage 2 (2006) Disinfectants / Disinfection By-Products Rules (DBPR). The DBPRs focus on four disinfection by-products - Trihalomethanes (THMs), Haloacetic Acids (HAAs), bromate and chlorite. This report will focus on the formation and regulation of THMs and HAAs and present THM data for systems on the Monongahela, Allegheny and Ohio Rivers.

### DBPR

The DBPR regulates four species of THMs and five (of a total of nine major) species of HAAs (Table 1).

**Table 1: Regulated THM and HAA Species**

DBP	Individual Species	Chemical Formula	Molecular Weight
Trihalomethane	Chloroform	CHCl <sub>3</sub>	119 g/mol
	Bromodichloromethane	CHCl <sub>2</sub> Br	164 g/mol
	Dibromochloromethane	CHClBr <sub>2</sub>	208 g/mol
	Bromoform	CHBr <sub>3</sub>	253 g/mol
Haloacetic Acids	Monochloroacetic acid	CH <sub>2</sub> ClCOOH	
	Dichloroacetic acid	CHCl <sub>2</sub> COOH	
	Trichloroacetic acid	CCl <sub>3</sub> COOH	
	Monobromoacetic acid	CHBrClCOOH	
	Dibromoacetic acid	CHBr <sub>2</sub> ClCOOH	

The DBPR establishes a Maximum Contaminant Level (MCL) in micrograms per liter (ug/L) for a total of the four species of THMs (TTHMs) and a total of the five HAA species (HAA5) (Table 2).

**Table 2: TTHM and HAA5 MCLs**

DBP	MCL (ug/L)
Total Trihalomethanes	80
Haloacetic Acids	60

The DBPR also establishes a Maximum Contaminant Level Goal (MCLG) for some of the species of DBPs (Table 3). The MCLG is the maximum level of a contaminant in drinking water at which no known or anticipated adverse health effects occur, allowing for an adequate margin of safety. MCLGs are non-enforceable health goals. EPA establishes the MCL based on the MCLG.

**Table 3: TTHM and HAA5 MCLGs**

<b>DBP</b>	<b>Individual Species</b>	<b>MCLG (ug/L)</b>
Trihalomethane	Chloroform	70
	Bromodichloromethane	Zero
	Dibromochloromethane	60
	Bromoform	Zero
Haloacetic Acids	Monochloroacetic acid	70
	Dichloroacetic acid	Zero
	Trichloroacetic acid	20

For the Stage 1 DBPR (current compliance monitoring), sample results are used to calculate an overall system running annual average (RAA) that is compared to the MCL. For the Stage 2 DBPR (compliance monitoring to start in 2012), sample results from each sample location will be used to calculate a location running annual average (LRAA) that will be compared to the MCL. This change to an LRAA more precisely determines a consumer's exposure to DBPs in a specific location during any given annual timeframe.

### **THM and HAA Formation**

THMs and HAAs are, simply stated, a product of a reaction between a disinfectant (chlorine or monochloramine) and a precursor (natural organic matter (NOM) and bromide). The overall formation is affected by various parameters including concentration of precursors, disinfectant dose and residual, time, temperature and pH.<sup>1</sup>

During DBP formation, the disinfectant will react with NOM to form the various species of by-products. If bromide is present in the source water or is introduced during treatment, it will become oxidized by aqueous chlorine and then react with NOM to form brominated DBPs.<sup>1</sup> In most fresh water sources, that are not influenced by saltwater intrusion or other bromide source, THM formation is dominated by chloroform and HAA formation is dominated by mono-, di- and trichloroacetic acids. When bromide is present, formation starts to include the brominated species of DBPs and as the ratio of bromide to NOM increases, the percentage of brominated DBPs will increase.<sup>1</sup> Studies have shown that the rate of THM formation is higher in water with increased concentrations of bromide.<sup>1</sup> Once the bromide reaches a certain level, the formation of DBPs will also be predominantly brominated unless very high chlorine doses are used, which will cause the chlorine to "out-compete" the bromide.<sup>1</sup>

In 2002 the Environmental Protection Agency (EPA) published a study entitled "The Occurrence of Disinfection By-Products (DBPs) of Health Concern in Drinking Water: Results of a Nationwide DBP Occurrence Study" (EPA/600/R-02/068) that examined DBP formation at systems throughout the United States. This study included drinking waters disinfected with the four common disinfectants: chlorine, chloramines, ozone, and chlorine dioxide. Because many of the high priority DBPs were brominated, the EPA study selected drinking water systems treating sources that contained relatively high bromide levels. In addition, many of the selected systems had source waters that were relatively high in TOC. These studies showed the same pattern of formation as described in the previous paragraph.

It is important to note that the EPA study found source water bromide levels as high as 0.40 mg/L (400 ug/L), which the report classified as high levels. The report referred to a bromide concentration of 0.15 mg/L (150 ug/L) as a moderate concentration and 0.02 mg/L (20 ug/L) as a low concentration. It is also important to note that the system that had the highest source water bromide concentration (400 ug/L), treated water impacted by saltwater intrusion.

Although DBP formation will tend towards the brominated species in the presence of bromide in the source water, overall formation is highly variable from drinking water system to system, even if source water characteristics are similar. Treatment techniques, treatment effectiveness and chemical dosages are factors affecting formation at a water treatment facility. Distribution system size, distribution system maintenance and water age are factors influencing formation in the distribution system.

<sup>1</sup> Formation and Control of Disinfection By-Products in Drinking Water, American Water Works Association, Denver, CO, 1999

## STUDY APPROACH

The objective was to determine if THM formation, and more specifically brominated species, increased during the same timeframe as the TDS event in the Monongahela (3<sup>rd</sup> and 4<sup>th</sup> quarters of 2008). If so, this may indicate that the source of the sulfate and TDS may also be a source of bromide that is impacting THM formation.

To determine if bromide is impacting THM formation at plants along the Monongahela, Allegheny or Ohio Rivers, historical THM data was collected from various drinking water systems that utilize these rivers for their source water. Lab sheets showing the breakdown of the THM species were obtained in order to determine the THM speciation since compliance monitoring data is reported as Total Trihalomethanes (TTHMs), which is the sum of the species.

Figure 1 is a map of the intakes and related Public Water System ID number (PWSID) for systems in the DEP Southwest Region that utilize the Ohio, Monongahela and Allegheny Rivers as at least one of their source waters. Table 4 is a list of the related system owners with the PWSIDs shown on the map. The green dots in Figure 1 represent the intakes of systems whose data is presented in this report and the green highlighted systems in Table 4 are associated with the intakes.

**Figure 1: DEP SW Region Drinking Water Intakes on the Ohio, Monongahela and Allegheny Rivers**



**Table 4: DEP SW Region Drinking Water Systems with Intakes on the Ohio, Monongahela and Allegheny Rivers**

PWSID	SYSTEM NAME	PRIMARY SOURCE
5630039	AUTH OF BORO OF CHARLEROI	MONONGAHELA RIVER
5020039	PA AMER WATER CO-PITTSBURGH	MONONGAHELA RIVER
5630045	TRI CNTY JT MUNI AUTH	MONONGAHELA RIVER
5260004	BELLE VERNON BORO MUNI AUTH	MONONGAHELA RIVER
5260005	PA-AMERICAN WATER-BROWNSVILLE	MONONGAHELA RIVER
5260009	WASHINGTON TWP MUNI AUTH	MONONGAHELA RIVER
5260013	MASONTOWN MUNI WATER WORKS	MONONGAHELA RIVER
5260014	NEWELL MUNI AUTH	MONONGAHELA RIVER
5300005	CARMICHAELS MUNI WATER AUTH	MONONGAHELA RIVER
5300007	DUNKARD VALLEY JT MUNI AUTH	MONONGAHELA RIVER
5300012	EAST DUNKARD WATER ASSN	MONONGAHELA RIVER
5300017	SOUTHWESTERN PA WATER AUTH	MONONGAHELA RIVER
5020036	OAKMONT BORO MUNI AUTH	ALLEGHENY RIVER
5020038	PITTSBURGH WATER & SEWER AUTH	ALLEGHENY RIVER
5650070	NEW KENSINGTON MUNI AUTH	ALLEGHENY RIVER
5020006	BRACKENRIDGE BORO WATER DEPT	ALLEGHENY RIVER
5020055	TARENTUM BORO WATER DEPT	ALLEGHENY RIVER
5020056	WILKINSBURG-PENN JT WATER AUTH	ALLEGHENY RIVER
5020108	HARRISON TWP WATER AUTH	ALLEGHENY RIVER
5030019	BUFFALO TWP MUN AUTH FREEPORT	ALLEGHENY RIVER
5020011	MOON TWP MUNI AUTH	OHIO RIVER
5020045	ROBINSON TWP MUNI AUTH	OHIO RIVER
5020043	WEST VIEW BORO MUNI AUTH	OHIO RIVER
5040038	MIDLAND BORO MUNI AUTH	OHIO RIVER
5040300	NOVA CHEMICALS BEAVER VLY PLT	OHIO RIVER

Data was obtained from two systems from each of the three rivers, including data from a consecutive system (Oakdale Borough) of PA American Water Company - Pittsburgh (7 total systems). Most of the systems where data was obtained utilize free chlorine as their primary disinfectant. The exception is Oakmont Borough which utilizes chloramination from May 15<sup>th</sup> to November 15<sup>th</sup>.

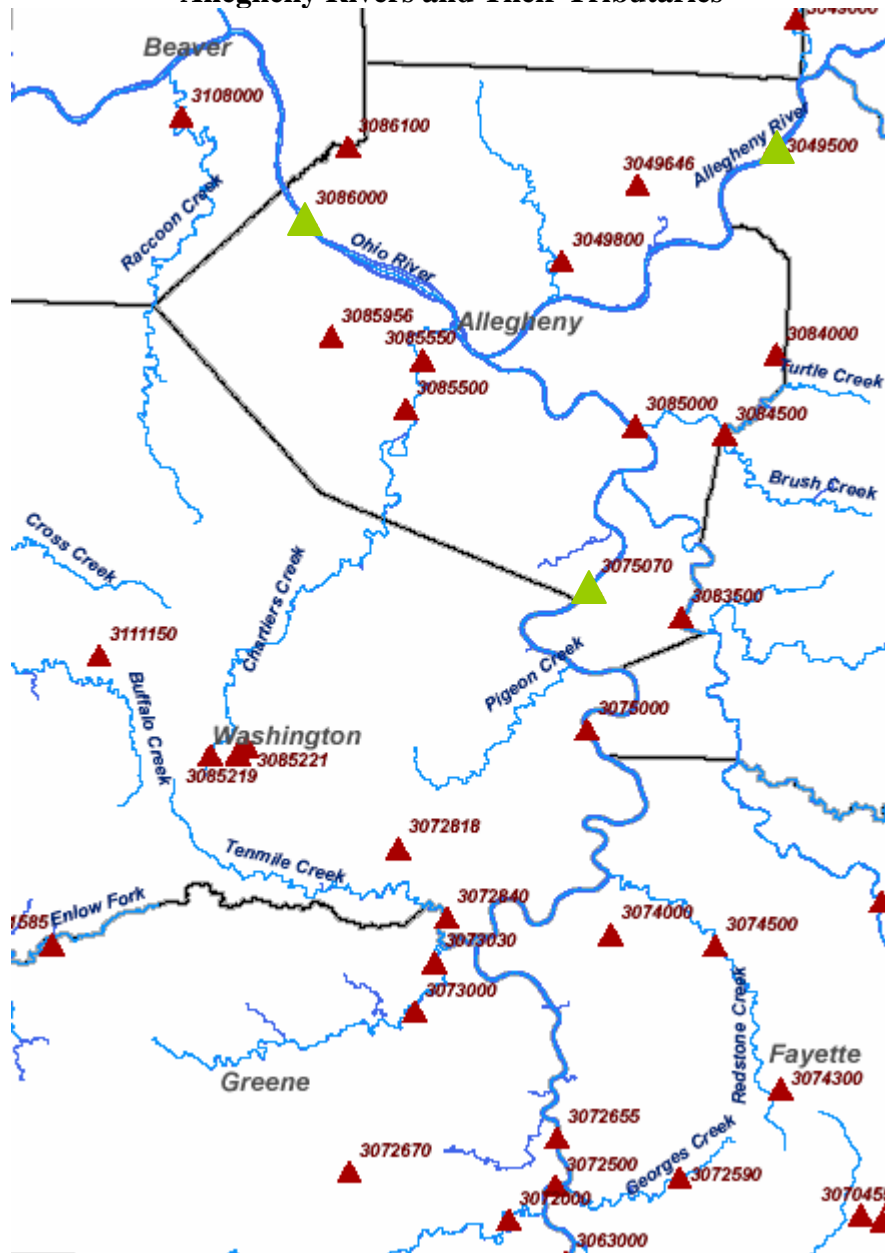
The goal was to obtain at least two years of DBP data for each system, although the data obtained varies from three and a half years to one year. This data was compiled using Microsoft Excel and graphed to determine if there was a trend in speciation that would indicate an increase in brominated species of THMs. The following items were trended graphically for each sample location where DBP samples were obtained:

