National Air Toxics Trends Study
Grand Junction, Colorado

January through December 2010

1876

Colorado Department
of Public Health
and Environment

Prepared by the Air Pollution Control Division

Technical Services Program

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I. EXECUTIVE SUMMARY

The Grand Junction air toxics monitors were originally established as a part of the Pilot Study for the National Air Toxics Trends Sites (NATTS). The network was created by the Environmental Protection Agency (EPA) in an effort to gather data that were suitable for identifying trends in air toxics concentration levels. Grand Junction was one of the five "rural" sites selected for the study initially. Since that time, the EPA has reconsidered, and decided that the site is more indicative of urban concentrations, and has changed the designation of the site from rural to urban.

Most of the compounds detected at Grand Junction in 2010 are found in urban air nationwide. There do not appear to be any compounds of local significance. The majority of compounds can be related to motor vehicle sources. These include formaldehyde, benzene, toluene, ethylbenzene, xylenes, and styrene. Chloroflourocarbons are also present, including chloromethane, dichlorodifluoromethane, trichlorofluoromethane, and trichlorotrifluoroethane. Polycyclic aromatic hydrocarbon compounds naphthalene, phenanthrene and acenaphthene are frequently detected.

This report has two companion documents. The report, "Documentation for Grand Junction Urban Air Toxics Trends Monitoring Locations – Site Maps and Photographs" provides information concerning the two air monitoring sites discussed in this report. The document, "Air Toxics Summary: Compounds Contributing to Cancer and Non-cancer Risks – Overview of Sources and Health Effects," provides a brief summary of many of the compounds monitored. This report discusses the chemical formula, sources and uses of each compound. The companion report also profiles potential health effects, such as carcinogenicity, the compound's potential to cause birth defects, and whether it damages target organs in the body.

II. INTRODUCTION

Background

The NATTS Network collects ambient air toxics monitoring data as a part of the Urban Air Toxic Strategy (UATS). Under Section 112 of the Clean Air Act (CAA), the EPA established a list of 188 toxic air pollutants, also known as hazardous air pollutants, or HAPs. These are pollutants that are known, or suspected, to cause cancer, or other major health issues. People who are exposed to these HAPs at sufficient concentration levels may have an increased chance of getting cancer, damaging their immune system, etc. Most air toxics originate from mobile sources, like cars, trucks, or buses, as well as stationary sources, such as factories, refineries, and power plants. Some air toxics also come from indoor sources as well, like cleaning solvents, and building materials.

Since it is not practical to monitor for each of the 188 compounds, the EPA developed a subset of HAPs that have the greatest impact on the public, as well as the environment, in urban areas. For the purposes of the NATTS Study, the list of 188 HAPs was pared down to a subset of 62 HAPs, 33 of which are on the "Urban HAP List."[1] The remaining 29 compounds were chosen because they have risk factors that were developed by the EPA. From the list of 62 compounds, a "core" list of 19 toxic air pollutants that must be monitored at all times was created. These compounds are considered to be "priority compounds" because they are major health risk drivers, based on a relative ranking performed by the EPA.[2] They are referred to as the "Method Quality Objective (MQO) Core Analytes."[3] These compounds can be seen in Table 1.

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[1] Technical Assistance Document for the National Air Toxics Trends Stations Program." US Environmental Protection Agency. April 1, 2009. http://www.epa.gov/ttnamti1/files/ambient/airtox/nattsTADRevision2_508Compliant.pdf

[2] *Ibid.*

[3] *Ibid.*

Table 1. NATTS HAPs with Mandatory Monitoring Requirements

VOCs	Carbonyls	PM_{10} Metals	TSP Metals	PAHs
Acrolein	Formaldehyde	Nickel	Hexavalent Chromium	Naphthalene
Tetrachloroethylene	Acetaldehyde	Arsenic		Benzo(a)pyrene
Benzene		Cadmium		
Carbon Tetrachloride		Manganese		
Chloroform		Beryllium		
Trichloroethylene		Lead		
1,3-Butadiene				
Vinyl Chloride				

The Grand Junction air toxics monitoring site was established in 2004. This site will measure air toxics for at least six years, to determine the success of the National Air Toxics Strategy in reducing the U.S. population exposure to cancer-causing substances in the air. The main test will be a comparison of mean concentrations of compounds for the first three years (2004-2006), versus the mean concentrations for successive three-year periods (2007-2009), starting from 2004 and continuing to the present. Data collected beyond the initial 6-year study scope will be used for trending analyses.

This report presents data from January 2010 through December 2010. It is separated into sections covering the various compounds of interest. Sections 3, 4, 5, 6, and 9 discuss the compounds monitored as a part of this study. Sections 7, 8 and 10 compare the PM_{10}, $PM_{2.5}$, and meteorological data collected as a part of the regular monitoring conducted in Grand Junction by the Colorado Department of Public Health and Environment (CDPHE) to the national ambient air quality standards (NAAQS). Each section begins with summary statistics for the compounds analyzed and then the percentage of samples in which each chemical was detected. Summary graphs of certain compounds are presented.

Site Information

The NATTS Study at Grand Junction collects samples at two separate locations. These two sites (Powell and Pitkin) are in close proximity to one another. The Powell site is located on top of the Powell Building (approximately three stories in height) at 650 South Avenue, and the Pitkin site is located approximately 50 meters to the NNW of the Powell Building on the roof of a small shelter, near ground level, at 654-1/4 Pitkin Avenue. The hexavalent chromium and particulate samplers are located on the Powell Building, and the carbon monoxide analyzer, air toxics samplers, and meteorological tower are located at the Pitkin site. Due to the different sampling heights, staff at Region VIII of the EPA suggested the sites be separately catalogued in the national air monitoring database. Documentation regarding these sites, including maps, photographs, and aerial views, is available in the companion report, "Documentation for Grand Junction Urban Air Toxics Trends Monitoring Locations – Site Maps and Photographs." The sites are located on the southern end of the city in an area of commercial/light industrial land use.

III. CARBONYLS

Summary Statistics

The carbonyls discussed in this section are the group of organic chemicals that contain a carbon atom double bonded to an oxygen atom. The generalized symbol for the carbonyl group is **R-C=O**, where the "R" is some other carbon compound. Twelve compounds were measured for this study. A listing of these compounds, as well as a summary of the collected data, is shown in Table 2 and Table 3. Of the twelve carbonyl compounds analyzed for, two are included on the mandatory monitoring list of 19 core HAPs. They are bolded in Table 2. The italicized compounds indicate a detection rate of less than 90% for the year.

Table 2. Carbonyl Average Concentration Comparison 2004-10

	Annual Averages (μg/m^3)						
Analyte	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
2,5-Dimethylbenzaldehyde	*0.08*	*0.06*	*0.02*	*0.03*	*0.03*	*0.00*	*0.01*
Acetaldehyde	**10.53**	**5.39**	**4.25**	**5.03**	**4.48**	**2.89**	**1.95**
Acetone	18.39	11.08	9.69	12.45	12.35	5.57	5.13
Benzaldehyde	1.11	0.95	1.45	1.41	1.30	0.34	0.31
Butyraldehyde	0.91	1.18	1.00	1.06	0.92	0.35	0.34
Crotonaldehyde	0.67	0.62	0.50	0.57	0.55	0.22	0.20
Formaldehyde	**3.45**	**3.83**	**4.94**	**4.94**	**5.04**	**4.01**	**2.74**
Hexaldehyde	0.56	0.43	0.46	0.43	0.52	0.12	0.13
Isovaleraldehyde	*0.04*	*0.07*	*0.15*	*0.08*	*0.08*	*0.01*	*0.01*
Propionaldehyde	0.39	0.75	0.74	0.73	0.91	0.39	0.35
Tolualdehydes	0.61	0.63	1.11	0.98	0.77	0.18	0.19
Valeraldehyde	0.18	0.71	0.59	0.06	0.52	0.15	0.11

Bold = MQO Core Analyte, *Italic = less than 90% detection rate*

Table 3. Carbonyl Sample Summary - 2010

Compound	CAS Number	# of ND's	% ND
Acetaldehyde	75-07-0	0	0%
Acetone	67-64-1	0	0%
Benzaldehyde	100-52-7	0	0%
Butyraldehyde	123-72-8	0	0%
Crotonaldehyde	123-73-9	0	0%
Formaldehyde	50-00-0	0	0%
Hexaldehyde	66-25-1	0	0%
Propionaldehyde	123-38-6	0	0%
Valeraldehyde	110-62-3	0	0%
Tolualdehydes	NA	3	5%
Isovaleraldehyde	590-86-3	59	97%
2,5-Dimethylbenzaldehyde	5779-94-2	61	100%

ND = Not Detected

Carbonyl compounds were sampled on an every-sixth-day basis for the year, for a total of 61 samples attempted. There were no samples that were invalidated. The data recovery rate of 100% exceeds the EPA goal for over 85% sample recovery.

The annual mean concentrations for each carbonyl compound, from 2004 through 2010, are listed in Table 2. The annual means were calculated by replacing all "non-detect" values with one-half of the sample minimum detection limit. This is an accepted conservative technique for calculating annual values when some of the samples were less than the laboratory's ability to detect. The most prevalent carbonyls in the ambient air in Grand Junction are formaldehyde, acetone, and acetaldehyde. The other nine compounds measured in this study occurred at concentration levels significantly below those of the top three compounds. Since 2004, the annual average concentrations for all the carbonyl compounds have dropped.

All of the carbonyls, except for isovaleraldehyde and 2,5-dimethylbenzaldehyde were present in over 95%

of the samples. The isovaleraldehyde detection percentage of 3% is a decrease from the 23% detection rate in 2009. Note that the true annual mean of 2,5-dimethylbenzaldehyde may be well below the number reported in the table. Due to the fact that this compound was never detected, one-half of the detection limit was used for the estimated concentration of the non-detects. Actual concentrations could have been at lower levels than these estimates. This compound has not been detected since 2006. During the pilot phase of this study in 2001-2002, 2,5-dimethylbenzaldehyde was detected 34 percent of the time. In 2005, the detection rate dropped to 4.8 percent, and it has not been found at detectable levels since that time.

Graphs

The summary data for carbonyl compounds measured during 2010 are graphed in Figure 1. The compounds in these graphs are ordered by ranking their maximum concentrations. The graphs show that acetaldehyde, acetone, and formaldehyde had the highest maximum and average concentrations. The maximums observed in 2010 were very similar to those in 2009. The means for the compounds during the two years were fairly close, with no consistent trend across compounds. In comparison, the national mean concentrations for acetaldehyde, acetone, and formaldehyde were 1.91, 2.85, and 2.47 micrograms per cubic meter, respectively.[4] The national average was calculated using data from the National Monitoring Programs (NMP), run by the EPA. The NMP includes the Photochemical Assessment Monitoring Stations (PAMS) network, Community-Scale Air Toxics Ambient Monitoring (CSATAM) Program, and the NATTS network. The formaldehyde and acetaldehyde values in Grand Junction were similar to the national averages, while the acetone average was larger.

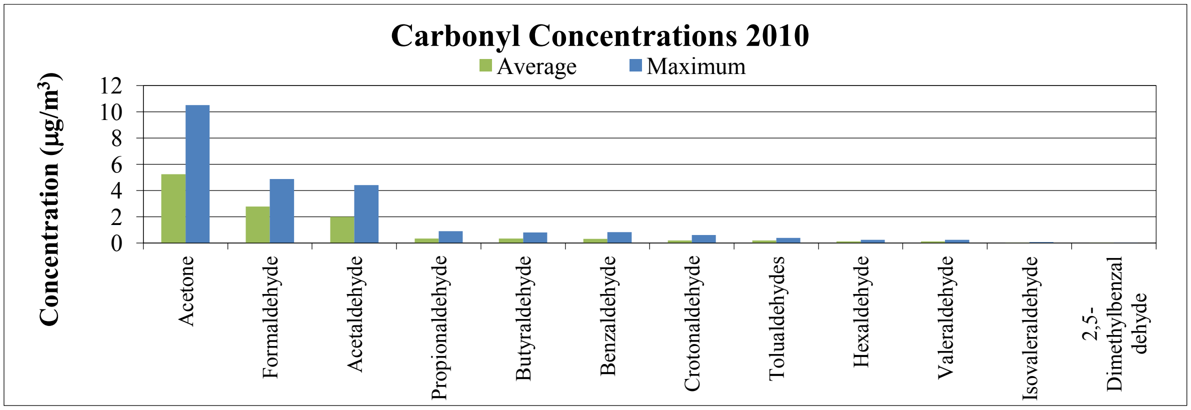

Figure 1. Annual Mean and Maximum Carbonyl Concentrations for 2010

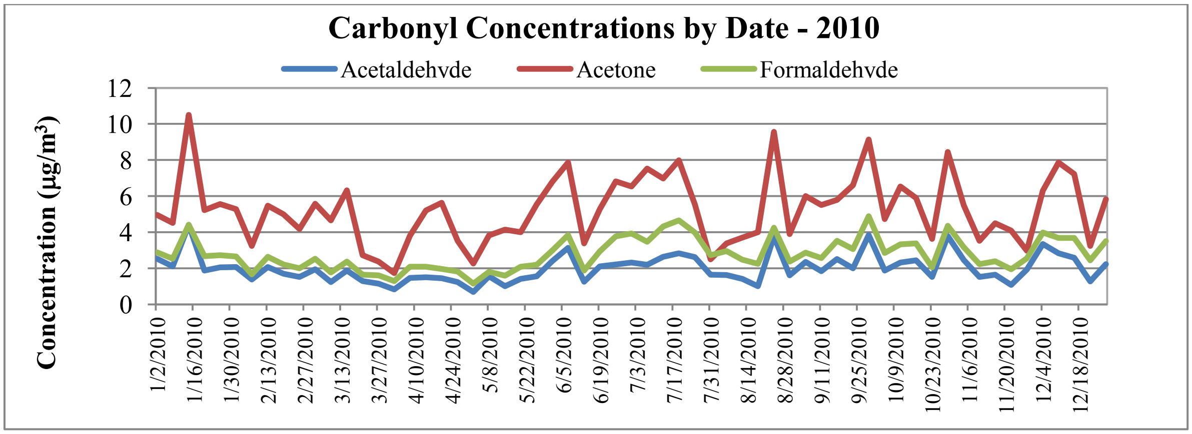

Figure 2. Carbonyl Sample Day Comparisons for 2010

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[4] "2010 National Monitoring Programs Annual Report (UATMP, NATTS, CSATAM). US EPA. November 2012. http://www.epa.gov/ttnamti1/files/ambient/airtox/2010NMPAnnualReportVol1.pdf.

Figure 2 shows the concentrations for select carbonyl compounds during the year. Much like past years, the compounds did not show much seasonal variation. This was also the case in 2009 as well. This is interesting, because it is generally believed that more formaldehyde is formed photochemically during the summer period of higher solar radiation. Formaldehyde plays a role in the formation of ozone, a chemical that peaks during the summer.

Figure 3 is a graph of the weekday versus weekend average carbonyl concentrations in 2010. As was expected, the average weekday concentrations were slightly higher than the average weekend concentrations, with the exceptions of 2,5-dimethylbenzaldehyde, isovaleraldehyde, valeraldehyde, and propionaldehyde. These compounds have weekday and weekend averages that are equal, as their concentrations are merely half the value of their respective MDLs for the entire year, since they were non-detectable in greater than half of all samples.