- Chloroform concentration in ug/L
- Bromodichloromethane concentration in ug/L
- Dibromochloromethane concentration in ug/L
- Bromoform concentration in ug/L
- Total trihalomethane concentration in ug/L
- % of the total trihalomethane concentration that are brominated species

Low river flows may also contribute to increased concentrations of contaminants, including bromide. Flow data from one United States Geological Survey (USGS) Stream Gauge on each river was obtained from the USGS National Water Information System. The monitoring station selected was the one most representative of flows near the intakes of the systems presented in this report. Figure 2 is a map of the USGS Stream Gauges on the Ohio, Monongahela and Allegheny Rivers, and their tributaries, in the DEP

Southwest Region. Table 5 is a list of the related monitoring station names with the ID numbers shown on the map, for those gauges that are located on the rivers. The green triangles in Figure 2 represent the monitoring stations whose data is presented in this report and the green highlighted names in Table 5 are associated with the stream gauges.

**Figure 2: DEP SW Region USGS Stream Gauges on the Ohio, Monongahela and Allegheny Rivers and Their Tributaries**



**Table 5: DEP SW Region USGS Stream Gauges on the Ohio, Monongahela and Allegheny Rivers**

STATION NUMBER	STATION NAME	RIVER
3075070	ELIZABETH, PA	MONONGAHELA RIVER
3063000	LOCK & DAM 8 AT POINT MARION, PA	MONONGAHELA RIVER
3072655	MASONTOWN, PA	MONONGAHELA RIVER
3075000	CHARLEROI, PA	MONONGAHELA RIVER
3049500	NATRONA, PA	ALLEGHENY RIVER
3086000	SEWICKLEY, PA	OHIO RIVER
3085734	EMSWORTH DAM LOWER POOL	OHIO RIVER
3108490	MONTGOMERY DAM & LOCKS AT OHIOVIEW, PA	OHIO RIVER



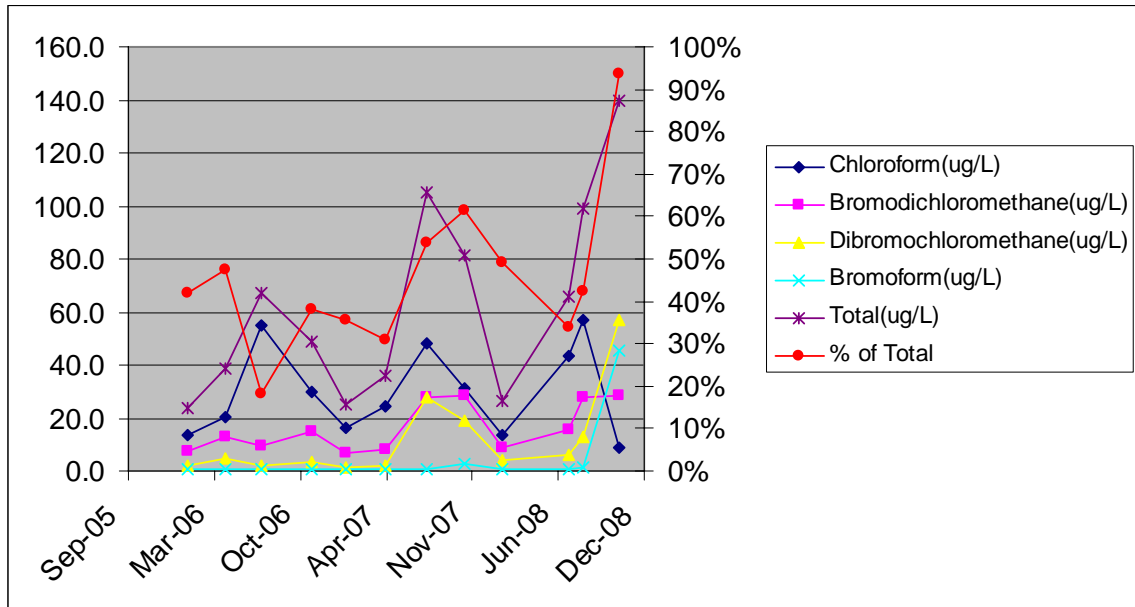
## STUDY RESULTS

The data is presented for each system by source. In order to better manage the size of this report, only one or two representative locations are shown for each system. These graphs represent typical speciation throughout the system. Tabular data for all systems and all sample locations is located in Appendix A. In Appendix A, the highest percentage of brominated species and highest TTHM value are highlighted in yellow for each sample location data set.

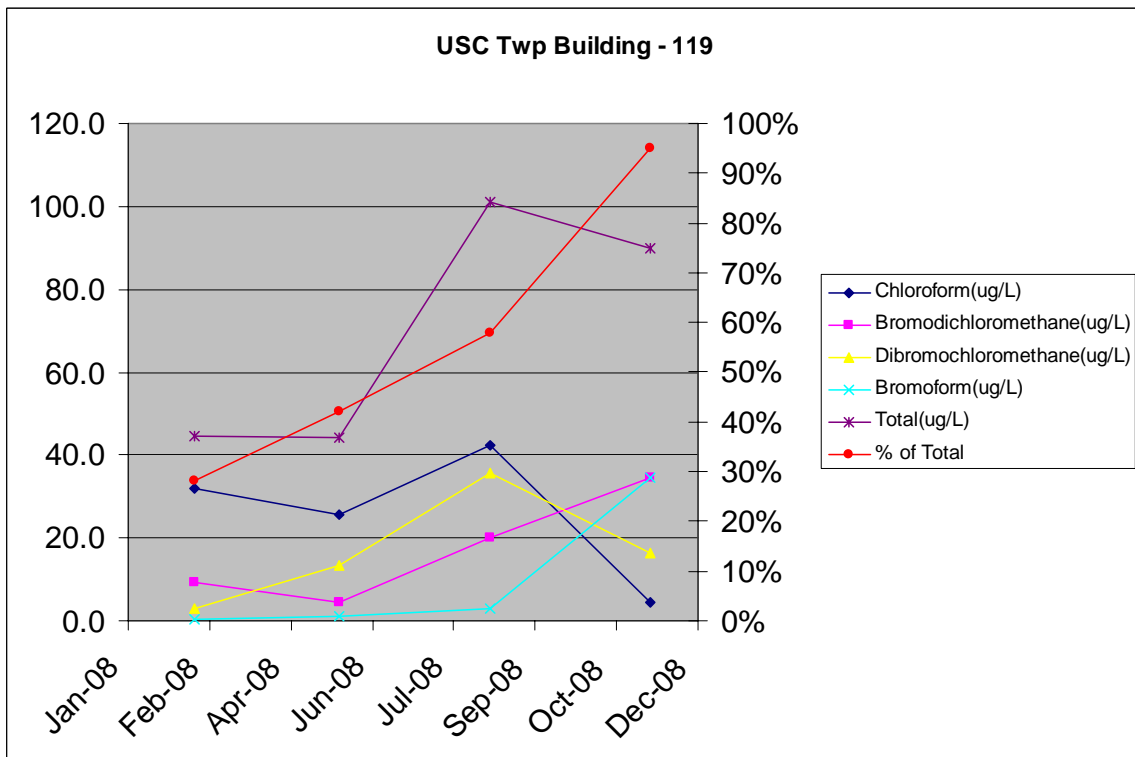
Flow data from one USGS monitoring station on each river is also presented graphically for the years 2005 through 2008.