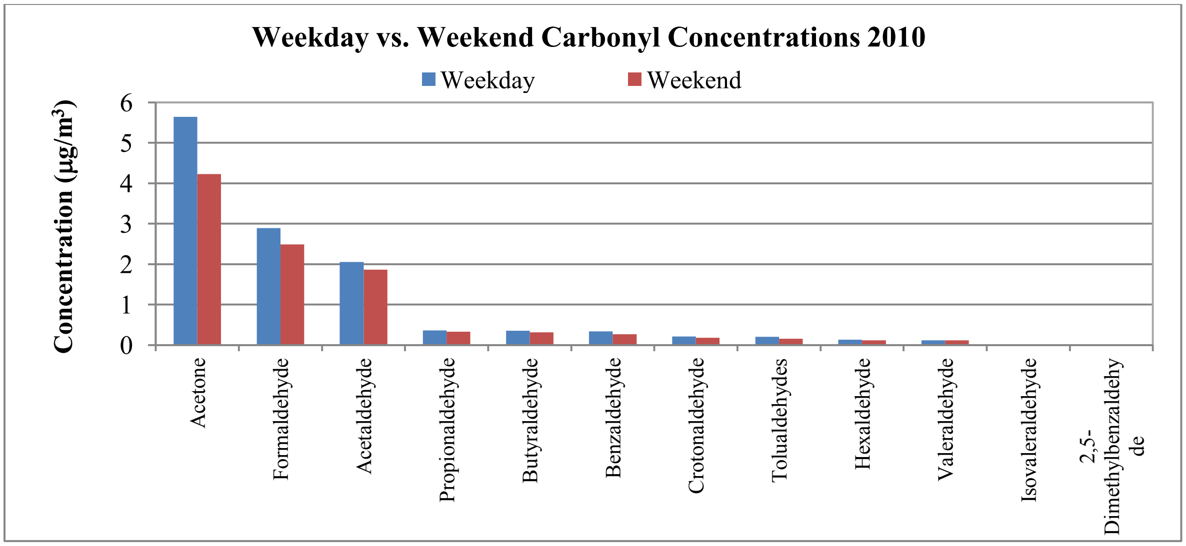

Figure 3. Weekday vs. Weekend Carbonyl Concentrations - 2010

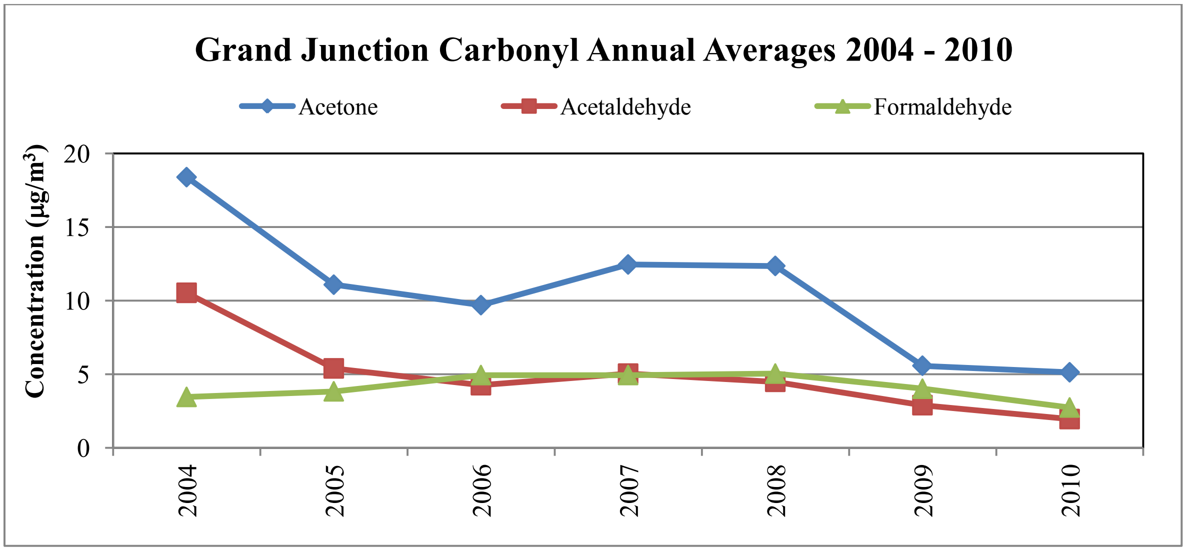

Figure 4. Carbonyl Annual Averages 2004 – 2010

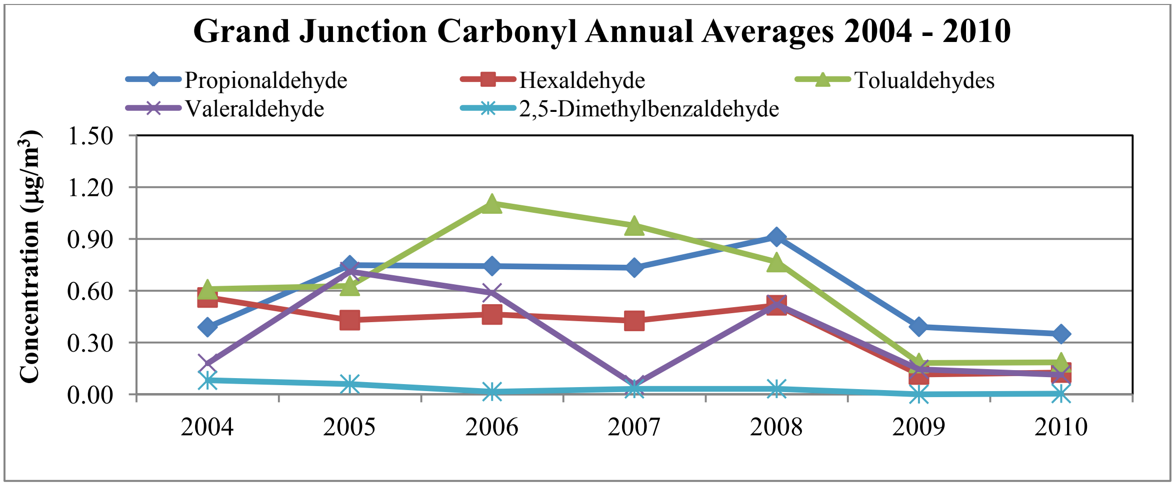

Figure 5. Carbonyl Annual Averages 2004 – 2010, ctd.

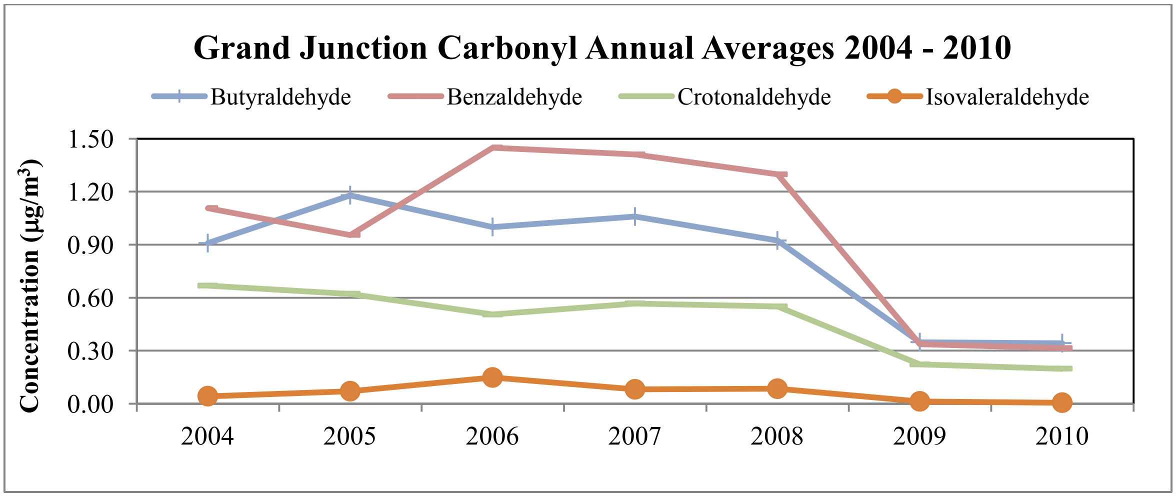

Figure 6. Carbonyl Annual Averages 2004 – 2010, ctd.

Figure 4 through Figure 6 are graphs of the annual average carbonyl concentrations at the Grand Junction site, for 2004 through 2010. The overall trend appears to be that the carbonyl concentrations are decreasing. The NATTS program was initially established to monitor the 3-year average concentrations of air toxics compounds, with the thought that successive 3-year averages would show at least a 15% drop in concentration values. Figure 7 below shows the 3 year average concentrations for acetone, acetaldehyde, and formaldehyde. The formaldehyde average increased by eight percent, while the other two averages dropped by 22% (acetone), and 38%. The annual average concentration value for acetone in 2010 is lower than the last 3 year average. The concentrations for acetaldehyde, and formaldehyde in 2010 were also both lower than the last 3-year average calculated for 2007 through 2009.

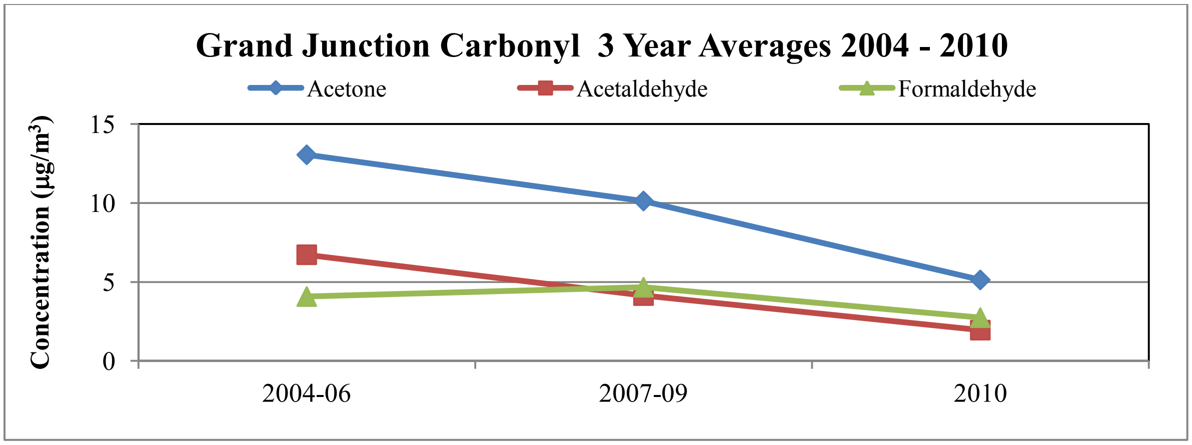

Figure 7. Carbonyl 3-Year Averages 2004 – 2010

Quality Assurance/Quality Control

Field Blanks

Field blanks were collected twelve times per year by attaching a blank sample cartridge to the sampler briefly, and then removing it. The purpose of these blanks was to assess contamination that might exist in the cartridge media, sample installation, or shipping. Most cartridges had very small amounts of formaldehyde, acetaldehyde, acetone, and propionaldehyde. Detailed information regarding field blank results is available upon request.

Precision of Sample Results

This project collected precision data in order to assess both sampling and analytical procedures. Six times during the year, a second carbonyl cartridge was sampled simultaneously with the primary sample. These additional samples, or duplicates, were collected to assess the precision (repeatability) of the sampling method. In general, agreement between the two samples was excellent. Detailed information regarding precision results is available upon request.

IV. VOLATILE ORGANIC COMPOUNDS

Summary Statistics

Volatile organic compound (VOC) data collected at the Grand Junction – Powell station from January through December 2010 are presented in this section. There were 60 VOCs analyzed for this study. The list of these VOCs and the number of times each was detected in samples during the study is found in Table 4. These are the same VOCs collected by all of the sites participating in the national air toxics study. VOCs were sampled on an every-sixth-day basis, for a total of 60 possible days. One sample was not collected, giving 59 samples on the year (98.3% sample recovery).

Table 4. VOC List with 2010 Detection Rates

Compound	CAS Number*	# of ND's	% ND
1,2,4-Trimethylbenzene	95-63-6	0	0%
1,3,5-Trimethylbenzene	108-67-8	0	0%
Acetonitrile	75-05-8	0	0%

Compound	**CAS Number***	**# of ND's**	**% ND**
Acetylene	74-86-2	0	0%
Acrolein	107-02-8	0	0%
Benzene	71-43-2	0	0%
Carbon Disulfide	75-15-0	0	0%
Chloromethane	74-87-3	0	0%
Dichlorodifluoromethane	75-71-8	0	0%
Dichloromethane	75-09-2	0	0%
Dichlorotetrafluoroethane	76-14-2	0	0%
Ethylbenzene	100-41-4	0	0%
m,p-Xylene	100-01-6	0	0%
Methyl Ethyl Ketone	78-93-3	0	0%
o-Xylene	95-47-6	0	0%
Propylene	115-07-1	0	0%
Styrene	100-42-5	0	0%
Tetrachloroethylene	127-18-4	0	0%
Toluene	108-88-3	0	0%
Trichlorofluoromethane	75-69-4	0	0%
Trichlorotrifluoroethane	76-13-1	0	0%
1,3-Butadiene	106-99-0	1	2%
Carbon Tetrachloride	56-23-5	1	2%
n-Octane	111-65-9	1	2%
Methyl Isobutyl Ketone	108-10-1	7	12%
Chloroform	67-66-3	9	15%
Bromomethane	74-83-9	16	27%
1,1,1-Trichloroethane	71-55-6	22	37%
Trichloroethylene	79-01-6	41	69%
Chloroethane	75-00-3	44	75%
p-Dichlorobenzene	106-46-7	46	78%
Acrylonitrile	107-13-1	51	86%
1,2-Dichloroethane	107-06-2	52	88%
Methyl Methacrylate	80-62-6	55	93%
1,2,4-Trichlorobenzene	120-82-1	56	95%
Dibromochloromethane	124-48-1	56	95%
Hexachloro-1,3-butadiene	87-68-3	57	97%
o-Dichlorobenzene	95-50-1	57	97%
trans-1,2-Dichloroethylene	156-60-5	57	97%
1,1-Dichloroethane	75-34-3	58	98%
1,1-Dichloroethene	75-35-4	58	98%
1,2-Dibromoethane	106-93-4	58	98%
m-Dichlorobenzene	541-73-1	58	98%
Vinyl chloride	75-01-4	58	98%
1,1,2,2-Tetrachloroethane	79-34-5	59	100%
1,1,2-Trichloroethane	79-00-5	59	100%
1,2-Dichloropropane	78-87-5	59	100%

Compound	CAS Number*	# of ND's	% ND
Bromochloromethane	74-97-5	59	100%
Bromodichloromethane	75-27-4	59	100%
Bromoform	75-25-2	59	100%
Chlorobenzene	108-90-7	59	100%
Chloromethylbenzene	100-44-7	59	100%
Chloroprene	126-99-8	59	100%
cis-1,2-Dichloroethylene	156-59-4	59	100%
cis-1,3-Dichloropropene	10061-01-5	59	100%
Ethyl Acrylate	140-88-5	59	100%
Ethyl tert-Butyl Ether	637-92-3	59	100%
Methyl tert-Butyl Ether	1634-04-4	59	100%
tert-Amyl Methyl Ether	994-05-8	59	100%
trans-1,3-Dichloropropene	10061-02-6	59	100%

*CAS Number refers to the Chemical Abstract System Number. This is an alternate way of referencing organic chemicals, which can have multiple names.
ND = Not Detected

In 2010 there were 24 compounds detected in at least 90% of the samples taken. In 2009 there were 29 compounds detected over 90% of the time. The five compounds on the 2009 90% list, but not on the 2010 list are 1,1,1-trichloroethane, bromomethane, chloroethane, chloroform, and methyl isobutyl ketone. These compounds were detected 63, 73, 25, 85, 88 percent of the time. Table 5 is an alphabetical listing of the 24 compounds most frequently detected in 2010. The compounds were detected in at least 90% of the samples analyzed. As such, in an effort to keep this report from becoming too cumbersome, only the compounds listed in Table 5 will be discussed from this point on in this section; with discussion of any other compounds specifically outlined in the text.