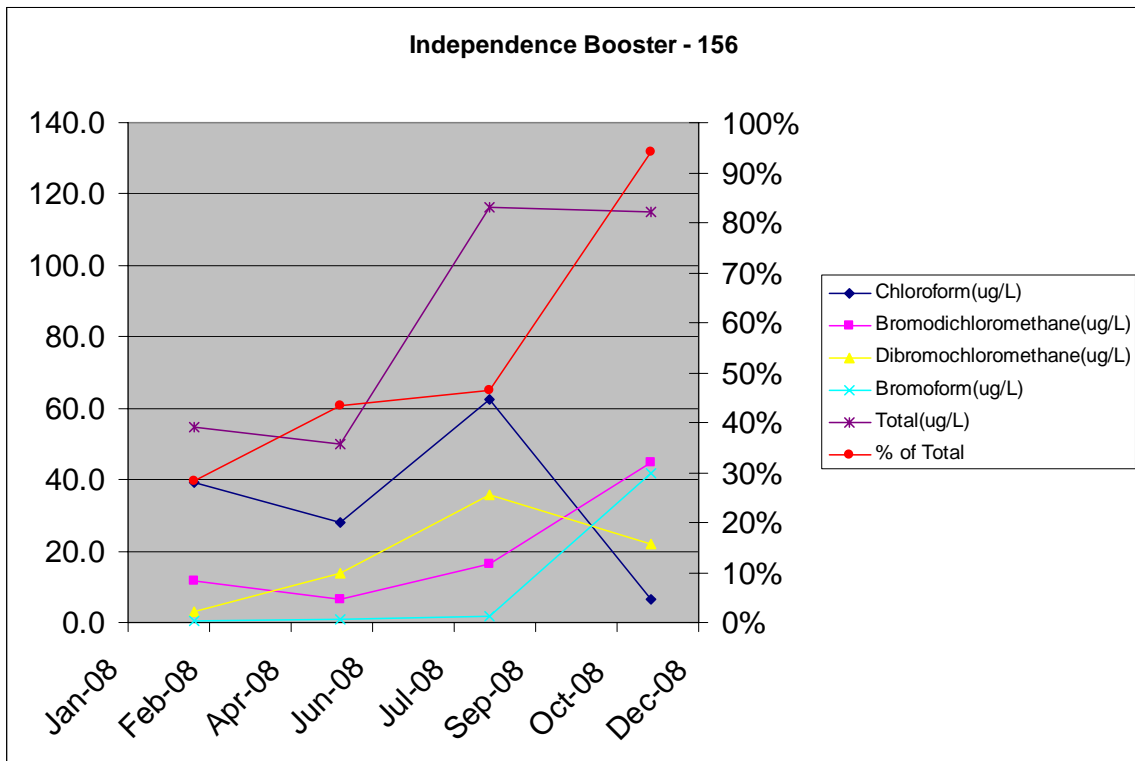
### Monongahela River

*Authority of the Borough of Charleroi*

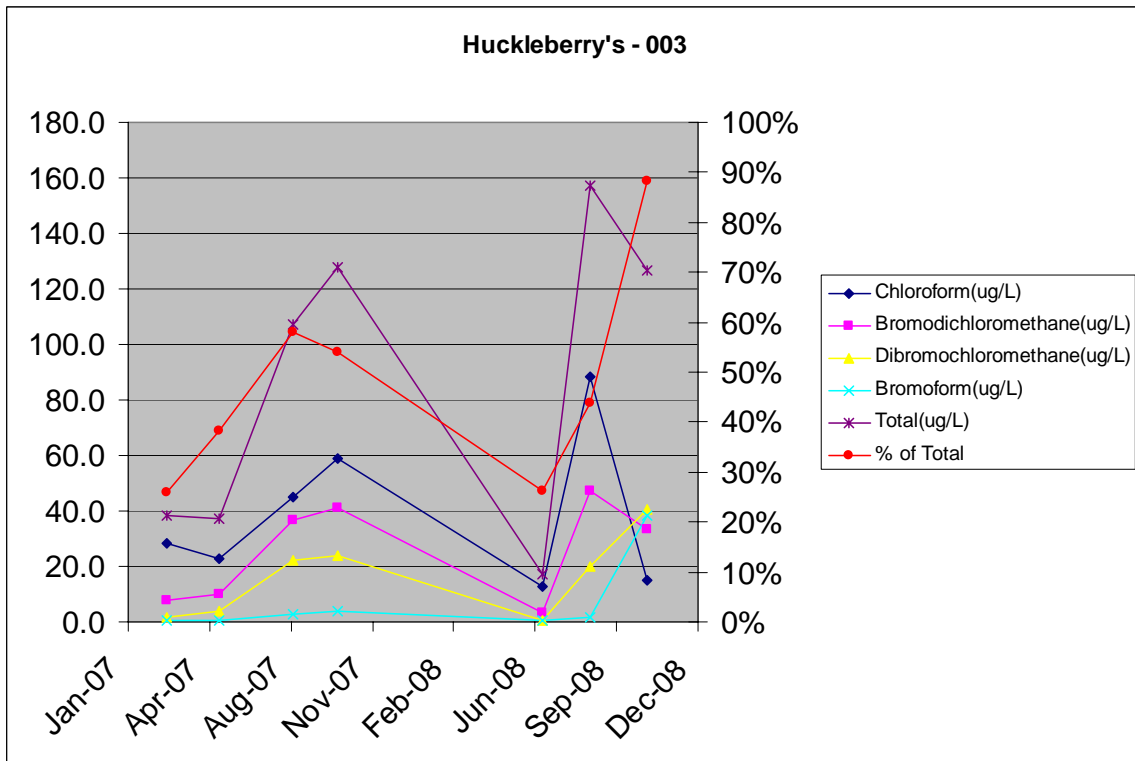


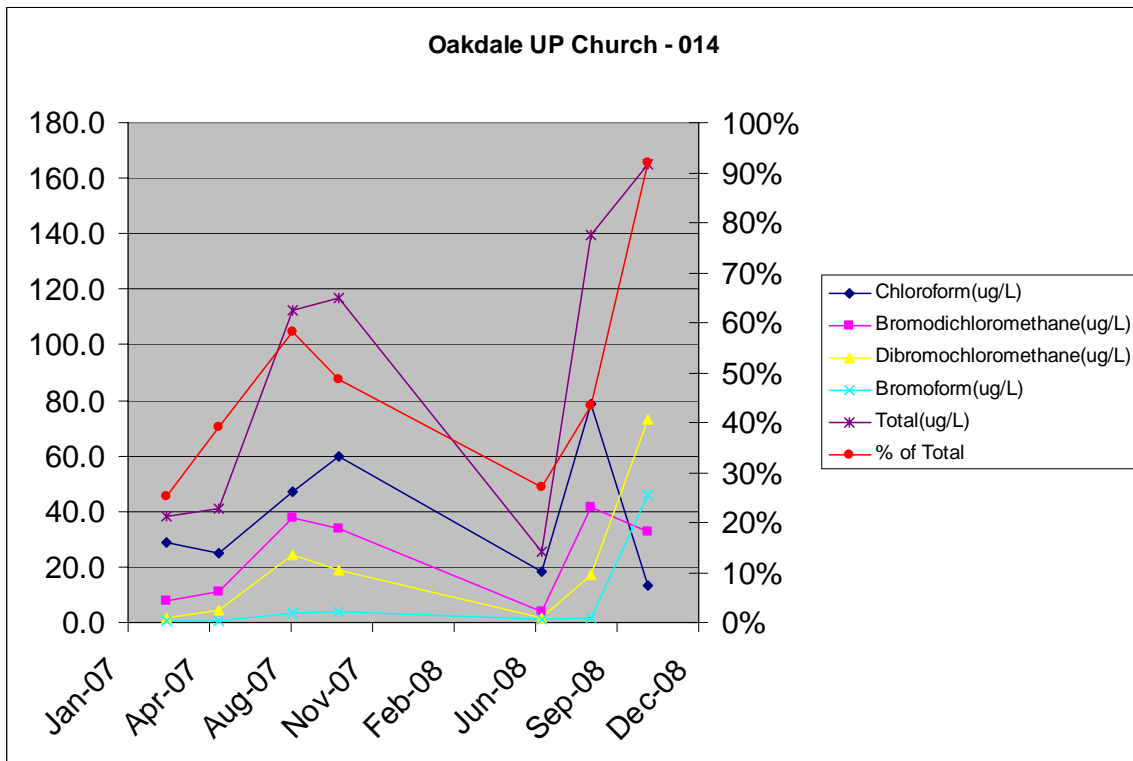
*PA American Water Company – Pittsburgh*





*Oakdale Borough*





**Discussion**

All three systems experienced a significant increase in the percentage of the TTHM that was brominated in the 4<sup>th</sup> quarter of 2008 (all sample results, including those not shown, indicated between 85% and 95% were brominated).

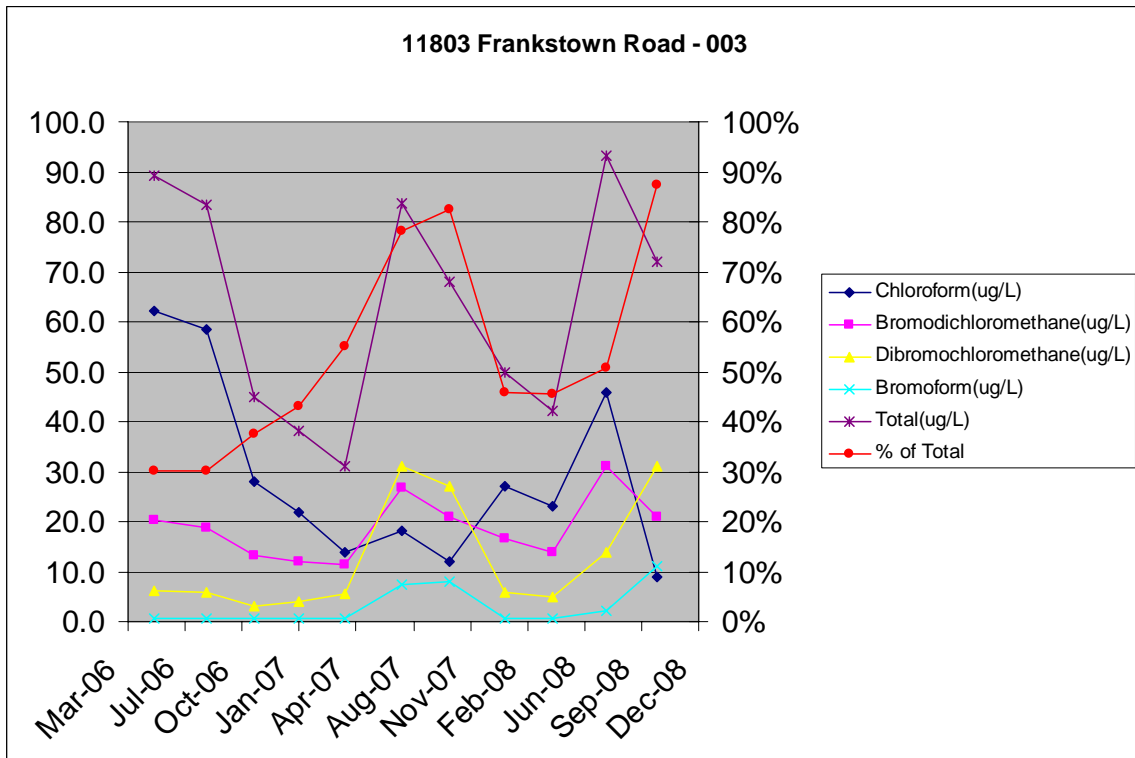
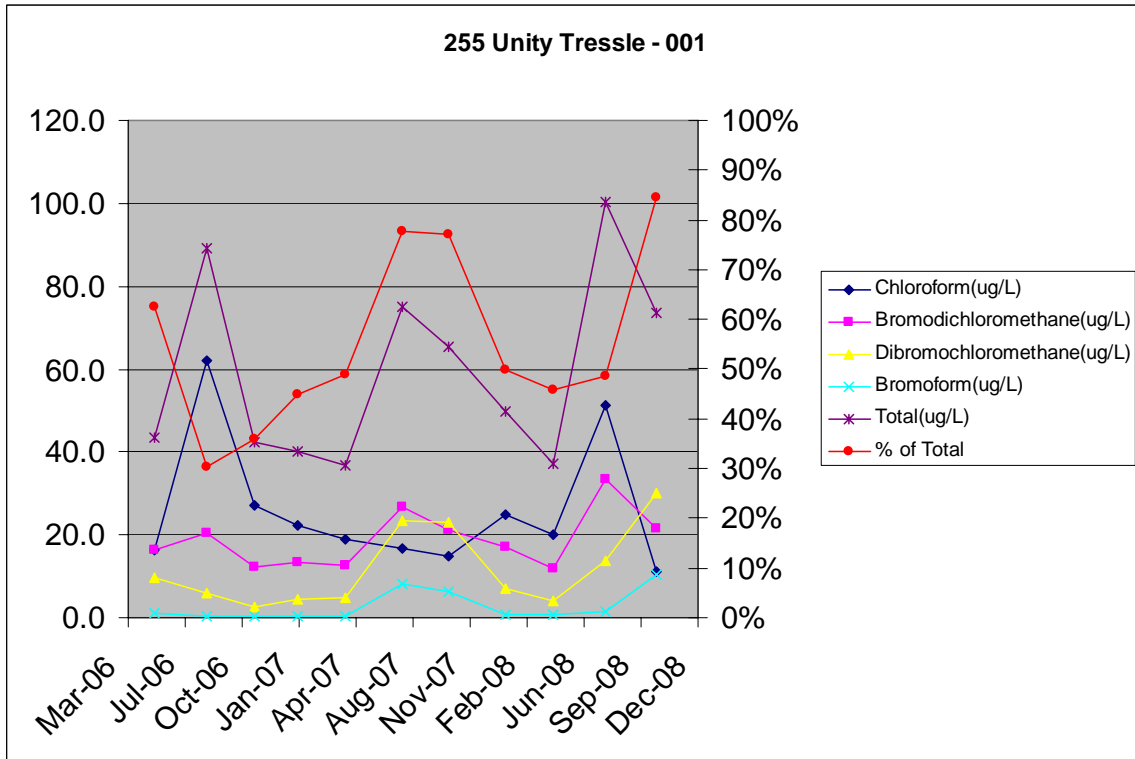
At the Authority of the Borough of Charleroi, the sample results for the 4<sup>th</sup> quarter 2008 showed, in conjunction with the increase in brominated species, the chloroform concentration decreased significantly. This would indicate a high bromide to NOM ratio since the speciation was predominantly brominated. Based on the data shown, the transfer of speciation to brominated species did lead to a significant increase in TTHMs, compared to the 3<sup>rd</sup> quarter 2008 results and historical data.

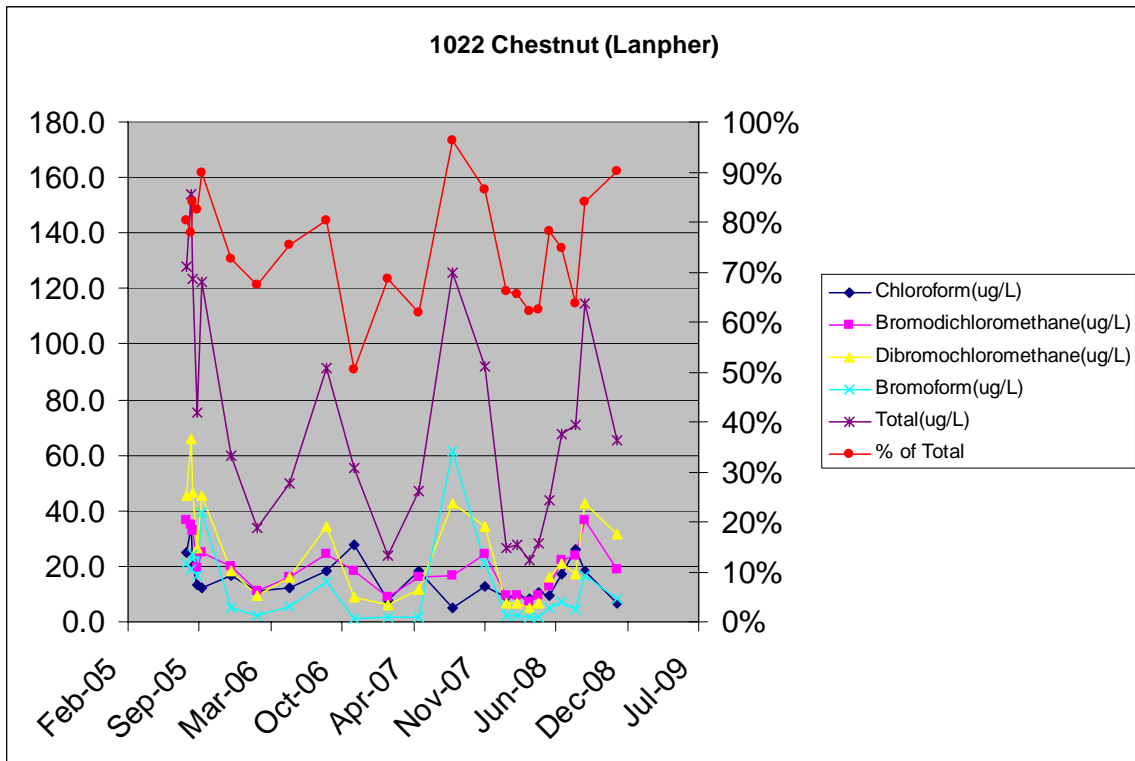
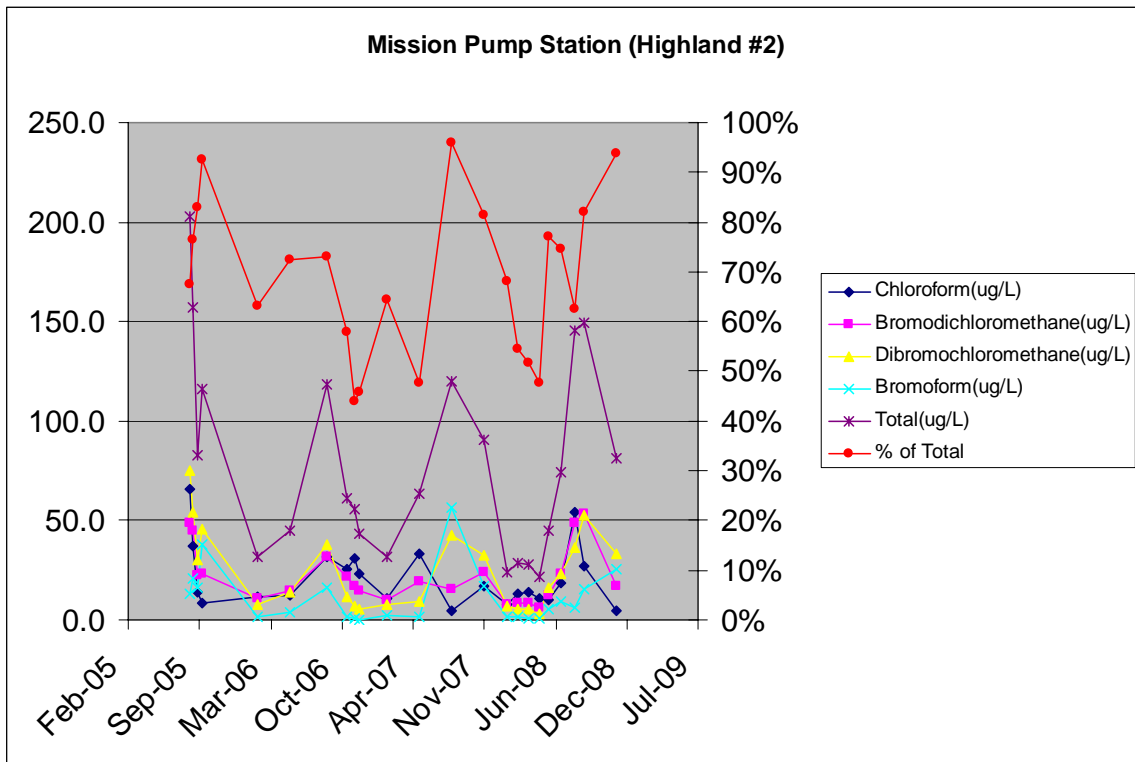
At the Pennsylvania American Water Company – Pittsburgh system, the sample results for the 4<sup>th</sup> quarter 2008 also showed, in conjunction with the increase in brominated species, the chloroform concentration decreased significantly, indicating a high bromide to NOM ratio since the speciation was predominantly brominated. Based on the data shown, the transfer of speciation to brominated species did not lead to an increase in TTHMs, compared to the 3<sup>rd</sup> quarter 2008 results. Although the brominated species appear to be trending upwards in the 3<sup>rd</sup> quarter 2008, which would indicate bromide in the source water, chloroform has the highest concentration of the four species of THMs.

At the Oakdale Borough consecutive system, the sample results for the 4<sup>th</sup> quarter 2008 also showed, in conjunction with the increase in brominated species, the chloroform concentration decreased significantly, indicating a high bromide to NOM ratio since the speciation was predominantly brominated. Based on the data shown, the transfer of speciation to brominated species did not lead to an increase in TTHMs at the Huckleberry’s sample location, compared to the 3<sup>rd</sup> quarter 2008 results or historical data. It did however produce the highest TTHM concentration at the Oakdale UP Church, compared to the historical data shown. Although the brominated species appear to be trending upwards in the 3<sup>rd</sup> quarter 2008 at both sites, which would indicate bromide in the source water, chloroform has the highest concentration of the four species of THMs.

# Allegheny River

Oakmont Borough Municipal Authority





**Discussion**

Both systems experienced an increase in the percentage of the TTHM that was brominated in the 4<sup>th</sup> quarter of 2008 (all sample results, including those not shown, indicated between 85% and 94% were brominated).

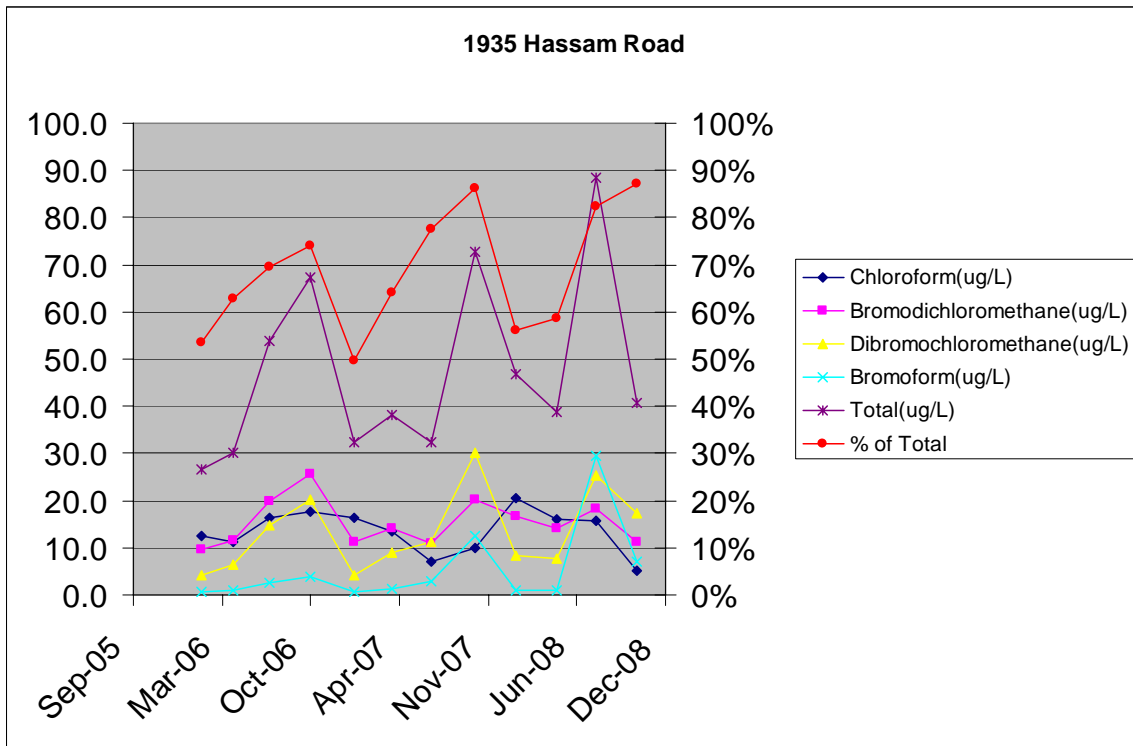
At the Oakmont Borough Municipal Authority, the sample results for the 4<sup>th</sup> quarter 2008 showed, in conjunction with the increase in brominated species, the chloroform concentration decreased significantly. This would indicate a high bromide to NOM ratio since the speciation was predominantly brominated. Based on the data shown, the