Table 5. VOCs Detected in Greater Than 90% of 2010 Samples

90% Detection Rate	
1,2,4-Trimethylbenzene	Dichlorotetrafluoroethane
1,3,5-Trimethylbenzene	Ethylbenzene
1,3-Butadiene	m,p-Xylene
Acetonitrile	Methyl Ethyl Ketone
Acetylene	n-Octane
Acrolein	o-Xylene
Benzene	Propylene
Carbon Disulfide	Styrene
Carbon Tetrachloride	Tetrachloroethylene
Chloromethane	Toluene
Dichlorodifluoromethane	Trichlorofluoromethane
Dichloromethane	Trichlorotrifluoroethane

There were 16 compounds that were not detected at all during 2010, which is up from the seven non-detects in 2009. There were 26 compounds that were detected in less than five percent of the samples in 2010. This is a slight increase from 2009, where 24 compounds were detected in less than five percent of the samples. The two additional compounds on the five percent list for 2010 are dibromochloromethane, and vinyl chloride. This list of 26 compounds includes many compounds that are chiefly emitted by stationary sources. It appears that these source types are not present in the immediate vicinity of the station.

Table 6 summarizes the annual maximum and mean concentrations for each of the 60 VOCs measured during the study. It should be noted that the annual means and maximums were calculated by replacing all “non-detect” values with one-half of the sample method detection limit. This is an accepted conservative technique for calculating annual values when some of the samples were less than the laboratory’s ability to measure. As a result of this technique, the average and maximum concentrations are the same if the compound was never detected. The compounds are listed in alphabetical order, with their respective MDLs for 2010, as well as their respective molecular weights. Bolded values indicate the compound is one of the 19 core HAPs. Italicized values indicate a detection rate of less than 90% on the year.

Table 6. VOC Data Summary 2010

Analyte	**Molecular Weight (g/mol)**	**Average (µg/m^3)**	**Maximum (µg/m^3)**	**Avg. MDL (µg/m^3)**
1,1,1-Trichloroethane	*133.41*	*0.086*	*1.730*	*0.005*
1,1,2,2-Tetrachloroethane	*167.85*	*0.034*	*0.034*	*0.021*
1,1,2-Trichloroethane	133.41	0.044	0.044	0.016
1,1-Dichloroethane	*98.96*	*0.031*	*0.032*	*0.008*
1,1-Dichloroethene	*96.94*	*0.023*	*0.024*	*0.012*
1,2,4-Trichlorobenzene	*181.45*	*0.071*	*0.482*	*0.052*
1,2,4-Trimethylbenzene	120.20	0.517	1.696	0.025
1,2-Dibromoethane	*187.87*	*0.041*	*0.046*	*0.008*
1,2-Dichloroethane	*98.96*	*0.034*	*0.113*	*0.008*
1,2-Dichloropropane	*112.99*	*0.052*	*0.052*	*0.014*
1,3,5-Trimethylbenzene	120.20	0.187	0.516	0.020
1,3-Butadiene	**54.09**	**0.136**	**0.467**	**0.007**
Acetonitrile	41.05	20.33	552.4	0.097
Acetylene	26.04	1.547	5.954	0.013
Acrolein	**56.07**	**1.368**	**31.42**	**0.034**
Acrylonitrile	*53.06*	*0.044*	*0.299*	*0.033*
Benzene	**78.12**	**1.414**	**3.157**	**0.019**
Bromochloromethane	*129.39*	*0.044*	*0.044*	*0.026*
Bromodichloromethane	*163.83*	*0.063*	*0.063*	*0.013*
Bromoform	*252.73*	*0.051*	*0.051*	*0.021*
Bromomethane	*94.94*	*0.079*	*0.932*	*0.008*
Carbon Disulfide	76.13	1.190	10.43	0.006
Carbon Tetrachloride	**153.82**	**0.534**	**0.862**	**0.013**
Chlorobenzene	*112.56*	*0.029*	*0.029*	*0.009*
Chloroethane	*64.52*	*0.023*	*0.119*	*0.005*
Chloroform	***119.38***	***0.087***	***0.215***	***0.010***
Chloromethane	50.49	1.338	1.985	0.012
Chloromethylbenzene	*126.58*	*0.039*	*0.039*	*0.010*
Chloroprene	*88.54*	*0.023*	*0.023*	*0.011*
cis-1,2-Dichloroethylene	*96.94*	*0.067*	*0.067*	*0.067*
cis-1,3-Dichloropropene	*110.97*	*0.031*	*0.031*	*0.014*
Dibromochloromethane	*208.29*	*0.041*	*0.043*	*0.009*
Dichlorodifluoromethane	120.91	2.902	3.536	0.020
Dichloromethane	84.94	91.65	5246	0.028

Analyte	**Molecular Weight (g/mol)**	**Average (μg/m^3)**	**Maximum (μg/m^3)**	**Avg. MDL (μg/m^3)**
Dichlorotetrafluoroethane	170.92	0.131	0.168	0.007
Ethyl Acrylate	*100.12*	*0.021*	*0.021*	*0.025*
Ethyl tert-Butyl Ether	*102.18*	*0.018*	*0.018*	*0.029*
Ethylbenzene	106.17	0.507	1.311	0.017
Hexachloro-1,3-butadiene	*260.76*	*0.063*	*0.064*	*0.128*
m,p-Xylene	106.17	1.548	4.646	0.030
m-Dichlorobenzene	*147.01*	*0.028*	*0.028*	*0.024*
Methyl Ethyl Ketone	72.11	1.456	8.523	0.115
Methyl Isobutyl Ketone	*100.16*	*0.174*	*0.836*	*0.020*
Methyl Methacrylate	*100.12*	*0.050*	*0.229*	*0.115*
Methyl tert-Butyl Ether	*88.15*	*0.017*	*0.017*	*0.050*
n-Octane	114.23	0.296	0.888	0.019
o-Dichlorobenzene	*147.01*	*0.033*	*0.066*	*0.024*
o-Xylene	106.17	0.550	1.585	0.013
p-Dichlorobenzene	*147.01*	*0.035*	*0.102*	*0.024*
Propylene	42.08	0.879	2.237	0.064
Styrene	104.16	2.572	40.73	0.013
tert-Amyl Methyl Ether	*102.18*	*0.026*	*0.026*	*0.029*
Tetrachloroethylene	**165.83**	**0.398**	**1.350**	**0.020**
Toluene	92.15	3.231	15.04	0.030
trans-1,2-Dichloroethylene	*96.94*	*0.025*	*0.032*	*0.012*
trans-1,3-Dichloropropene	*110.97*	*0.033*	*0.033*	*0.014*
Trichloroethylene	***131.29***	***0.055***	***0.177***	***0.011***
Trichlorofluoromethane	137.37	1.604	2.051	0.011
Trichlorotrifluoroethane	187.38	0.722	0.874	0.023
Vinyl chloride	***62.50***	***0.015***	***0.015***	***0.005***

MDL = Minimum Detection Level

Bold = MQO Core Analyte, *Italic = less than 90% detection rate*

In general, the concentrations from 2010 compared well with the 2009 data. However, some compounds did show average concentrations that were significantly increased from their 2009 values. For instance, dichloromethane, acetonitrile, and styrene all showed much larger annual average concentrations in 2010 as opposed to 2009. In 2009, their respective annual average concentrations were 1.956, 0.131, and 0.625 μg/m^3. In 2010, they were 91.65, 20.33, and 2.572 μg/m^3. The large increase in concentrations arises from significantly elevated concentrations of these compounds on four sample days, which will be discussed in more detail in the following section. The MDL levels did change slightly for some of the compounds, but this is to be expected as the laboratory calculates new MDLs every year.

Graphs

Figure 8 through Figure 10 are graphs showing the 24 hour maximum, and annual mean concentrations for each of the 24 compounds that were detected in greater than 90% of the samples in 2010. These graphs are ordered from highest to lowest annual mean concentration. Note that the graphs' scales vary from a full-scale level at 50 micrograms per meter cubed to a full-scale value of 1.8 micrograms per meter cubed. The compounds with the five largest annual average concentrations are dichloromethane, acetonitrile, toluene, dichlorodifluoromethane, and styrene. To compare, the respective averages for these compounds in Grand Junction were 91.65, 20.32, 3.23, 2.90, and 2.57 micrograms per cubic meter, while the NMP network national average concentrations for the compounds were 10.60, 44.16, 2.20, 2.86, and 0.31 micrograms per cubic meter.[5]

Figure 11 shows that the maximum concentrations for toluene, acetonitrile and dichloromethane were recorded on the same day, Sunday, October 17, 2010. It also shows that there were three other days where acetonitrile concentrations spiked, three other days where dichloromethane concentrations spiked, and four other days where styrene concentrations spiked. At this point in time, it is unclear to what the cause of these high concentration values is due. Toluene is a common solvent used in the dissolution of paints, paint thinners, rubber, adhesives, etc. It is also used in the manufacture of polyurethane foam and TNT, and can be found in automobile exhaust.[6] Dichloromethane, or methylene chloride, is used as a solvent in paint strippers, pharmaceutical manufacturing, metal cleaning and degreasing, adhesives manufacturing, as a propellant in aerosol paint and automobile products, and as an agent in urethane foam blowing.[7] Acetonitrile occurs naturally in coal tar and tobacco smoke. Other sources of the compound include auto exhaust, as well as its use as a solvent in the manufacture of pharmaceuticals, for spinning fibers/casting/molding of plastic materials, and in lithium batteries.[8]

A glance at Figure 12 shows that methyl ethyl ketone (MEK) concentrations also spiked on three of the same days that acetonitrile concentrations did: 03/15/2010 (Monday), 04/26/2010 (Monday), and 07/25/2010 (Sunday). MEK is a strong cleaning solvent, and is also a component of cigarette smoke and automobile exhaust. The maximum styrene concentration occurred on Sunday, July 25, 2010. The second largest acetonitrile concentration was recorded on this day as well. Styrene is used primarily in the production of polystyrene plastics and resins, but is also found in cigarette smoke and automobile exhaust.[9] The maximum dichlorodifluoromethane concentration was observed on Monday, November 22, 2010. Dichlorodifluoromethane, also known as Freon-12, was used as a foaming agent, a refrigerant, and an aerosol spray propellant before its use was banned in the United States in 1996.[10]

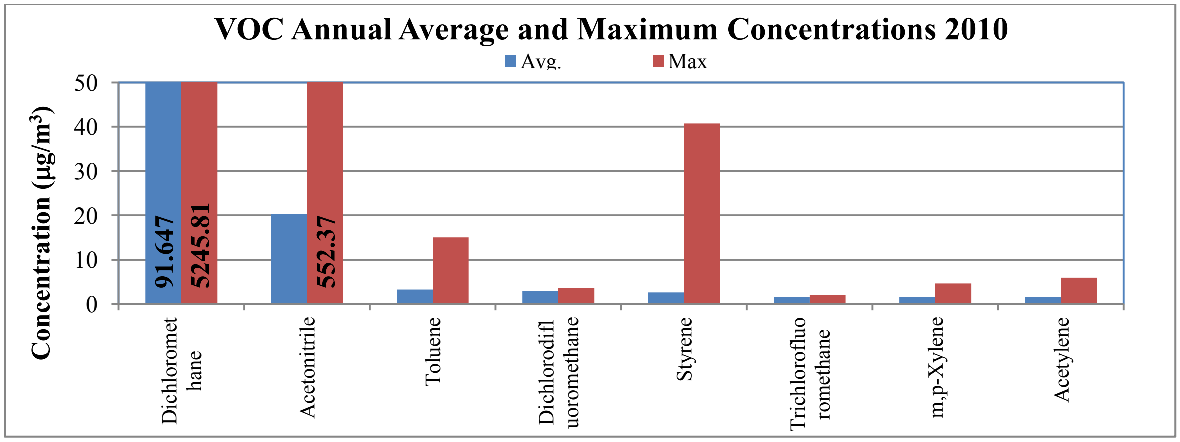

Figure 8. VOC Annual and Maximum Concentrations 2010

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[5] "2010 National Monitoring Programs Annual Report (UATMP, NATTS, CSATAM). US EPA. November 2012. http://www.epa.gov/ttnamti1/files/ambient/airtox/2010NMPAnnualReportVol1.pdf.

[6] http://www.epa.gov/ttnchie1/le/toluene.pdf

[7] http://www.epa.gov/ttnatw01/hlthef/methylen.html#ref1

[8] http://www.epa.gov/ttnatw01/hlthef/acetonit.html

[9] http://www.epa.gov/ttnatw01/hlthef/styrene.html

[10] http://pubchem.ncbi.nlm.nih.gov/summary/summary.cgi?cid=6391#x351

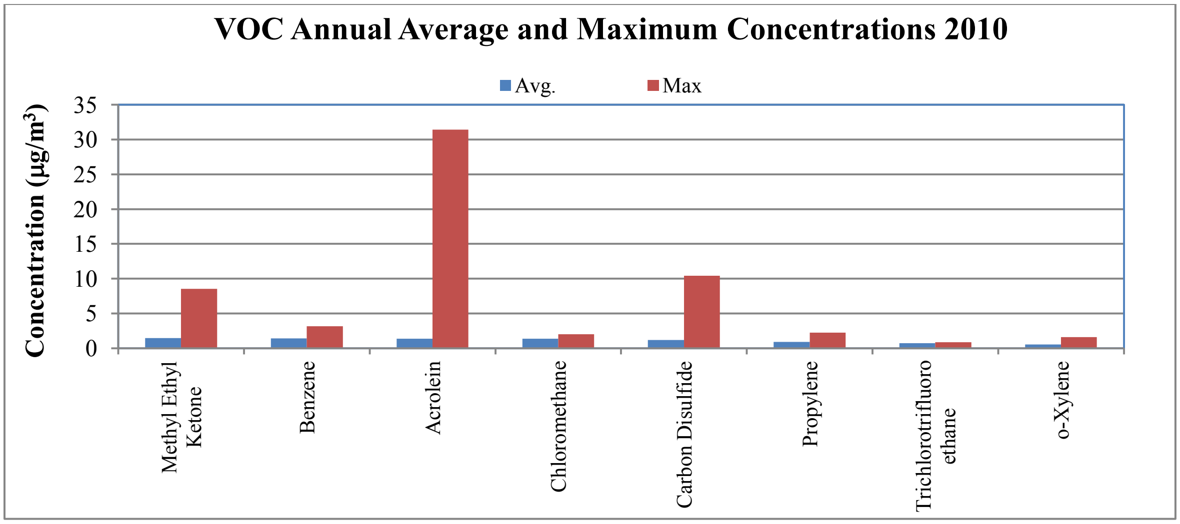

Figure 9. VOC Annual and Maximum Concentrations 2010, ctd.

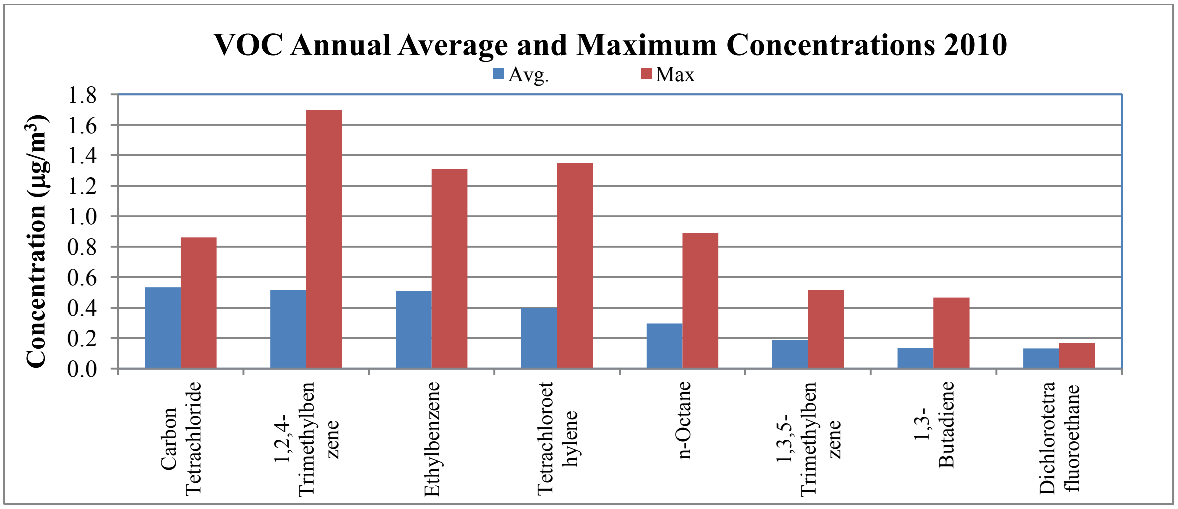

Figure 10. VOC Annual and Maximum Concentrations 2010, ctd.

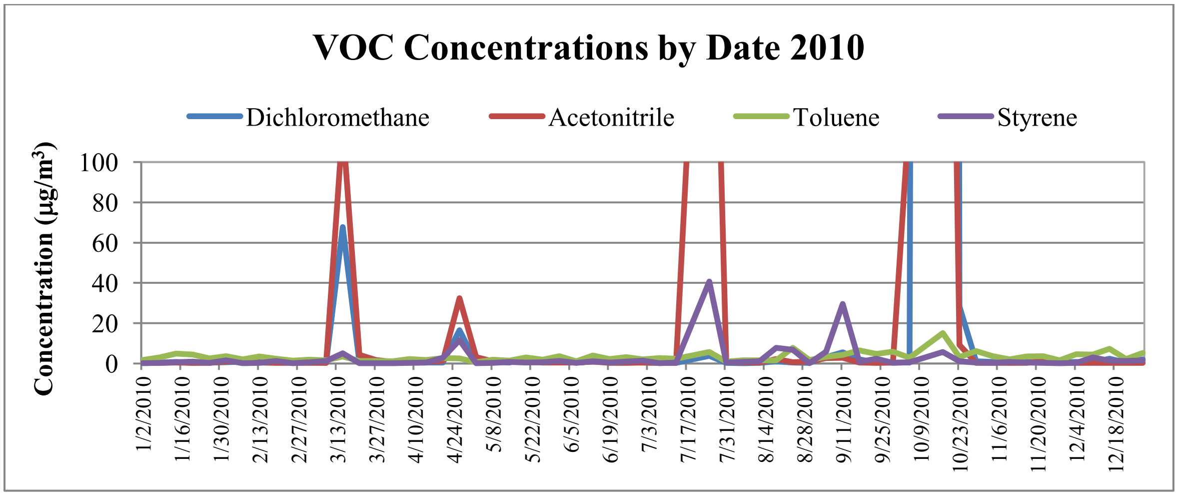

Figure 11. VOC Concentrations by Date 2010

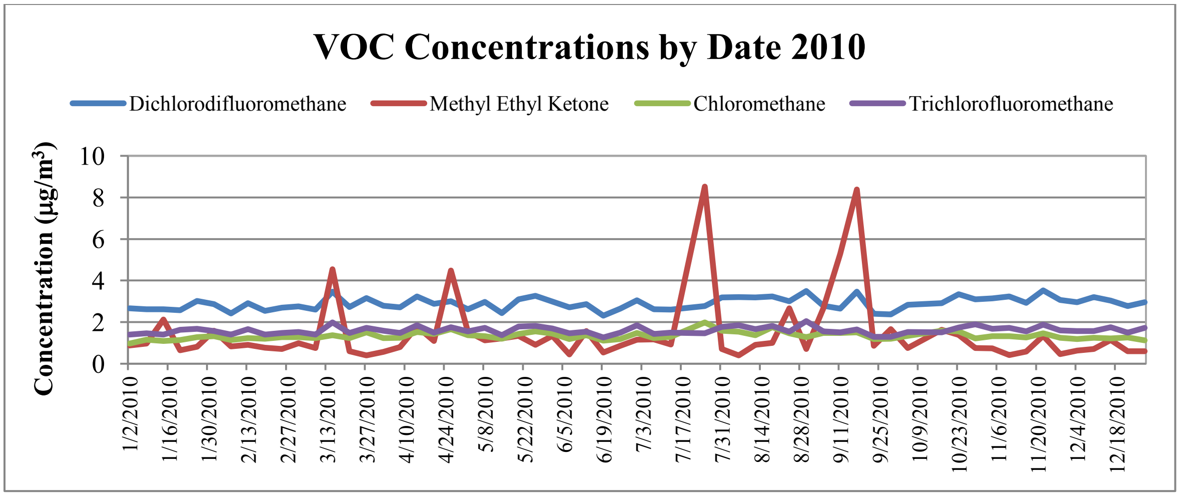

Figure 12. **VOC Concentrations by Date 2010, ctd.**

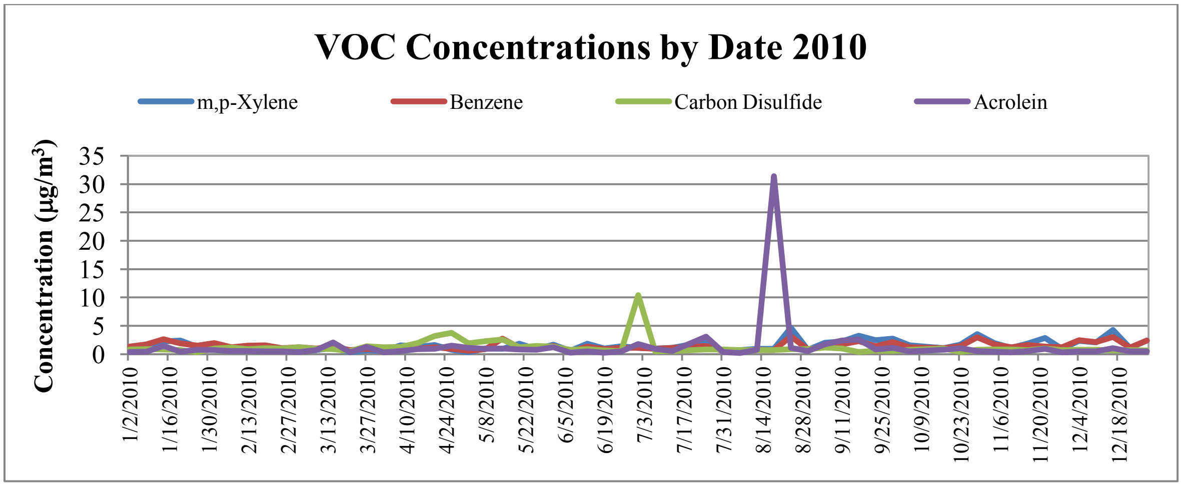

Figure 13. **VOC Concentrations by Date 2010, ctd.**

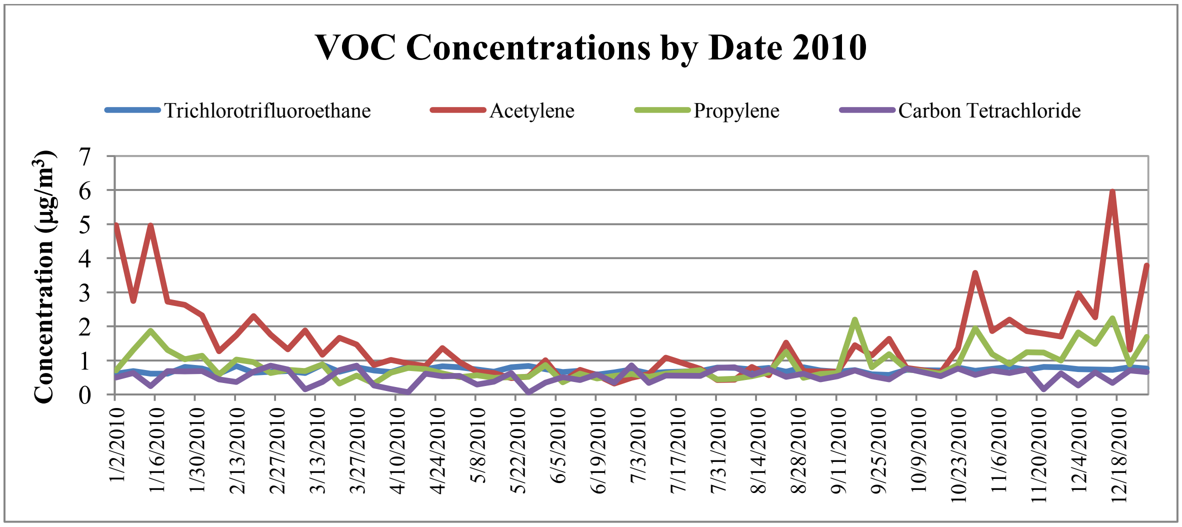

Figure 14. **VOC Concentrations by Date 2010, ctd.**

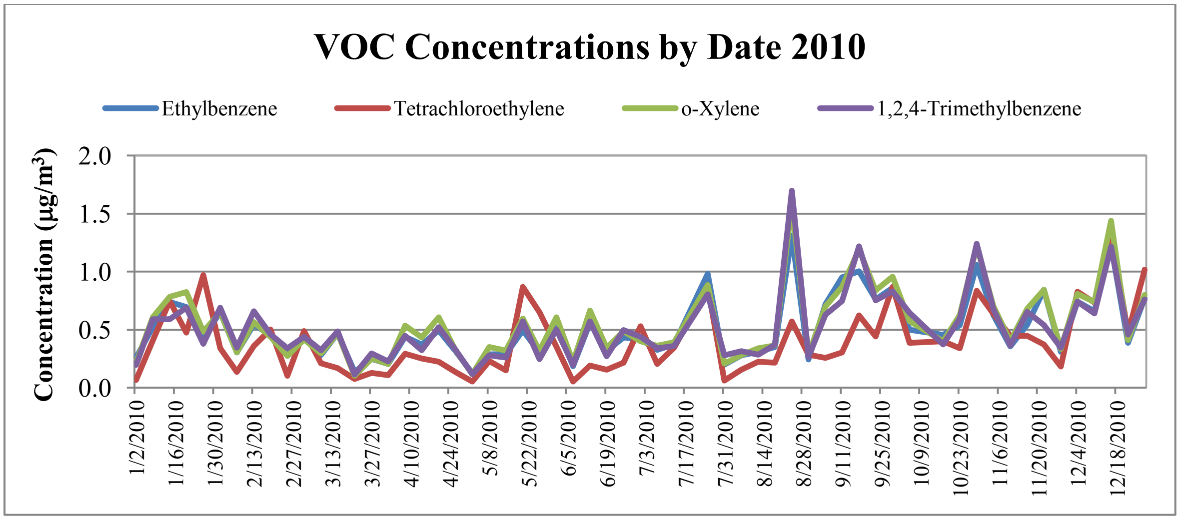

Figure 15. **VOC Concentrations by Date 2010, ctd.**

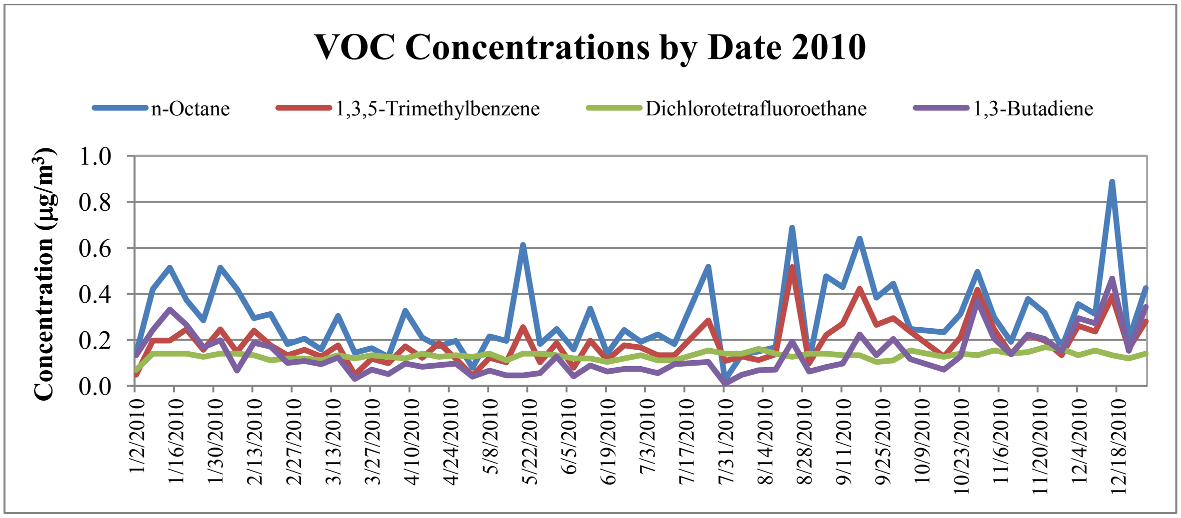

Figure 16. **VOC Concentrations by Date 2010, ctd.**

Figure 11 through Figure 16 show the concentrations of the 24 most detected VOCs by date. The concentrations tended to trend well with each other. Some of the compounds do show a seasonal variation in their concentrations. This is most easily seen in the graphs of acetylene and propylene in Figure 14. VOC concentrations are typically higher in the summer due to the higher temperatures, and longer availability of ultraviolet rays for the photolytic process.

Figure 17 through Figure 24 graphically illustrate the weekday versus weekend VOC concentrations in 2010 for all 60 compounds. It should be noted here that compounds showing the same weekday and weekend averages are reflecting concentrations that are equal to one-half of the MDL; that is, they were never detected. The compounds are separated into four groups: alkanes, alkenes, alkynes, and aromatics. The alkane compounds have carbon atoms with only one single bond. The alkenes have carbon atoms with double bonds, and the alkynes have triple bonds. The aromatics are ring structures, like benzene, with other substituents bonded to the ring.

In general, the weekday concentrations for most compounds were larger than those on the weekend. This is expected, as many of the compounds emitted are associated with automobile emissions, and traffic in the area is usually decreased on the weekends. There were, however, a few exceptions to this. Eleven of the compounds had higher weekend concentrations than weekday concentrations. These compounds are dichloromethane, chloromethane, carbon tetrachloride, bromomethane, acetonitrile, chloroethane, MEK, trans-1,2-dichloroethylene, acrylonitrile, toluene, and styrene. Of these, bromomethane was detected in only 73% of the samples taken. Chloroethane was detected in only 25% of the samples taken. Trans-1,2-dichloroethylene was detected in only 3% of the samples taken, while acrylonitrile was detected in 14% of the samples taken. For the compounds that were not detected consistently, their concentrations are heavily based on their respective MDLs, and not much should be read into their weekend versus weekday concentrations. Five of the remaining seven compounds observed significant concentration spikes on weekend days, as was discussed previously. It is unclear why the remaining two compounds, chloromethane and carbon tetrachloride, had higher weekend concentrations.