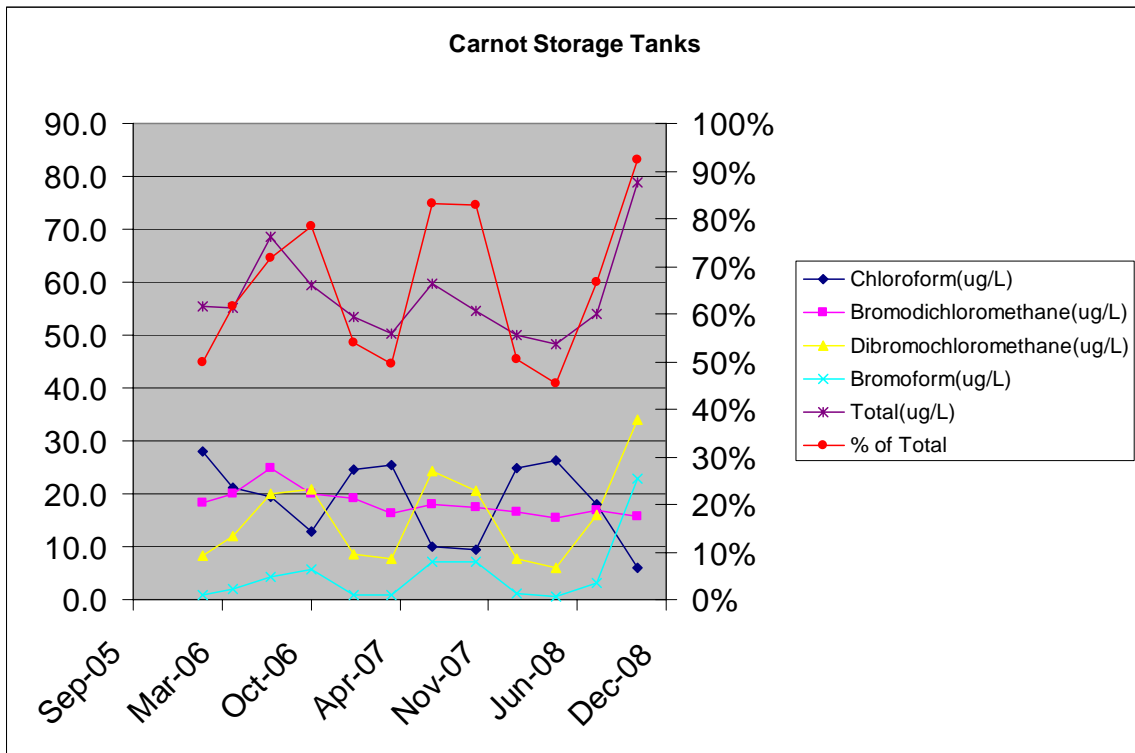
transfer of speciation to brominated species did not lead to an increase in TTHMs, compared to the 3<sup>rd</sup> quarter 2008 results or historical data. During 2007, the same pattern occurred with increased brominated species in the 4<sup>th</sup> quarter, but a lower TTHM result compared to the 3<sup>rd</sup> quarter, which was also predominantly brominated. The elevated 3<sup>rd</sup> quarter TTHMs during 2007 appear to be related to elevated bromide in the source water (i.e. elevated brominated species) compared to the elevated 3<sup>rd</sup> quarter 2008 TTHM results in which chloroform is present in the highest concentration. It is important to note that the Oakmont Borough Municipal Authority utilizes chloramines as their primary disinfectant from May 15<sup>th</sup> to November 15<sup>th</sup>. Therefore, the majority of the DBPs formed during this timeframe are formed in the treatment process, prior to chloramination.

Sample results for the 4<sup>th</sup> quarter 2008 from the Pittsburgh Water and Sewer Authority also showed, in conjunction with the increase in brominated species, the chloroform concentration decreased significantly. This would indicate a high bromide to NOM ratio since the speciation was predominantly brominated. Based on the data shown, the transfer of speciation to brominated species did not lead to an increase in TTHMs, compared to the 3<sup>rd</sup> quarter 2008 results. Samples taken during the 3<sup>rd</sup> quarter 2008, specifically August 19<sup>th</sup>, had results that also showed elevated brominated species (all sample results from August 19<sup>th</sup>, including those not shown, indicated between 82% and 84% were brominated). These results did produce a significant increase in TTHM. During 2007, the same pattern occurred with elevated TTHMs in the 3<sup>rd</sup> quarter, but in 2007 the percentage of brominated species was higher in the 3<sup>rd</sup> quarter compared to the 4<sup>th</sup> quarter results. Both of the elevated 3<sup>rd</sup> and 4<sup>th</sup> quarter 2007 TTHMs appear to be related to elevated bromide in the source water (i.e. elevated brominated species).

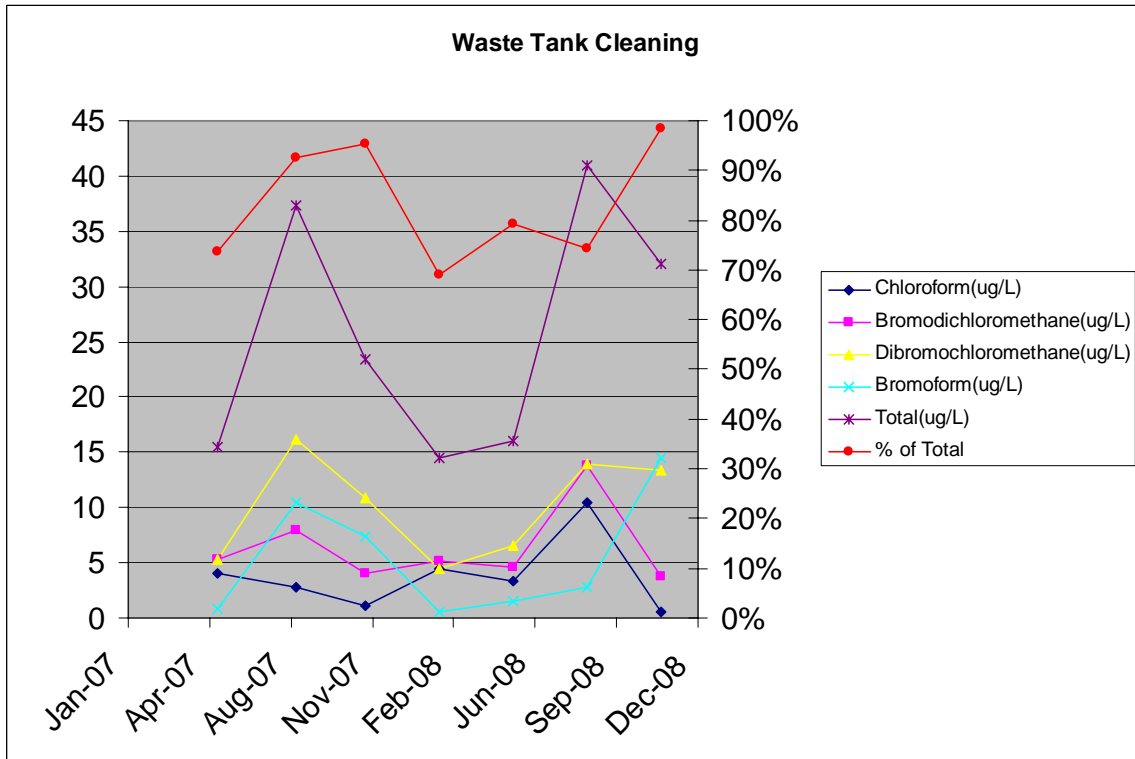
## Ohio River

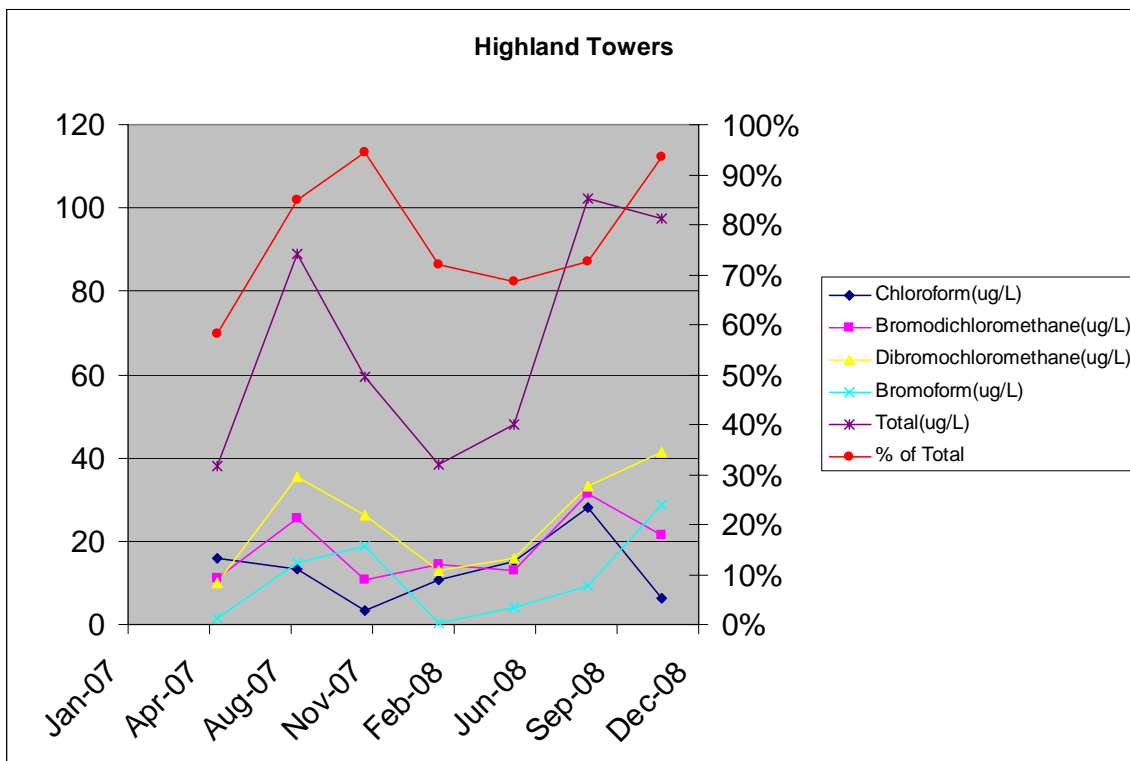
### *Moon Township Municipal Authority*





*Municipal Authority of the Township of Robinson*





### Discussion

Both systems experienced an increase in the percentage of the TTHM that was brominated in the 4<sup>th</sup> quarter of 2008 (all sample results, including those not shown, indicated between 87% and 98% were brominated).