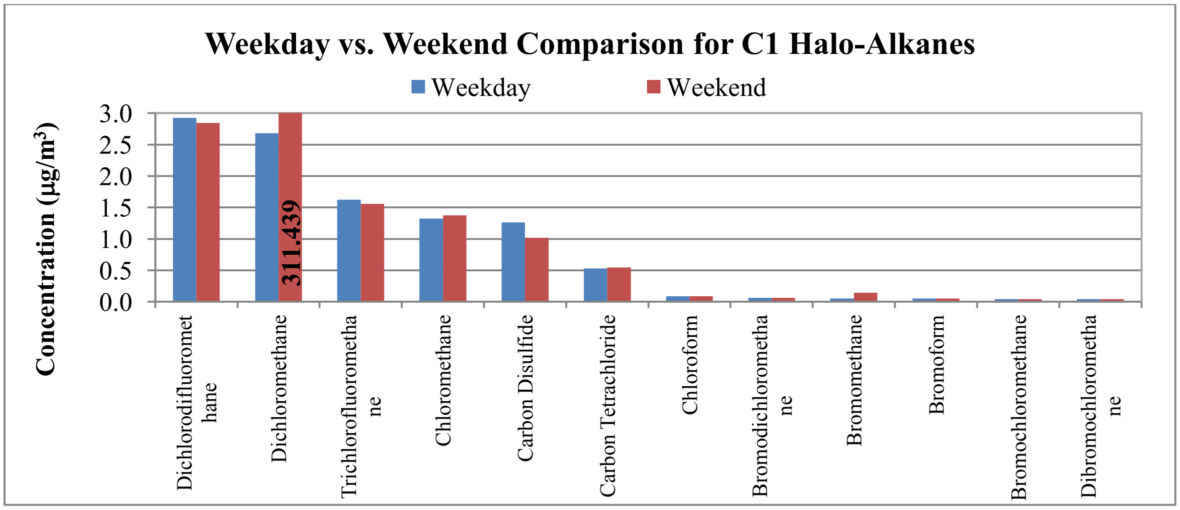

Figure 17. VOC Weekday vs. Weekend Comparison for C1 Alkanes

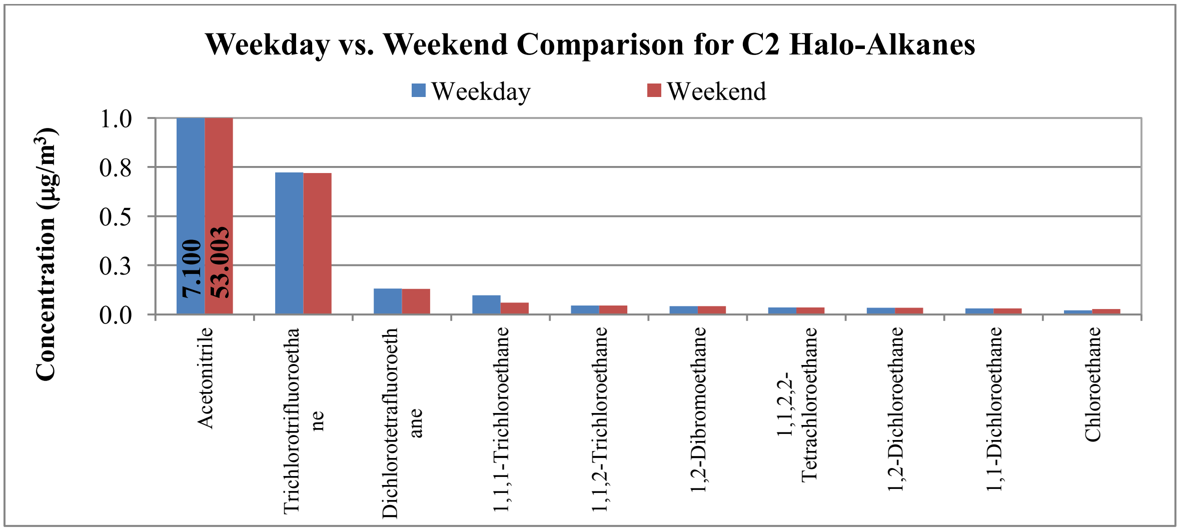

Figure 18. VOC Weekend vs. Weekday Concentrations for C2 Alkanes

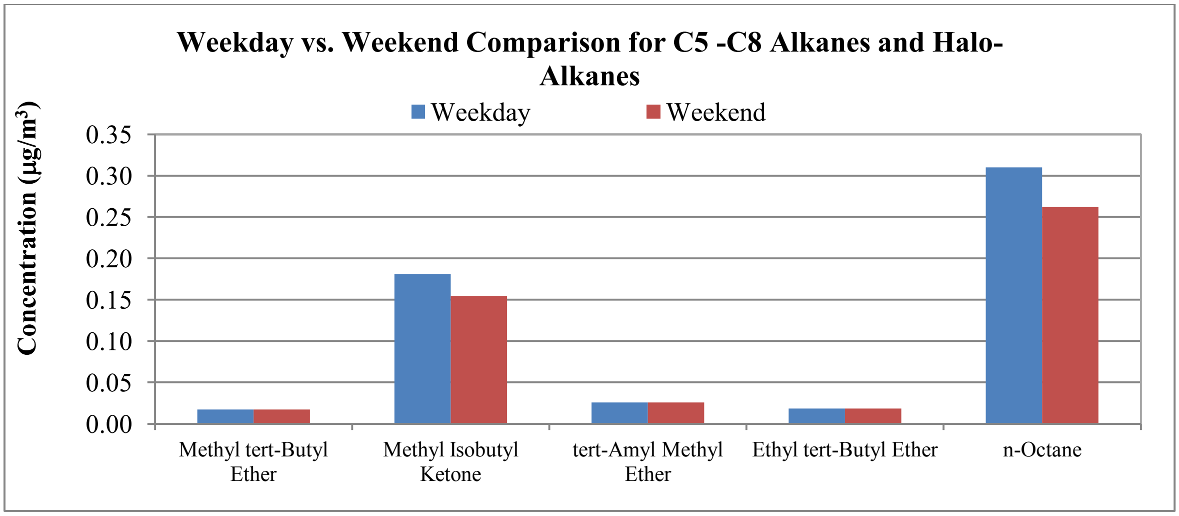

Figure 19. VOC Weekend vs. Weekday Concentrations for C5 – C8 Alkanes

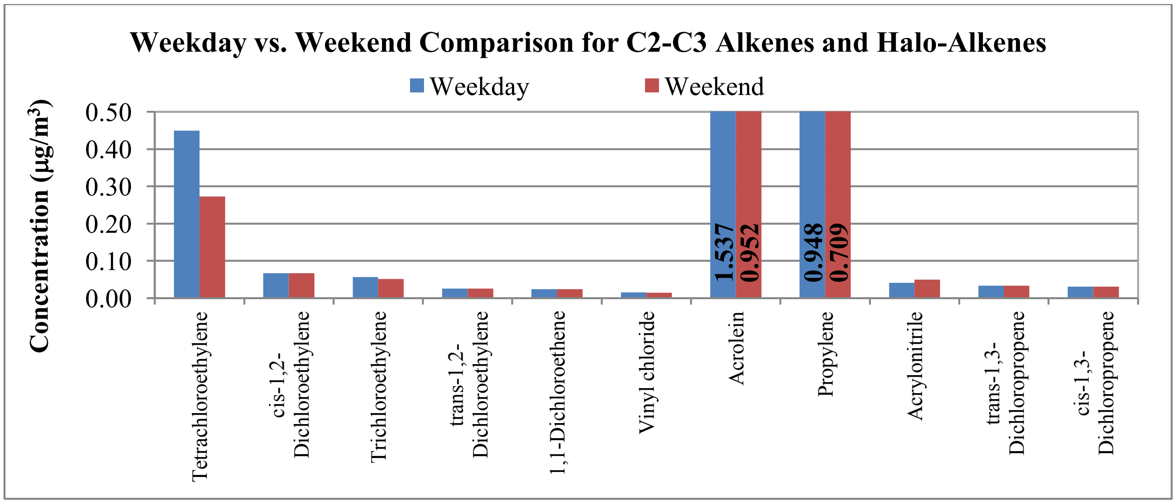

Figure 20. VOC Weekend vs. Weekday Concentrations for C2-C3 Alkenes

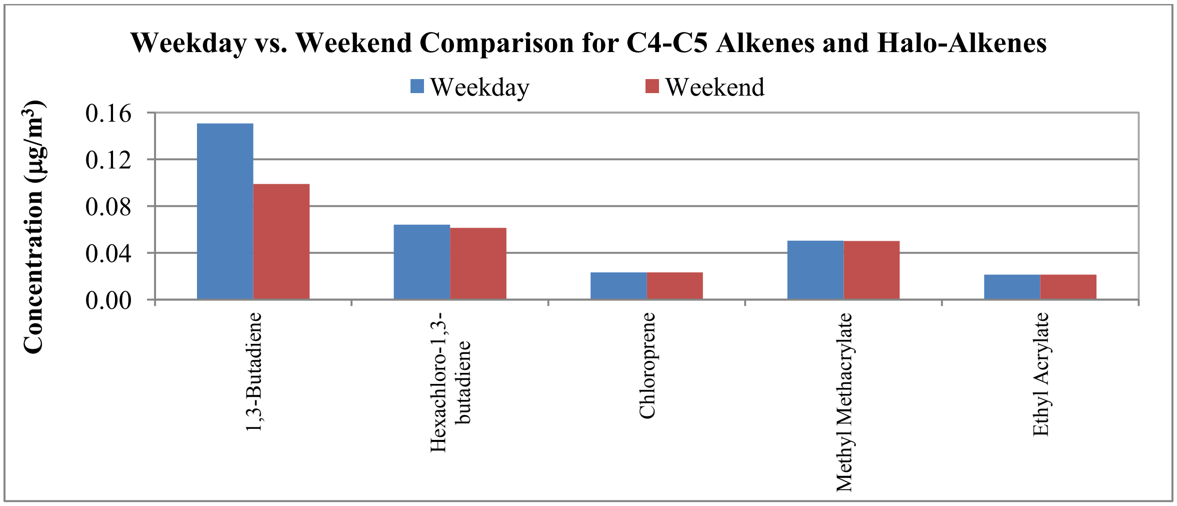

Figure 21. VOC Weekend vs. Weekday Concentrations for C4-C5 Alkenes

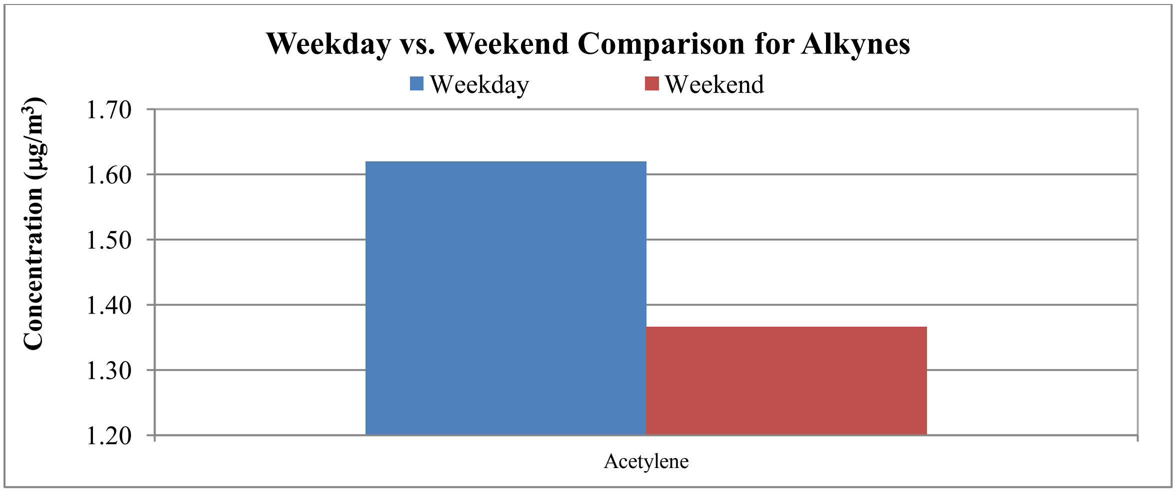

Figure 22. VOC Weekend vs. Weekday Concentrations for Alkynes

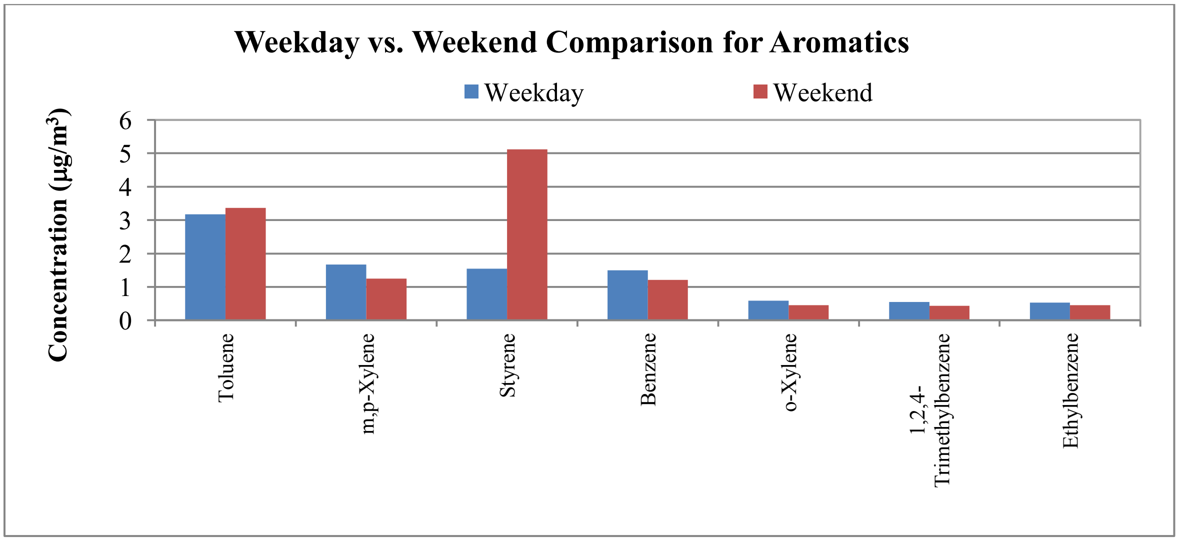

Figure 23. VOC Weekend vs. Weekday Concentrations for Aromatics

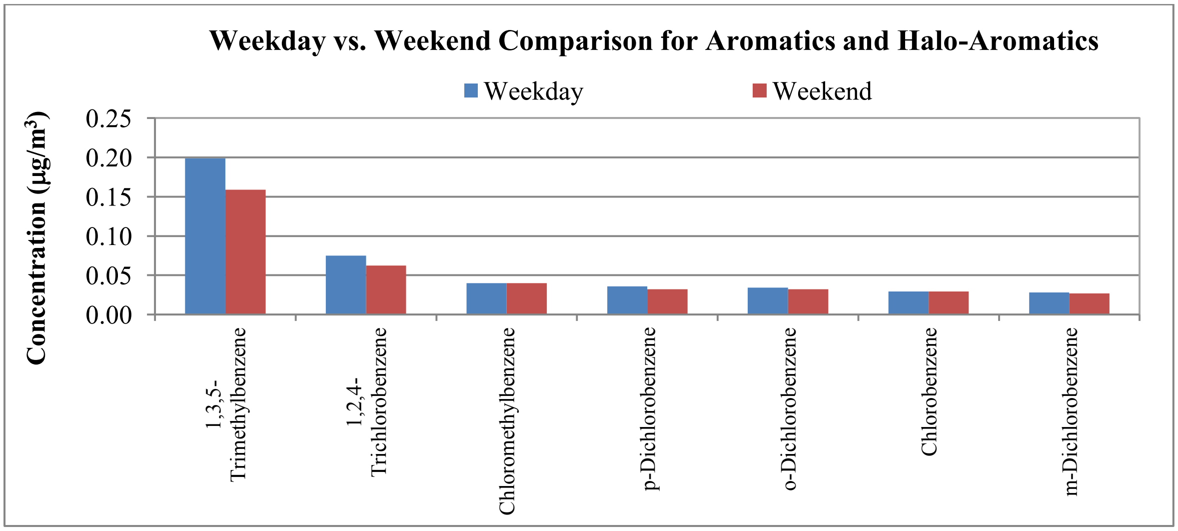

Figure 24. VOC Weekend vs. Weekday Concentrations for Aromatics, ctd.