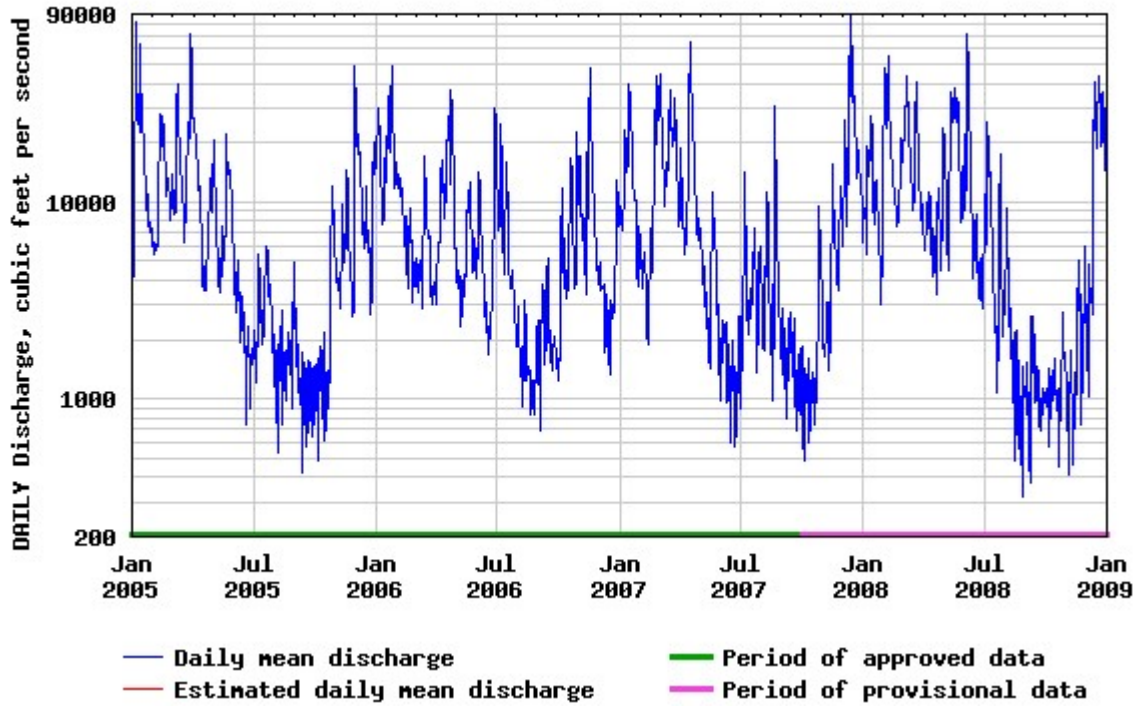
At the Moon Township Municipal Authority, the sample results for the 4<sup>th</sup> quarter 2008 showed, in conjunction with the increase in brominated species, the chloroform concentration decreased significantly. This would indicate a high bromide to NOM ratio since the speciation was predominantly brominated. Based on the data shown, the transfer of speciation to brominated species did not lead to an increase in TTHMs at one sample location, 1935 Hassam Road, but did at the other sample location, Carnot Storage Tanks. Compared to historical data, the increase in TTHMs at the Carnot Storage Tanks during the 4<sup>th</sup> quarter 2008 was significant. During 2006 and 2007, the same pattern occurred with increased brominated species in the 4<sup>th</sup> quarter and associated elevated TTHM results at only the 1935 Hassam Road sample location. The 3<sup>rd</sup> and 4<sup>th</sup> quarter 2007 sample results at the Carnot Storage Tanks were very similar, with elevated brominated speciation but only slightly elevated TTHMs.

At the Municipal Authority of the Township of Robinson, the sample results for the 4<sup>th</sup> quarter 2008 showed, in conjunction with the increase in brominated species, the chloroform concentration decreased significantly, indicating a high bromide to NOM ratio since the speciation was predominantly brominated. Based on the data shown, the increase in speciation to the brominated species in the 4<sup>th</sup> quarter 2008 did not lead to an increase in TTHMs, compared to the 3<sup>rd</sup> quarter 2008 results, where the THMs were also highly brominated. Compared to historical data, the increase in TTHMs at all sample locations, including those not shown, during the 3<sup>rd</sup> quarter 2008 was significant. During 2007, the same pattern occurred with increased brominated species in the 4<sup>th</sup> quarter, but a lower TTHM value compared to the 3<sup>rd</sup> quarter, where the THMs were highly brominated as well (all sample results, including those not shown, indicated between 84% and 93% were brominated).

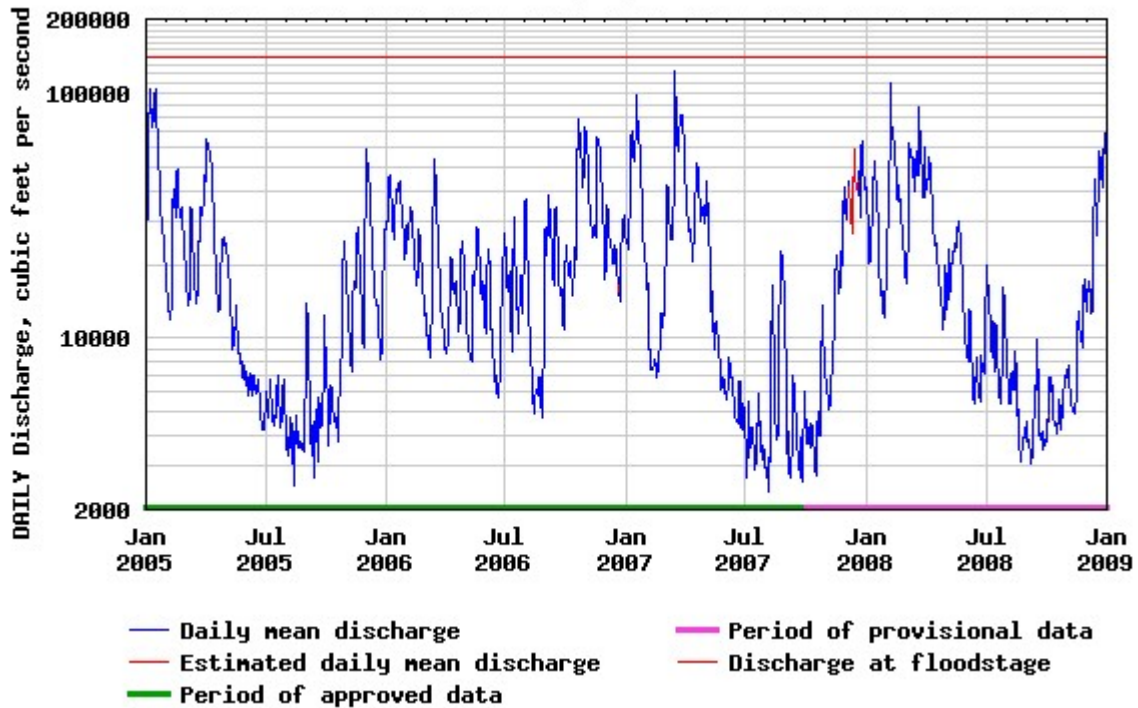


# River Flow Data

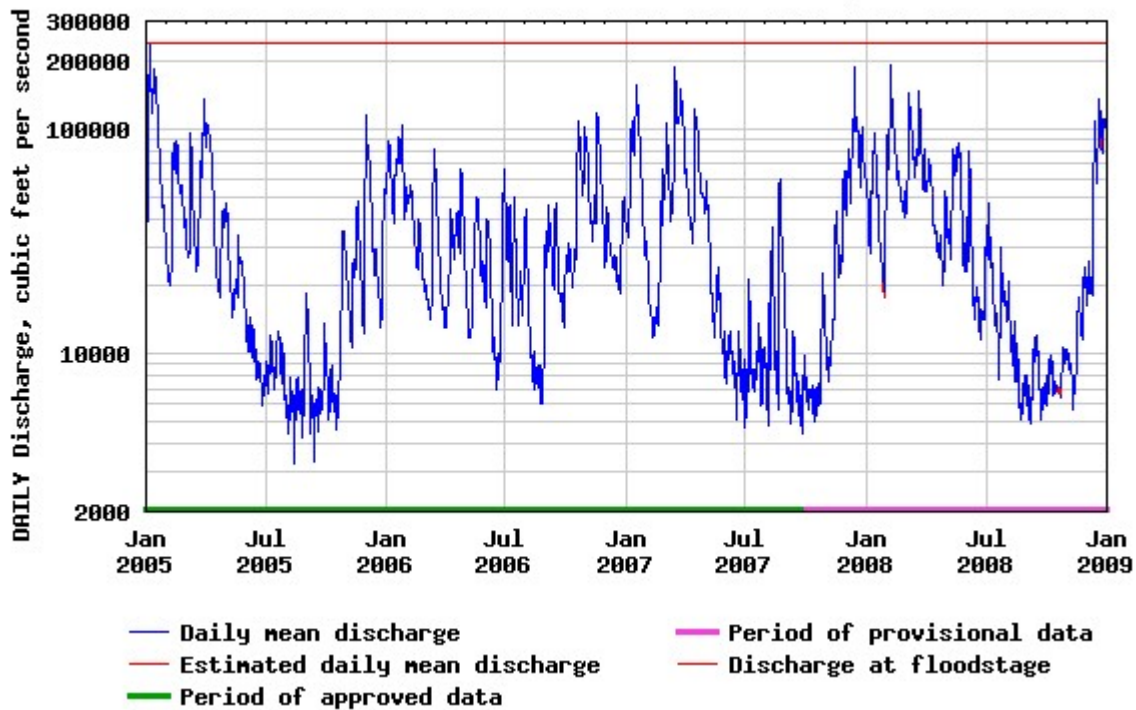
USGS 03075070 Monongahela River at Elizabeth, PA



USGS 03049500 Allegheny River at Natrona, PA



USGS 03086000 Ohio River at Sewickley, PA



**Discussion**

All three rivers have had significant seasonal changes in flow from 2005 though 2008. With the exception of occasional spikes during any given seasonal cycle, most likely due to precipitation or snow melt, the flows are typically lower during the warmer and typically dryer months (summer and early fall) and higher in the cooler and typically more precipitant months (late winter and spring).

The Monongahela River has very comparable seasonal high and low flows, with the exception of the summer and early fall of 2008, which, at times, had slightly lower than normal flows. The lower flows may have contributed to the increased concentrations of TDS, sulfates and, potentially, bromide.

The Allegheny and Ohio Rivers also have very comparable seasonal high and low flows. The exception is on the Ohio River during the summer and early fall of 2005 which, at times, had slightly lower than normal flows.

**Conclusion**

Overall, the systems that were used in this study have TTHM concentrations that are impacted by bromide in the source water at various times during the year. In some cases the TTHM concentration that was comprised of mostly brominated species produced the highest historical TTHM value. In conjunction, the systems on the Monongahela River appear to have been impacted directly by the source of the TDS and sulfate, which is most likely also a source of bromide. Elevated concentrations of bromide, as well as TDS and sulfates, may also have been impacted by low river flows during the 3<sup>rd</sup> and 4<sup>th</sup> quarters 2008, compared to historical seasonal flows. Without source water bromide sample results it is difficult to make a direct correlation between the TDS and sulfate event and the elevated brominated THM species. However, based on the speciation there appears to be a strong correlation between THM formation and elevated source water bromide concentrations in the Monongahela River.

The water systems on the Allegheny and Ohio Rivers have a more historical and seasonal cycle of brominated THM formation. As with the Monongahela, the source of the bromide contributing to the seasonal increases in brominated THMs is unknown;

although, there appears to be a correlation between low seasonal flows and increased brominated THM formation. During the 3<sup>rd</sup> and 4<sup>th</sup> quarter 2008, the drinking water systems on the Ohio River may have been impacted by the same source of bromide as the systems on the Monongahela River, since it feeds into the Ohio River.