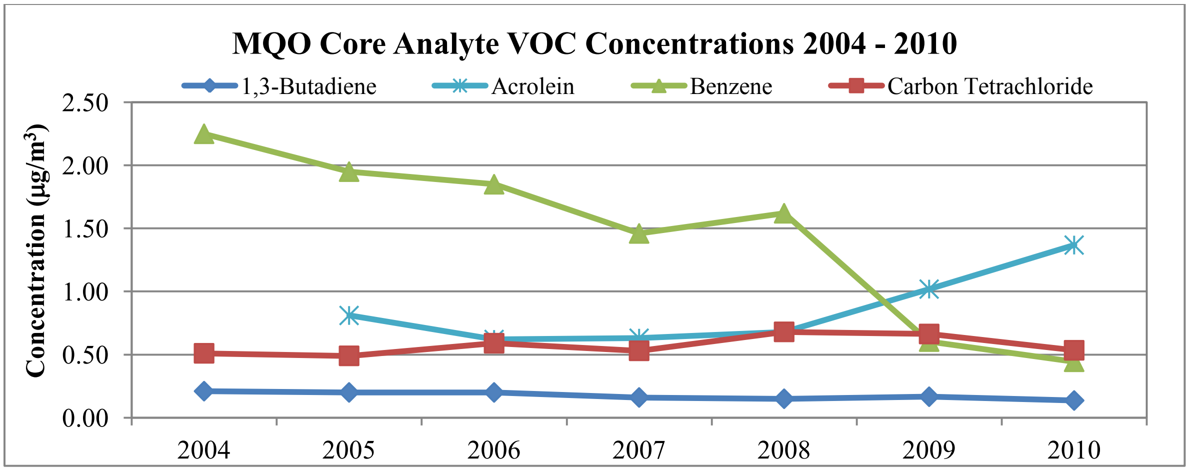

Figure 25. **MQO Core Analyte VOC Concentrations 2004 – 2010**

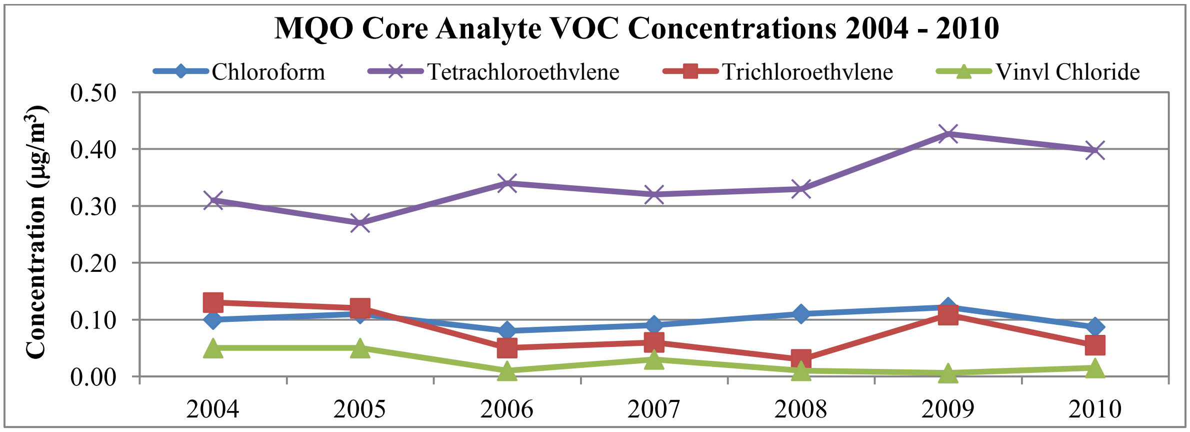

Figure 26. **MQO Core Analyte VOC Concentrations 2004 – 2010, ctd.**

Figure 25 and Figure 26 graph the annual average concentrations of the eight MQO core analytes. The graphs indicate an overall downward trend in concentration values since 2004 for benzene, 1,3-butadiene, trichloroethylene, and vinyl chloride. A calculation of the 3-year average concentrations for each of those four compounds also shows that the overall concentration average is dropping by as much as 22 to 58% of the previous three year average. The remaining four compounds, acrolein, carbon tetrachloride, chloroform, and tetrachloroethylene appear to have average concentrations that are trending upward, with increases of 9 to 18% between successive three year averages.

Quality Assurance/Quality Control

Field Blanks

The volatile organic compound sampling method involves sampling in stainless steel canisters with specially treated interior surfaces. The canisters are re-used. After a full canister is analyzed, it is pumped out repeatedly to a high vacuum. This procedure cleans it for the next use. Periodically, one canister from each cleaning batch is tested to make sure the method is performing adequately. The test canister is filled with ultra-pure air, and then analyzed. If it shows no contamination, the batch is released for use. If contamination is found, the entire batch is sent through the cleaning process for a second time. The canisters arrive in the field closed, and under a vacuum of 20 to 30 inches of mercury. Therefore, field blanks are not used in this method. The canisters are “blanked” at the laboratory prior to shipping to the field.

Precision of Sample Results

On six random sampling dates throughout the year, a second canister was sampled simultaneously with the primary sample. These additional samples, known as duplicates, were collected in order to assess the precision (repeatability) of the canister sampling method. In general, repeatability for the two collocated samples was excellent. Information regarding precision and accuracy results is available upon request to the Air Pollution Control Division.

V. PM_{10} METALS

The metals data included in the initial version of this report, published January 6, 2014, were found to have various errors due to the contracted laboratory not following correct procedures for establishing the method detection limits (MDLs). The concentrations for some of the metals rely heavily on the MDL values, as one-half the value of the MDL is substituted for the concentration in instances where the metal is not detected during the analysis. Because it is impossible to go back and calculate the MDLs being used for the 2010 data, a new MDL study was performed by the lab in 2014. The values obtained as a result of this study will be used for the analysis of 2010-2013 metals data, in an effort to keep from losing several years' worth of valuable data.

In previous years, antimony and total chromium were also a part of the suite of compounds CDPHE had the lab analyze for. These two compounds are not required as a part of the NATTS program. As such, when the new MDL study was performed they were dropped from the list of compounds. Any data associated with those two compounds will not be in this, or future, reports.

Summary Statistics

During the study, metals were sampled on the every sixth day schedule, for a total of 61 samples attempted. Of those 61 samples, none were voided, but three were missed, due to equipment issues, leaving a total of 58 samples collected (95% sample collection rate). Table 7 shows the percentage of the samples in which each metal was detected. Arsenic, nickel, lead, and manganese were detected in at least 90% or more of the samples. Beryllium was never detected, while cadmium was detected in 3% of the samples.

Table 7. Metals List with 2010 Detection Rates

Compound	CAS Number	# of ND's	% ND
Arsenic	7440-41-7	0	0%
Manganese	7439-92-1	0	0%
Nickel	7440-36-0	0	0%
Lead	7440-02-0	6	10%
Cadmium	7440-47-3	56	97%
Beryllium	7440-43-9	58	100%

Table 8 summarizes the annual mean concentrations for each of the metals measured during the study, from 2004 through 2010, and is organized from the highest 2010 annual average concentration value to the lowest. Annual means were calculated by using one-half of the method detection limit in place of the non-detect samples. This is an accepted conservative technique for calculating annual values when some of the samples were less than the laboratory's ability to measure. Compounds that were detected less than 85% of the time, and their results, are italicized in the table. The bolded compounds are those that are a part of the 19 MQO Core Analytes. Results show that manganese was the compound with the highest annual average. The other metals were present at much lower concentrations. The manganese and lead concentrations were very similar for 2009 and 2010. Nickel and arsenic were both higher than their 2009 values.

Table 8. Metals Data Summary 2010

Analyte	**2004 Average ($\mu g/m^3$)**	**2005 Average ($\mu g/m^3$)**	**2006 Average ($\mu g/m^3$)**	**2007 Average ($\mu g/m^3$)**	**2008 Average ($\mu g/m^3$)**	**2009 Average ($\mu g/m^3$)**	**2010 Average ($\mu g/m^3$)**
Manganese	**0.01300**	**0.01199**	**0.01504**	**0.01523**	**0.01474**	***0.00870***	**0.00834**
Lead	**0.00490**	**0.00401**	**0.00433**	**0.00426**	**0.00248**	***0.00209***	**0.00205**
Nickel	**0.00060**	**0.00091**	**0.00119**	**0.00144**	**0.00143**	***0.00088***	**0.00180**
Arsenic	**0.00030**	**0.00213**	**0.00288**	**0.00422**	**0.00243**	***0.00087***	**0.00132**
Cadmium	***0.00010***	***0.00035***	***0.00026***	***0.00024***	***0.00014***	***0.00023***	***0.00020***
Beryllium	***0.00010***	***0.00091***	***0.00059***	***0.00069***	***0.00019***	***0.00013***	***0.00014***

Bold = MQO Core Analyte, *Italic = Detection rate of less than 90%*

Graphs

The metal compounds measured during the study are graphed in Figure 27. This figure shows that manganese and lead were the metals with the largest average concentrations. Figure 28 and Figure 29 indicate that most of the metals were at low concentration levels throughout the year. There does not appear to be any seasonal trending in the metals values based on the 2010 data. Manganese has the largest amount of variability in the concentration values recorded, with values ranging from just slightly over zero to near 0.035 micrograms per meter cubed. To compare, the Grand Junction average concentrations for manganese, and lead were 0.0089, and 0.0021 micrograms per meter cubed, while the NMP national averages were 0.0068, and 0.0037 micrograms per cubic meter.[11]

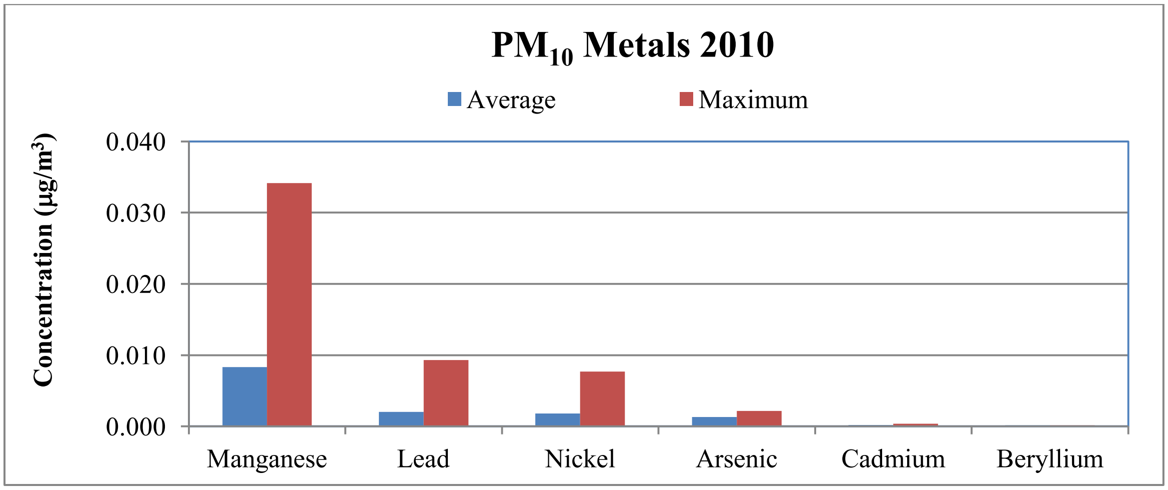

Figure 27. **PM_{10} Metals Average and Maximum Concentrations 2010**

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[11] "2010 National Monitoring Programs Annual Report (UATMP, NATTS, CSATAM). US EPA. November 2012. http://www.epa.gov/ttnamti1/files/ambient/airtox/2010NMPAnnualReportVol1.pdf.

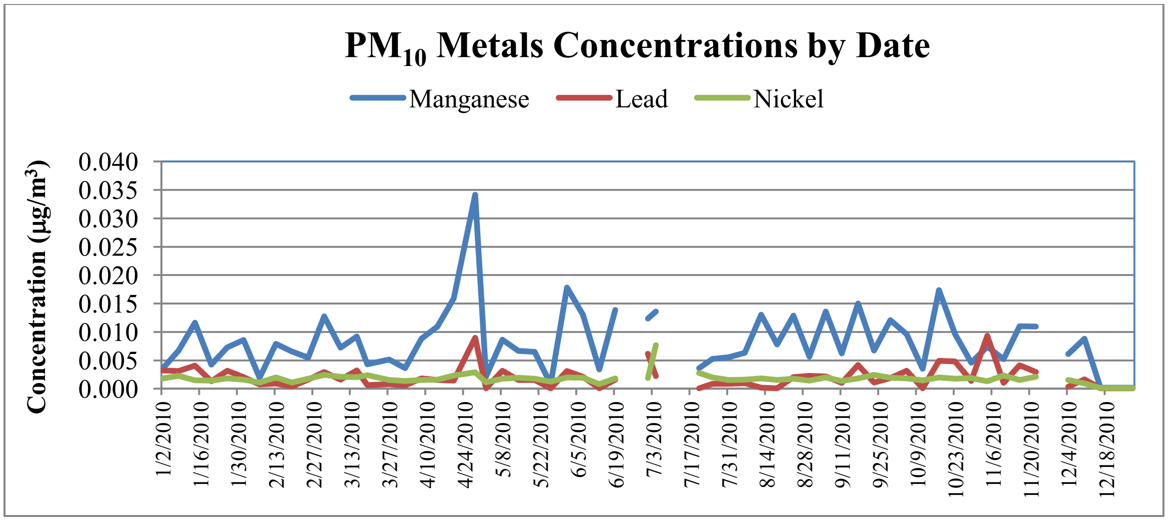

Figure 28. **PM$_{10}$ Metals Concentrations by Date 2010**

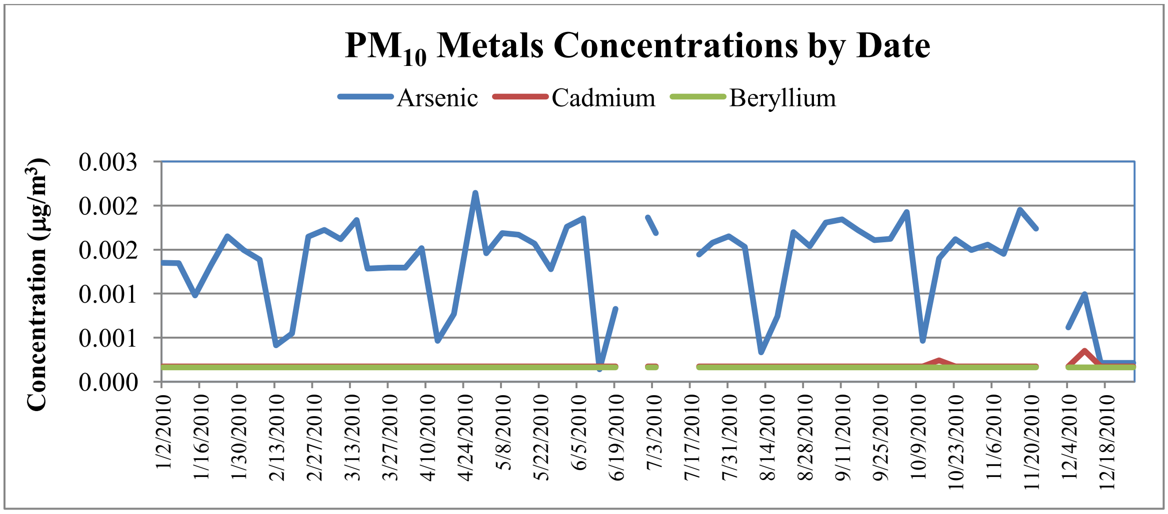

Figure 29. PM$_{10}$ Metals Concentrations by Date 2010, ctd.

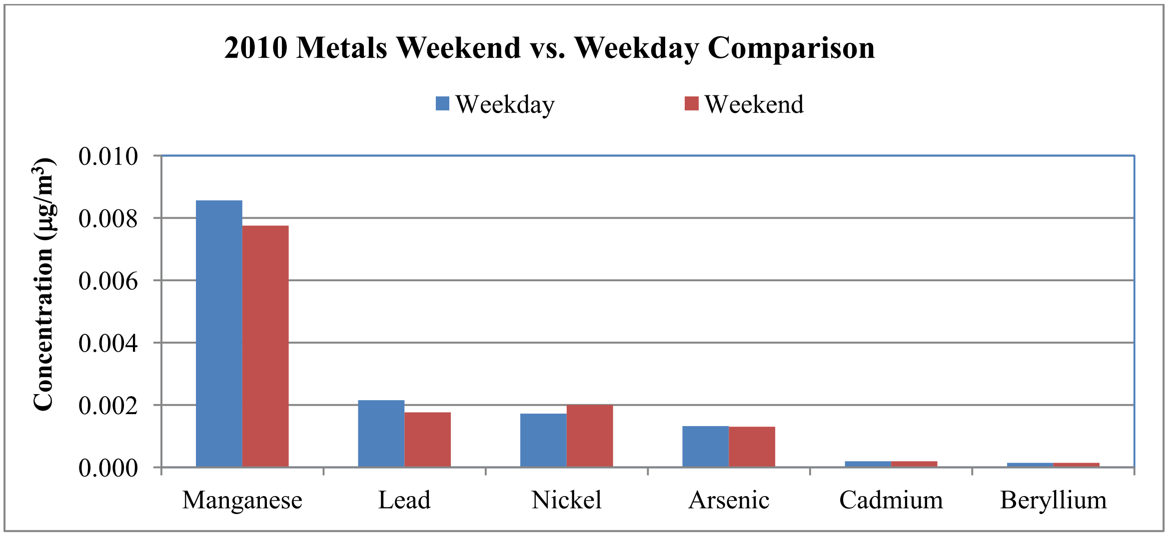

Figure 30. **PM$_{10}$ Metals Weekend versus Weekday Comparison 2010**

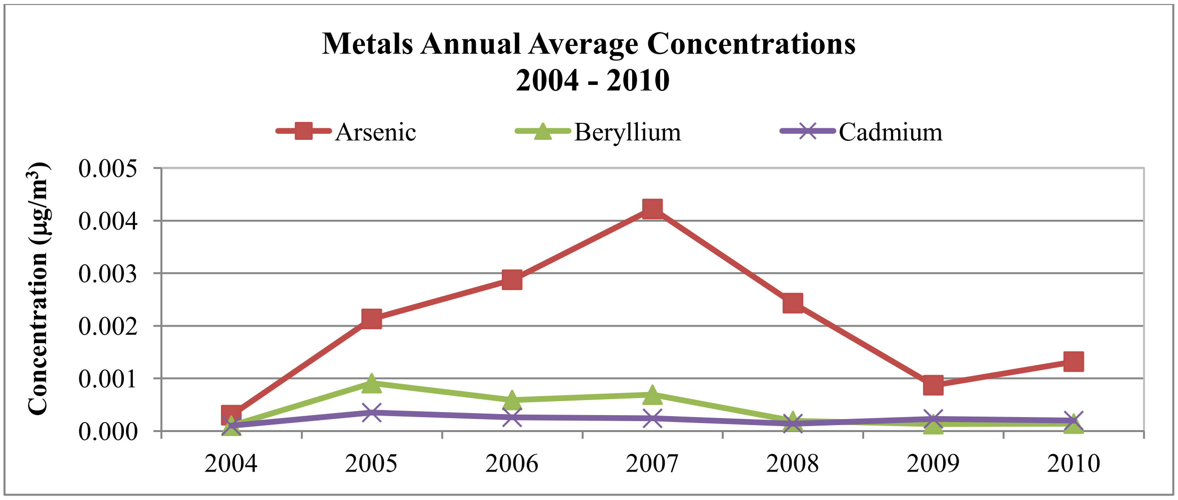

Figure 31. PM$_{10}$ Metals Annual Average Concentrations 2004 – 2010

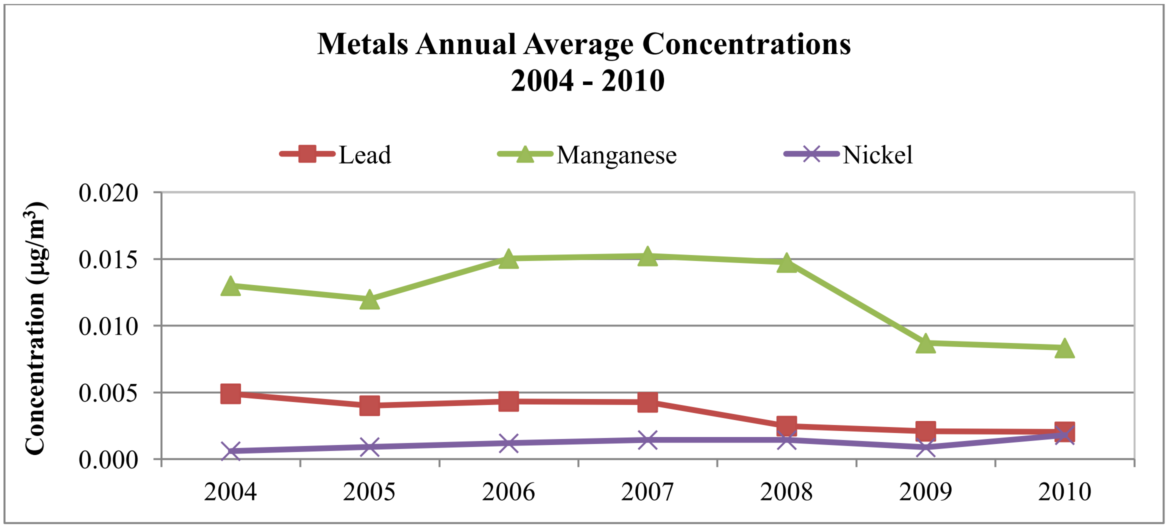

Figure 32. PM$_{10}$ Metals Annual Average Concentrations, 2004 – 2010

Figure 30 is a chart of the weekend versus weekday concentrations for the PM$_{10}$ metals. All of the compounds had weekend averages that were less than, or equal to, the weekday averages, except nickel. Cadmium, arsenic and beryllium were rarely detected, meaning the concentration values are heavily dependent on their MDL values, thus giving weekend versus weekday concentrations that are equal. Figure 31 and Figure 32 are graphs of the annual average concentrations for each of the PM$_{10}$ metals from 2004 through 2010. The graphs show a general downward trend in the concentration values for all the compounds but nickel, which shows a slight increase. The arsenic annual averages show a spike in 2010. Since the compound was not consistently detected, however, it's annual average was heavily dependent on the lab's respective MDLs. A calculation of the 3-year averages from 2004 to 2006, and 2007 to 2009, shows a decrease in concentrations for all compounds except arsenic and nickel. At this time, it is unclear what is behind this phenomenon.

Quality Assurance/Quality Control

Field and Filter Blanks

Periodically, the laboratory analyzes a "blank," or unused, filter for metals. The purpose of this extra analysis is to determine if there was any contamination of the filter during manufacturing or during laboratory processing. In 2010, CDPHE switched to using a different analytical laboratory. As a result of this switch, no blank filters were analyzed, and therefore, no data was available from the lab. In 2004, total chromium contamination was a problem for the national air toxics network. These chromium contamination findings were believed to be related to the use of metal knives in cutting individual filters from the giant sheets prepared at the factory. At the extremely low levels of metals in ambient air that the national air toxics network is assessing, such filter contamination is a concern. The national project team evaluated new filter materials and sampling methods, and recommended changing to Teflon filters, and low volume PM_{10} samplers in early 2005. Blank amounts are subtracted from the raw concentration data.

Precision of Sample Results

Twelve duplicate precision samples were run in 2010. The agreement between samples was generally very good, with a fifteen percent or less difference between the concentration values for the compounds that were detected in both the primary and duplicate samples (arsenic, lead, and manganese). For nickel, however, the average percent difference was at 42% on the year. This could be due to possible problems with the extraction process in the lab.

VI. HEXAVALENT CHROMIUM

Summary Statistics

Hexavalent chromium data collected at the Grand Junction – Powell station in 2010 are presented in this section. In 2005, a new hexavalent chromium sampler was added to the Grand Junction site. The technical steering committee made this decision for the nationwide air toxics monitoring network. The previous method only measured total chromium and could not distinguish between the trivalent (Cr^{3+}) and the hexavalent (Cr^{6+}) forms. These two forms are quite different in their health effects. The Cr^{6+} form is a carcinogen, while the Cr^{3+} form is not. This new method is described in the document, “Hexavalent Chromium Method Development: Final Report, Work Assignment 5-03,” by Eastern Research Group in Morrisville, North Carolina on September 30, 2005. Note that, due to its sensitivity, this method gives results in nanograms per cubic meter of air (ng/m^3), a unit one thousand times lower than the micrograms per cubic meter ($\mu g/m^3$) used elsewhere in this report.

During the year long period, hexavalent chromium was sampled on an every sixth day basis, with several extra samples taken throughout the year. A total of 61 samples were attempted, with 61 being analyzed (100% sample recovery). Table 9 shows that hexavalent chromium was detected in greater than 60 percent of the samples taken in 2010. Table 10 shows the average hexavalent chromium concentrations recorded from 2005 through 2010. The annual mean was calculated by using one-half of the minimum detection limit in place of the non-detect samples. This is an accepted conservative technique for calculating annual values when some of the samples were less than the laboratory’s ability to measure. The average and maximum values in 2010 are greater than those from 2009. Until then, the average and maximum values seen in 2009 were lower than those seen in 2008 (0.0208 and 0.6850 ng/m^3, respectively), and 2007 (0.0155 and 0.0928 ng/m^3, respectively).

Table 9. Hexavalent Chromium Sample Summary 2009-10

Compound	CAS Number	2009		2010	
		# of ND's	% ND	# of ND's	% ND
Hexavalent Chromium	1854-02-99	38	61%	23	38%

Table 10. Hexavalent Chromium Average and Maximum Concentrations 2009-10

Analyte	2005 Average (ng/m^3)	2006 Average (ng/m^3)	2007 Average (ng/m^3)	2008 Average (ng/m^3)	2009 Average (ng/m^3)	2010 Average (ng/m^3)
Hexavalent Chromium	0.023	0.03	0.0155	0.0208	0.0082	0.0121

Graphs

Figure 33 shows the annual average and maximum hexavalent chromium concentrations for 2009 and 2010. Figure 34 shows hexavalent chromium concentrations during the 2010 calendar year. All concentrations were less than 0.050 ng/m^3 for the year. The maximum concentrations in 2009 and 2010 occurred on September 28, 2009, and June 1, 2010. To compare, the NMP national average concentration for hexavalent chromium in 2010 was 0.037 nanograms per cubic meter.[12]

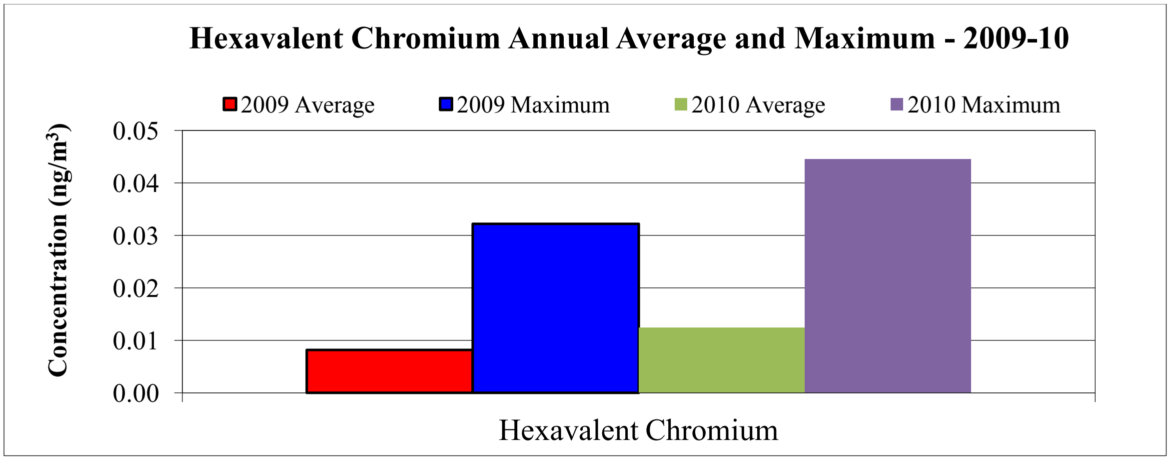

Figure 33. **Hexavalent Chromium Annual Average and Maximum 2009-10**

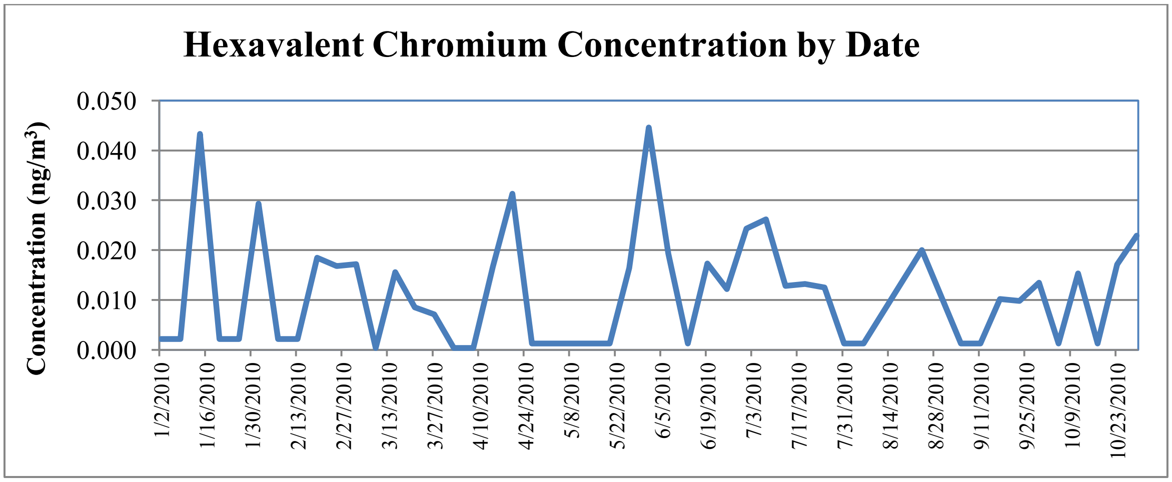

Figure 34. **Hexavalent Chromium Concentrations by Date 2010**

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[12] "2010 National Monitoring Programs Annual Report (UATMP, NATTS, CSATAM). US EPA. November 2012. http://www.epa.gov/ttnamti1/files/ambient/airtox/2010NMPAnnualReportVol1.pdf.