As stated previously, it is important to note that THMs are, simply stated, a product of a reaction between a disinfectant (chlorine or monochloramine) and a precursor (natural organic matter (NOM) and bromide). In order to control DBP formation various parameters must be properly managed including the concentration of precursors, disinfectant dose and residual, time, temperature and pH. Although THM formation will tend towards the brominated species in the presence of bromide in the source water, overall formation is highly variable from drinking water system to system, even if source water characteristics are similar. Treatment techniques, treatment effectiveness and chemical dosages are factors affecting formation at a water treatment facility. Distribution system size, distribution system maintenance and water age are factors influencing formation in the distribution system.

When contemplating and investigating options to control DBP formation, it is important to remember that the primary function of water treatment and distribution system management is the removal or inactivation of pathogens and prevention of pathogenic contamination and consumption. Pathogens present an acute (conditions are severe and sudden in onset), and potentially widespread, health risk. DBPs, on the other hand, present a chronic (long-developing syndrome) health risk from continued exposure over an extended timeframe. Although the control of DBPs is an important aspect of water treatment and distribution, the treatment for the removal or inactivation of pathogens should not be compromised in an effort to reduce DBP formation.

**APPENDIX A  
MONONGAHELA RIVER**

**Charleroi**

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppm)	Total(ppb)	% of Total
1/23/06	13.8	7.2	2.3	0.5	23.8	42%
4/18/06	20.4	13.0	5.0	0.5	38.9	48%
7/12/06	54.9	9.4	2.2	0.5	67.0	18%
11/6/06	30.1	14.7	3.3	0.5	48.6	38%
1/22/07	16.4	6.9	1.6	0.5	25.4	35%
4/27/07	24.6	8.4	2.1	0.5	35.6	31%
7/30/07	48.5	28.1	28.1	0.7	105.3	54%
10/25/07	31.5	28.5	18.8	2.6	81.3	61%
1/22/08	13.5	8.5	4.0	0.5	26.5	49%
6/24/08	43.5	15.9	6.0	0.5	65.9	34%
7/30/08	57.0	28.0	13.0	1.2	99.2	43%
10/20/08	9.0	28.3	57.2	45.1	139.6	94%

**PA American - Pittsburgh**

*USC Twp Building - 119*

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
2/13/08	32.1	9.3	2.8	0.5	44.7	28%
5/12/08	25.7	4.4	13.2	1.0	44.3	42%
8/12/08	42.5	20.2	35.7	2.8	101.2	58%
11/19/08	4.5	34.7	16.2	34.6	90.0	95%

*PAWC - Valley Operations Center - 145*

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
2/13/08	36.1	11.9	3.2	0.5	51.7	30%
5/12/08	26.2	4.5	14.5	1.0	46.2	43%
8/12/08	47.0	19.1	34.9	2.6	103.6	55%
11/19/08	5.6	34.7	16.7	32.9	89.9	94%

*Independence Booster - 156*

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
2/13/08	39.2	11.8	3.2	0.5	54.7	28%
5/12/08	28.2	6.6	14.0	1.0	49.8	43%
8/12/08	62.4	16.4	35.7	1.8	116.3	46%
11/19/08	6.6	44.8	22.1	41.7	115.2	94%

*Malone Ridge Booster - 136*

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
2/13/08	38.7	12.6	3.6	0.5	55.4	30%
5/12/08	20.4	5.1	12.5	1.0	39.0	48%
8/12/08	59.2	19.0	37.3	2.5	118.0	50%
11/19/08	4.4	15.4	32.1	33.2	85.1	95%

# Appendix A

*Independence Booster – 156*

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
2/13/08	44.2	10.9	2.5	0.5	58.1	24%
5/12/08	51.5	5.3	19.0	1.0	76.8	33%
8/12/08	58.3	19.1	37.2	2.2	116.8	50%
11/19/08	5.2	14.9	11.8	7.3	39.2	87%

*Malone Ridge Booster – 136*

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
2/13/08	46.3	13.7	3.4	0.5	63.9	28%
5/12/08	51.4	4.5	17.1	1.0	74.0	31%
8/12/08	55.0	16.5	34.6	1.9	108.0	49%
11/19/08	6.3	16.5	14.0	7.6	44.4	86%

*Homestead PRV Station - 151*

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
2/13/08	44.2	10.7	2.4	0.5	57.8	24%
5/12/08	51.0	4.2	18.0	1.0	74.2	31%
8/12/08	49.9	15.7	32.1	1.7	99.4	50%
11/19/08	4.6	12.5	10.1	6.0	33.3	86%

*Waterways Plumbing - 138*

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
2/13/08	45.9	13.4	3.4	0.5	63.2	27%
5/12/08	55.6	4.3	16.4	1.0	77.3	28%
8/12/08	52.8	15.3	32.1	1.8	102.0	48%
11/19/08	6.8	17.1	14.1	7.9	45.9	85%

## Oakdale Borough (PA American Pittsburgh Consecutive)

*Oakdale Maintenance Garage - 012*

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
3/7/07	30.0	8.1	1.8	0.5	40.4	26%
5/10/07	28.0	11.0	4.3	0.5	43.8	36%
8/8/07	48.2	37.4	21.8	2.7	110.1	56%
10/3/07	62.0	44.0	22.0	3.9	131.9	53%
6/9/08	28.7	6.7	2.1	1.0	38.5	25%
8/7/08	90.8	45.4	18.6	1.4	156.2	42%
10/17/08	14.6	39.0	78.8	61.2	193.6	92%

*Huckleberry's - 003*

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
3/7/07	28.6	7.8	1.7	0.5	38.6	26%
5/10/07	23.0	9.8	4.0	0.5	37.3	38%
8/8/07	45.2	36.9	22.3	3.0	107.4	58%
10/3/07	59.0	41.0	24.0	4.0	128.0	54%
6/9/08	12.6	3.5	0.5	0.5	17.1	26%
8/7/08	88.4	47.3	19.8	1.6	157.1	44%
10/17/08	14.9	33.5	40.4	38.1	126.9	88%

# Appendix A

*Oakdale UP Church - 014*

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
3/7/07	28.6	7.6	1.6	0.5	38.3	25%
5/10/07	25.0	11.0	4.5	0.5	41.0	39%
8/8/07	46.9	37.5	24.4	3.5	112.3	58%
10/3/07	60.0	34.0	19.0	3.7	116.7	49%
6/9/08	18.5	4.0	1.8	1.1	25.4	27%
8/7/08	78.8	41.7	17.4	1.4	139.3	43%
10/17/08	13.2	32.6	73.3	46.2	165.3	92%

*405 Clinton Ave. Ext. - 011*

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
3/7/07	32.8	10.1	2.4	0.5	45.8	28%
5/10/07	32.0	12.0	4.5	0.5	49.0	35%
8/8/07	46.8	34.4	19.6	2.5	103.3	55%
10/3/07	64.0	40.0	22.0	3.7	129.7	51%
6/9/08	27.8	6.8	2.7	1.2	38.5	28%
8/7/08	88.0	45.8	19.4	1.6	154.8	43%
10/17/08	14.4	39.6	71.1	55.9	181.0	92%

## ALLEGHENY RIVER

## Pittsburgh Water and Sewer Authority

Mission Pump St. (Highland #2)

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
8/11/05	66.1	49.0	75.2	12.8	203.1	67%
8/16/05	37.2	45.0	54.3	20.6	157.1	76%
8/30/05	14.2	22.5	29.8	16.1	82.5	83%
9/13/05	8.8	23.3	45.6	38.3	115.9	92%
2/14/06	11.8	10.5	8.1	1.5	31.8	63%
5/16/06	12.4	14.3	14.0	4.1	44.9	72%
8/29/06	31.9	31.9	38.0	16.3	118.1	73%
10/25/06	25.6	22.0	11.7	1.5	60.9	58%
11/14/06	31.3	16.7	7.1	0.8	55.9	44%
11/29/06	23.6	14.6	5.3	0.0	43.5	46%
2/15/07	11.2	10.2	7.5	2.5	31.4	64%
5/15/07	33.0	19.5	9.5	1.3	63.3	48%
8/14/07	5.0	15.8	42.7	56.6	120.1	96%
11/14/07	16.7	24.4	32.6	16.7	90.3	82%
1/15/08	7.7	7.4	7.2	1.8	24.1	68%
2/14/08	12.9	8.8	5.3	1.3	28.3	55%
3/18/08	13.6	8.3	5.2	1.1	28.1	52%
4/15/08	11.2	6.0	3.5	0.8	21.5	48%
5/13/08	10.3	12.6	16.2	5.7	44.8	77%
6/17/08	18.9	23.0	23.3	9.4	74.5	75%
7/24/08	54.5	49.0	36.4	5.9	145.8	63%
8/19/08	26.9	53.5	53.0	15.9	149.2	82%
11/18/08	5.0	17.3	33.3	25.9	81.4	94%

Bedford Fire House

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
8/1/05	25.9	34.7	44.9	20.0	125.5	79%
8/11/05	43.1	36.7	66.0	12.9	158.7	73%
8/16/05	18.2	30.8	46.1	26.1	121.2	85%
8/30/05	7.7	13.4	24.4	18.3	63.8	88%
9/13/05	19.0	27.9	44.0	27.3	118.3	84%
2/14/06	8.0	8.4	7.1	1.6	25.0	68%
5/16/06	6.4	12.8	15.2	7.3	41.8	85%
8/29/06	13.8	21.9	35.7	14.9	86.2	84%
11/14/06	21.4	14.2	7.7	0.9	44.2	51%
2/15/07	5.5	7.1	6.4	2.5	21.6	75%
5/15/07	18.5	14.4	11.2	1.8	45.9	60%
8/14/07	5.8	16.7	40.5	49.1	112.1	95%
11/14/07	12.2	22.1	25.4	12.6	72.3	83%
1/15/08	8.7	7.6	6.8	2.0	25.1	65%
2/14/08	10.7	7.6	4.3	0.8	23.4	54%
3/18/08	8.1	6.4	4.7	1.5	20.7	61%
4/15/08	10.7	8.4	6.8	1.3	27.2	61%
5/13/08	9.1	10.4	13.7	5.3	38.5	76%
6/17/08	11.0	17.0	22.6	10.6	61.2	82%
7/24/08	41.9	43.0	32.0	6.6	123.6	66%
8/19/08	15.8	27.0	39.4	14.6	96.8	84%
11/18/08	5.6	15.7	26.5	20.1	67.8	92%

# Appendix A

1022 Chestnut (Lanpher)

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
8/1/05	25.1	36.4	45.6	20.9	128.0	80%
8/11/05	34.4	35.1	66.1	18.7	154.2	78%
8/16/05	19.8	32.9	46.4	24.5	123.6	84%
8/30/05	13.2	19.2	26.7	16.4	75.4	83%
9/13/05	12.4	25.1	45.4	39.2	122.1	90%
12/2/05	16.4	20.1	18.1	5.1	59.7	73%
2/14/06	11.0	11.3	9.4	1.9	33.6	67%
5/16/06	12.3	16.1	16.1	5.3	49.8	75%
8/29/06	18.1	24.5	34.5	14.4	91.5	80%
11/14/06	27.5	18.3	8.8	1.0	55.5	51%
2/15/07	7.5	8.8	6.0	1.6	24.0	69%
5/15/07	18.1	16.0	11.6	1.5	47.2	62%
8/14/07	4.8	16.8	42.7	61.3	125.6	96%
11/14/07	12.5	24.1	34.2	21.0	91.7	86%
1/15/08	9.0	9.3	6.4	2.1	26.7	66%
2/14/08	9.4	9.2	6.7	2.1	27.4	66%
3/18/08	8.4	7.0	5.2	1.6	22.2	62%
4/15/08	10.6	9.4	6.9	1.4	28.4	63%
5/13/08	9.5	12.8	16.1	5.1	43.6	78%
6/17/08	17.2	22.1	21.0	7.5	67.8	75%
7/24/08	25.8	24.0	16.9	4.3	71.1	64%
8/19/08	18.5	36.5	42.7	16.9	114.5	84%
11/18/08	6.5	18.9	31.8	8.2	65.4	90%

Homestead Fire House

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
8/1/05	22.5	32.6	44.2	20.9	120.2	81%
8/11/05	46.6	33.9	56.7	12.9	150.0	69%
8/16/05	22.5	28.0	39.4	25.2	115.1	80%
8/30/05	8.4	12.9	21.3	16.6	59.1	86%
9/15/05	38.2	36.9	49.4	31.9	156.4	76%
2/14/06	10.2	9.7	8.6	1.9	30.4	67%
5/16/06	8.3	13.4	15.5	6.5	43.6	81%
8/29/06	15.3	23.1	29.6	12.6	80.5	81%
11/14/06	23.7	14.7	8.6	1.1	48.1	51%
2/15/07	3.3	6.9	7.1	3.4	20.7	84%
5/15/07	18.2	12.2	10.9	1.6	43.0	58%
8/14/07	6.7	12.9	32.8	45.4	97.8	93%
11/14/07	9.2	17.6	26.1	16.4	69.4	87%
1/15/08	9.1	8.4	7.1	1.9	26.5	66%
2/14/08	12.2	8.3	5.4	1.5	27.5	55%
3/18/08	9.5	7.1	5.3	1.4	23.3	59%
4/15/08	10.2	8.3	7.2	1.8	27.4	63%
5/13/08	10.7	11.1	13.3	3.9	39.0	72%
6/17/08	7.8	8.8	9.8	3.4	29.8	74%
7/24/08	33.0	33.0	29.8	7.4	103.3	68%
8/19/08	12.8	24.2	30.7	11.7	79.4	84%
11/18/08	7.5	17.8	28.8	16.3	70.3	89%



**Appendix A**  
**Oakmont Borough Municipal Authority**

*255 Unity Tressle - 001*

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
5/9/06	16.3	16.5	9.8	1.0	43.6	63%
8/8/06	62.1	20.4	6.1	0.5	89.1	30%
11/1/06	27.1	12.1	2.6	0.5	42.3	36%
1/16/07	22.2	13.2	4.3	0.5	40.2	45%
4/9/07	18.8	12.6	5.0	0.5	36.9	49%
7/17/07	16.7	26.9	23.3	8.1	75.0	78%
10/8/07	15.0	21.0	23.0	6.5	65.5	77%
1/14/08	25.0	17.2	6.9	0.6	49.7	50%
4/7/08	20.1	12.0	4.0	0.9	37.0	46%
7/8/08	51.4	33.6	13.6	1.6	100.2	49%
10/7/08	11.3	21.5	30.1	10.5	73.4	85%

*238 McClure Drive - 002*

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
5/9/06	16.3	16.5	9.8	1.0	43.6	63%
8/8/06	62.1	20.4	6.1	0.5	89.1	30%
11/1/06	27.1	12.1	2.6	0.5	42.3	36%
1/16/07	22.2	13.2	4.3	0.5	40.2	45%
4/9/07	18.8	12.6	5.0	0.5	36.9	49%
7/17/07	16.7	26.9	23.3	8.1	75.0	78%
10/8/07	15.0	21.0	23.0	6.5	65.5	77%
1/14/08	25.0	17.2	6.9	0.6	49.7	50%
4/7/08	20.1	12.0	4.0	0.9	37.0	46%
7/8/08	51.4	33.6	13.6	1.6	100.2	49%
10/7/08	11.3	21.5	30.1	10.5	73.4	85%

*11803 Frankstown Road - 003*

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
5/9/06	62.1	20.4	6.1	0.5	89.1	30%
8/8/06	58.4	18.9	5.7	0.5	83.5	30%
11/1/06	28.0	13.2	3.1	0.5	44.8	38%
1/16/07	21.7	12.0	3.9	0.5	38.1	43%
4/9/07	14.0	11.3	5.4	0.5	31.2	55%
7/17/07	18.2	26.9	31.1	7.4	83.6	78%
10/8/07	12.0	21.0	27.0	8.1	68.1	82%
1/14/08	27.0	16.5	5.8	0.5	49.8	46%
4/7/08	23.0	13.9	4.8	0.5	42.2	45%
7/8/08	46.0	31.2	13.9	2.2	93.3	51%
10/7/08	9.0	20.8	31.1	11.2	72.1	88%

*Best Wholesale Tire - 004*

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
5/9/06	59.4	19.4	5.7	0.5	85.0	30%
8/8/06	61.4	18.9	5.5	0.5	86.3	29%
11/1/06	29.7	14.4	3.6	0.5	48.2	38%
1/16/07	29.2	17.4	6.4	0.5	53.5	45%
4/9/07	17.5	12.4	5.3	0.5	35.7	51%
7/17/07	18.6	27.9	32.8	8.3	87.6	79%
10/8/07	16.0	22.0	25.0	7.1	70.1	77%
1/14/08	25.8	15.8	6.4	0.5	48.5	47%
4/7/08	22.5	13.8	4.4	0.5	41.2	45%
7/8/08	42.3	31.6	18.3	3.2	95.4	56%
10/7/08	10.8	21.8	29.4	9.8	71.8	85%

**OHIO RIVER**

**Moon Township Municipal Authority**

*1935 Hassam Road*

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
2/7/06	12.4	9.7	4.1	0.5	26.8	54%
4/18/06	11.2	11.5	6.4	1.1	30.1	63%
7/10/06	16.3	20.0	14.9	2.5	53.7	70%
10/10/06	17.5	25.6	20.2	3.9	67.2	74%
1/16/07	16.3	11.3	4.3	0.5	32.4	50%
4/10/07	13.6	14.0	9.1	1.3	38.0	64%
7/10/07	7.2	10.9	11.3	2.8	32.2	78%
10/16/07	10.0	20.3	30.1	12.4	72.8	86%
1/15/08	20.6	16.8	8.4	1.0	46.8	56%
4/15/08	16.0	14.2	7.6	0.9	38.7	59%
7/15/08	15.6	18.2	25.2	29.4	88.4	82%
10/14/08	5.2	11.2	17.4	7.0	40.8	87%

*1000 Stoop Ferry Road*

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
2/7/06	11.7	10.0	4.5	0.5	26.6	56%
4/18/06	10.1	8.8	4.0	0.6	23.5	57%
7/10/06	12.4	16.1	11.0	1.7	41.2	70%
10/10/06	11.4	18.5	15.5	3.2	48.6	77%
1/16/07	19.3	13.3	5.2	0.6	38.4	50%
4/10/07	12.7	12.8	8.4	1.3	35.2	64%
7/10/07	6.0	9.9	10.1	2.3	28.3	79%
10/16/07	5.8	13.0	18.5	8.0	45.3	87%
1/15/08	17.2	12.2	5.7	0.8	35.9	52%
4/15/08	13.9	12.3	6.5	0.8	33.5	59%
7/15/08	9.9	11.0	9.6	1.5	32.0	69%
10/14/08	3.7	9.5	17.6	10.0	40.8	91%

*1700 Beaver Road*

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
2/7/06	16.0	10.5	3.9	0.5	30.9	48%
4/18/06	17.3	19.4	13.1	0.5	50.3	66%
7/10/06	19.1	20.0	14.0	2.2	55.3	65%
10/10/06	15.8	23.3	20.2	4.5	63.8	75%
1/16/07	22.1	15.5	6.0	0.7	44.3	50%
4/10/07	25.0	14.3	6.1	0.5	45.9	46%
7/10/07	8.3	14.5	18.3	5.3	46.4	82%
10/16/07	10.8	19.9	19.9	8.9	59.5	82%
1/15/08	19.5	12.8	5.9	0.9	39.1	50%
4/15/08	15.2	13.4	7.2	0.9	36.7	59%
7/15/08	13.3	12.8	9.5	1.5	37.1	64%
10/14/2008	4.2	11.1	18.7	9.2	43.2	90%

*Carnot Storage Tank*

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
2/7/06	27.9	18.4	8.3	0.9	55.5	50%
4/18/06	21.1	20.1	12.1	1.9	55.2	62%
7/10/06	19.4	25.0	19.9	4.2	68.5	72%
10/10/06	12.9	20.1	20.8	5.6	59.4	78%
1/16/07	24.7	19.1	8.7	1.0	53.5	54%
4/10/07	25.3	16.3	7.8	0.8	50.2	50%
7/10/07	10.1	18.1	24.3	7.1	59.6	83%
10/16/07	9.4	17.5	20.6	7.1	54.6	83%
1/15/08	24.8	16.5	7.7	1.1	50.1	50%
4/15/08	26.4	15.3	6.1	0.5	48.3	45%
7/15/08	18.0	17.0	15.9	3.1	54.0	67%
10/14/2008	6.1	15.7	34.0	23.0	78.8	92%

Appendix A

**Municipal Authority of the Township of Robinson**

*Waste Tank Cleaning*

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
5/7/07	4.1	5.3	5.3	0.8	15.5	74%
8/13/07	2.8	8	16.1	10.5	37.4	93%
11/5/07	1.1	4.1	10.8	7.4	23.4	95%
2/4/08	4.5	5.1	4.4	0.5	14.5	69%
5/5/08	3.3	4.6	6.6	1.5	16.0	79%
8/4/08	10.5	13.8	13.9	2.8	41.0	74%
11/3/08	0.5	3.7	13.4	14.5	32.1	98%

*Robinson Public Works*

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
5/7/07	15	11	9.8	1.2	37.0	59%
8/13/07	9	18.9	33.7	18.4	80.0	89%
11/5/07	8.3	21	45.7	31.5	106.5	92%
2/4/08	7.5	9.1	6.2	0.9	23.7	68%
5/5/08	5.1	6.2	7.3	1.5	20.1	75%
8/4/08	19.1	20.9	19.7	3.5	63.2	70%
11/3/08	1.5	8.6	22.4	19.0	51.5	97%

*Highland Towers*

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
5/7/07	16	11	9.9	1.3	38.2	58%
8/13/07	13.4	25.3	35.6	14.8	89.1	85%
11/5/07	3.3	10.8	26.3	19	59.4	94%
2/4/08	10.8	14.3	12.9	0.5	38.5	72%
5/5/08	15.1	13.0	16.0	3.9	48.0	69%
8/4/08	27.9	31.5	33.4	9.3	102.1	73%
11/3/08	6.2	21.3	41.2	28.8	97.5	94%

*MATR Office*

Date	Chloroform(ppb)	Bromodichloromethane(ppb)	Dibromochloromethane(ppb)	Bromoform(ppb)	Total(ppb)	% of Total
05/07/07	17	11	11	1.5	40.5	58%
08/13/07	15.3	26	37	15.5	93.8	84%
11/05/07	6.9	18.4	40.5	28.2	94.0	93%
2/4/08	11.9	15.3	14.5	0.7	42.4	72%
5/5/08	20.0	14.3	16.2	3.6	54.1	63%
8/4/08	32.4	32.6	33.4	9.0	107.4	70%