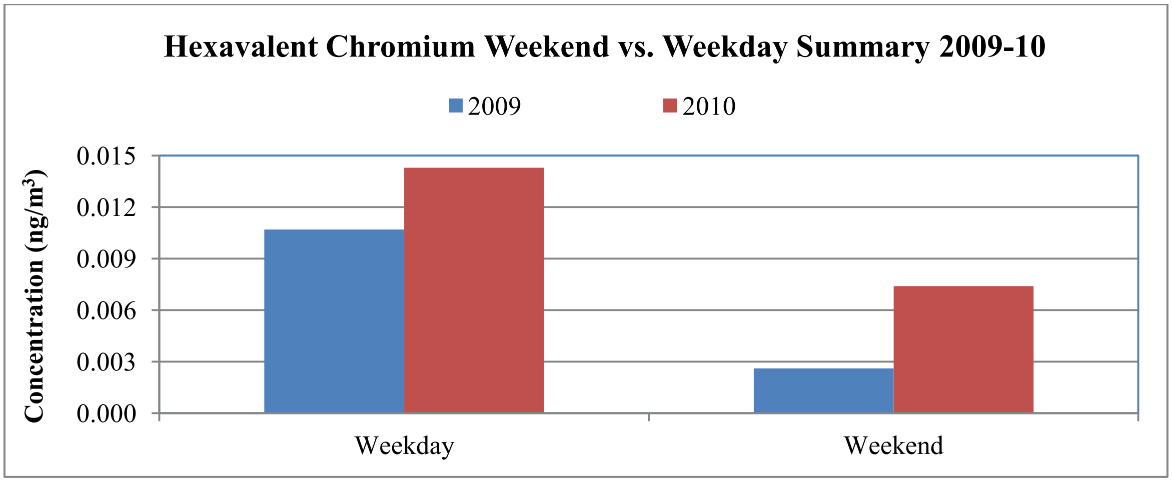

Figure 35. **Hexavalent Chromium Weekend vs. Weekday Summary**

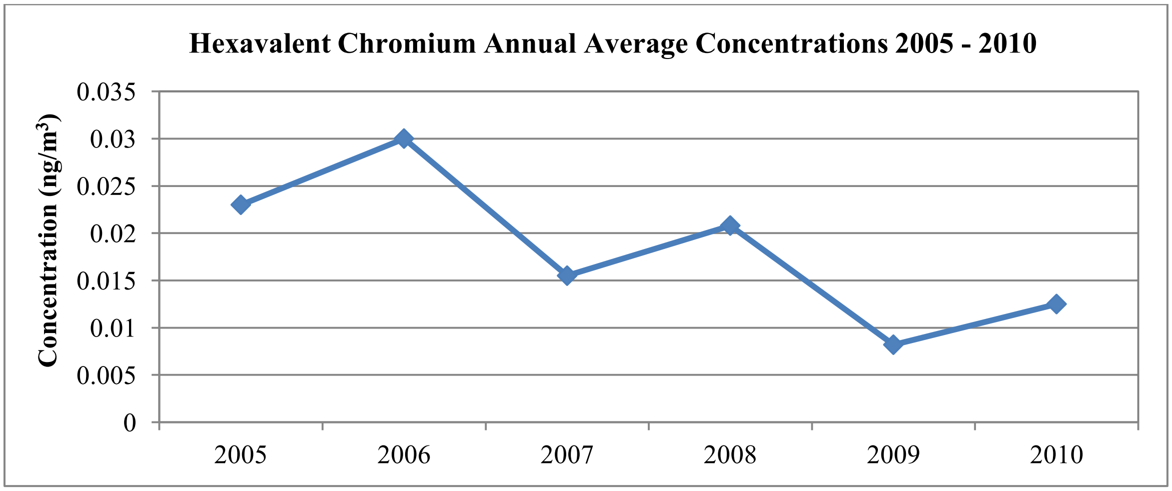

Figure 36. **Hexavalent Chromium Annual Average Concentrations 2005 – 2010**

Figure 35 is a summary of the weekday versus weekend hexavalent chromium concentrations. The average weekday concentration is approximately five times larger than the weekend concentration. This is expected, as hexavalent chromium is primarily used in industrial processes and would be used during the week. Figure 36 is a graph of the annual average hexavalent chromium concentrations from 2005 through 2010. The graph indicates a general downward trend in the concentrations for this compound. A calculation of the 3-year averages from 2005 through 2007, and 2008 through 2010, shows a decrease from 0.023 to 0.014 ng/m^3, which is a decrease of nearly 40%.

Quality Assurance/Quality Control

Field Blanks

Once a month, a filter was transported to the field, placed on the sampler, and immediately removed, without having any air passed through it. These “field blanks” were taken to assess whether contamination in the field or the sampling materials is significant. Out of 12 blanks taken, none showed detectable levels of hexavalent chromium. Unlike total chromium samples discussed in the previous section, hexavalent chromium samples are not potentially compromised by high blank levels. This is good, because the concentrations of hexavalent chromium are more relevant in risk assessment studies than total chromium.

Precision of Sample Results

Six times during the year, a laboratory split sample was analyzed. An incoming sample was split into two separate samples, and then analyzed by the lab. A comparison of the results obtained gives an idea of the precision of the analytical method. In general, the duplicate samples showed good agreement.

VII. PM_{10}

Sample Statistics Summary

The Colorado Department of Public Health and Environment operates samplers for particulate matter 10 microns or less in diameter (PM_{10}) and particulate matter 2.5 microns or less in diameter ($PM_{2.5}$) at the Grand Junction – Powell station. These samplers serve to indicate the status of Grand Junction regarding the National Ambient Air Quality Standards (NAAQS) for PM_{10} and $PM_{2.5}$. Results of the statewide particulate matter monitoring network are discussed in "Colorado: 2010 Air Quality Data Report" by the Air Pollution Control Division. In 2010, the percentage of PM_{10} data recovery was 83.1 percent, with 130 samples attempted, and 108 collected on the primary sampler. For 12 of the 22 missed/voided samples, the collocated sampler was in operation, and those values replaced the missing values for the primary sampler. This brings the data recovery rate to 92.3%.

Table 11. PM_{10} Average Concentrations 2004 – 2010

Analyte	**2004 Average ($\mu g/m^3$)**	**2005 Average ($\mu g/m^3$)**	**2006 Average ($\mu g/m^3$)**	**2007 Average ($\mu g/m^3$)**	**2008 Average ($\mu g/m^3$)**	**2009 Average ($\mu g/m^3$)**	**2010 Average ($\mu g/m^3$)**
PM_{10} (every 3rd day)	29	25.6	30.1	29.6	28.7	24.8	22.4
PM_{10} (every 6th day)	----	----	----	----	----	25.9	19.2

Table 11 lists the annual average concentrations observed at the Grand Junction site in 2009 and 2010. The table lists average concentrations from the primary sampler for the entire every third day sampling period, from 2004 through 2010, as well as the subset of those concentrations that reflect the same days that the air toxics analyzers were in operation (every sixth day), from 2009 through 2010. It should be noted here that there is a collocated sampler in operation at this site, and on days where the primary sample was voided, but the collocated sample was not, the value for the collocated sample was substituted in for the primary sampler's value to keep the data consistent. The averages are similar for the third and sixth day sampling, and are less than half of the former annual standard level of 50 micrograms per meter cubed. The maxima for the third and sixth day sampling are not similar in 2010. In fact, the 2010 maximum for samples taken every third day exceeds the 24-hour maximum standard of 150 micrograms per meter cubed, with a value of 155 micrograms per meter cubed. This occurred on May 23, 2010, which was not a 1-in-6 sampling day. The every sixth day sampling maximum concentration was approximately 1/3 the value of the standard, at 57 micrograms per meter cubed.

Graphs

Figure 37 is a graph of the PM_{10} concentration data recorded every sixth sampling day. The graph indicates no seasonal variability for the coarse particulate matter.

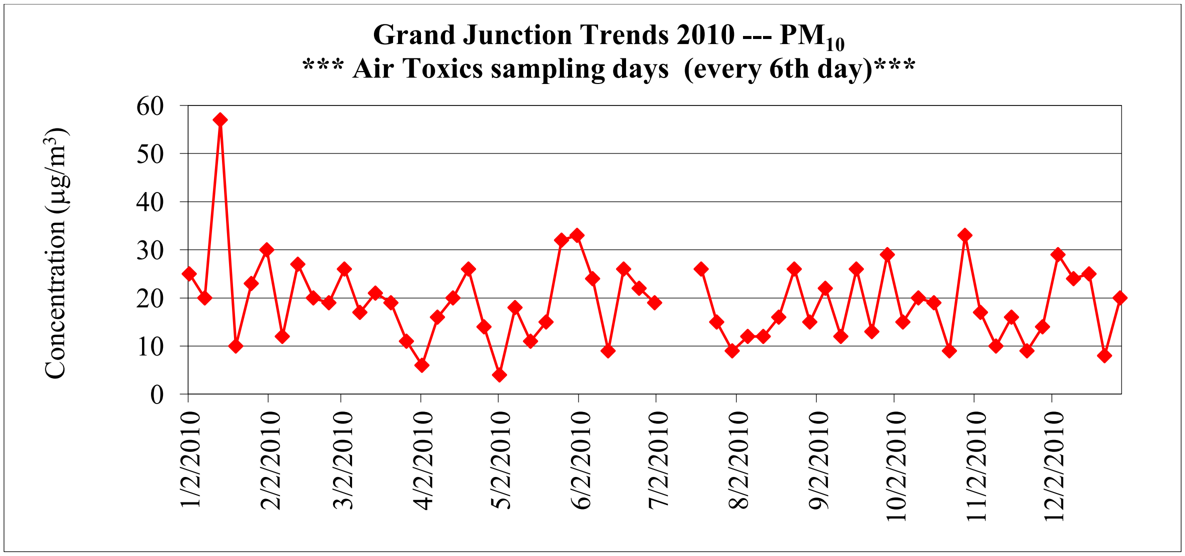

Figure 37. PM_{10} Concentrations by Date (every 6th Day)

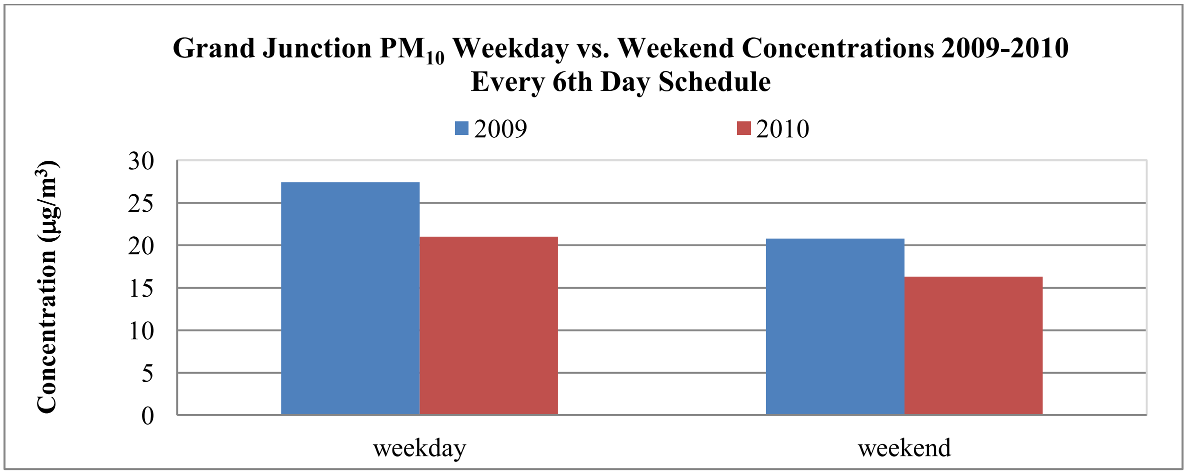

Figure 38. PM_{10} Weekend vs. Weekday Comparison 2009-10, every 6th day

Figure 38 is a graph of the weekend versus weekday concentrations for PM_{10} on the every third and sixth day sampling schedules. The weekday average is larger than the weekend average. PM_{10} is dominated by surface disturbance of earth materials (street sand, windblown dust). The PM_{10} levels are subject to change due to daily weather conditions. Figure 39 is a graph of the annual average PM_{10} concentrations from 2004 through 2010. Because PM_{10} is heavily weather dependent, no trend in concentration values is expected to be seen.

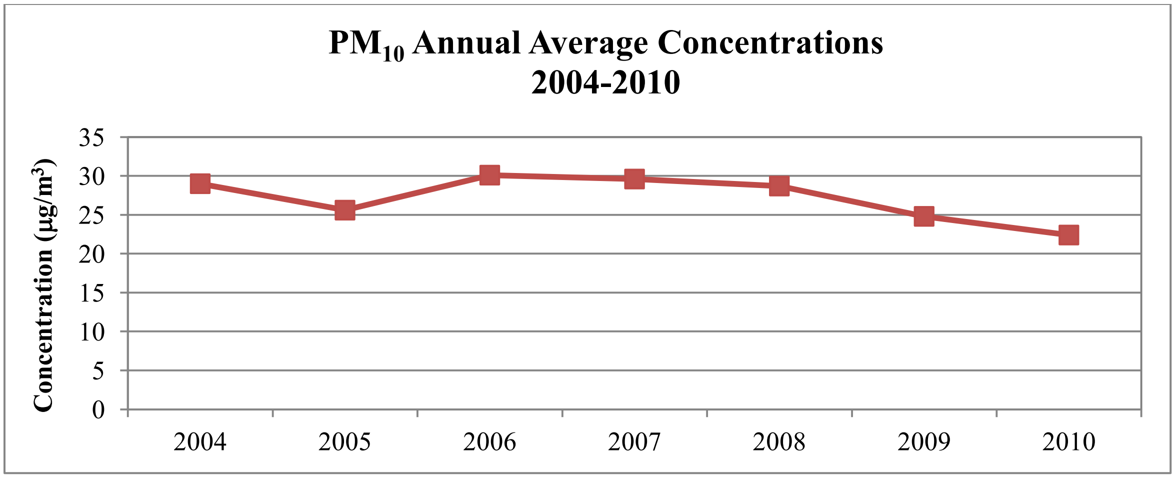

Figure 39. **PM_{10} Annual Average Concentrations 2004 – 2010**

Quality Assurance/Quality Control

Field Blanks

There were no field blanks taken for PM_{10}.

Precision of Sample Results

Collocated samples were run approximately half as frequently as the primary samples were run. This is done in an effort to validate the collected data. There is good agreement between the primary and collocated sampler concentrations.

VIII. $PM_{2.5}$

Sample Statistics Summary

The Colorado Department of Public Health and Environment operates samplers for particulate matter 2.5 microns or less in diameter ($PM_{2.5}$) at the Grand Junction – Powell and Grand Junction – Pitkin stations. These samplers serve to indicate the status of Grand Junction regarding the National Ambient Air Quality Standards (NAAQS) for and $PM_{2.5}$. Results of the statewide particulate matter monitoring network are discussed in "Colorado: 2010 Air Quality Data Report" by the Air Pollution Control Division. The National Air Toxics Trends Study chose to monitor air toxics in Grand Junction because of the availability of $PM_{2.5}$ speciation data, which gives insight into air toxics in particulate matter. It should be noted here, however, that the speciation sampler previously located in Grand Junction was removed, and relocated to the state's NCore site in Denver at the end of 2009. The $PM_{2.5}$ data discussed here is the gravimetric filter data only, and does not include any speciated results. In 2010, the percentage of $PM_{2.5}$ data recovery was 91.5 percent, with 130 samples attempted, and 119 collected.

Table 12. $PM_{2.5}$ Average Concentrations 2009-10

Analyte	2005 Average (μg/m^3)	2006 Average (μg/m^3)	2007 Average (μg/m^3)	2008 Average (μg/m^3)	2009 Average (μg/m^3)	2010 Average (μg/m^3)
$PM_{2.5}$ (every 3rd day)	8.36	9.70	9.49	9.11	9.80	9.00
$PM_{2.5}$ (every 6th day)	----	----	----	----	10.5	8.4

Table 12 lists the annual average $PM_{2.5}$ concentrations at the Grand Junction sites for 2005 through 2010. $PM_{2.5}$ emissions are generated by agriculture, and the combustion of automobile fuels, coal, wood, etc. The table lists concentrations for the entire every third day sampling period, for 2005 through 2010, as well as concentrations obtained on the same days that the air toxics analyzers were in operation (every sixth day), for 2009 and 2010. It should be noted here that there are not collocated samplers in operation for the $PM_{2.5}$ data, as there are for the PM_{10} data. The "every sixth day" values presented in Table 12 are a subset of the "every third day" sample set, and represents data collected in tandem with the air toxics analyzers. The averages are very similar for the third and sixth day sampling, and are less than two-thirds of the annual standard level of 15 micrograms per meter cubed. The maxima for the third and sixth day sampling are the same, at 43.3 micrograms per meter cubed, and above the 24-hour maximum standard of 35 micrograms per meter cubed.

Graphs

A graph of the daily concentration values for every sixth day sampling is shown in Figure 40. It shows that the $PM_{2.5}$ concentrations are generally pretty consistent throughout the year, but tend to vary more during the winter months, when there is more smoke in the air from agriculture, and household wood burning.

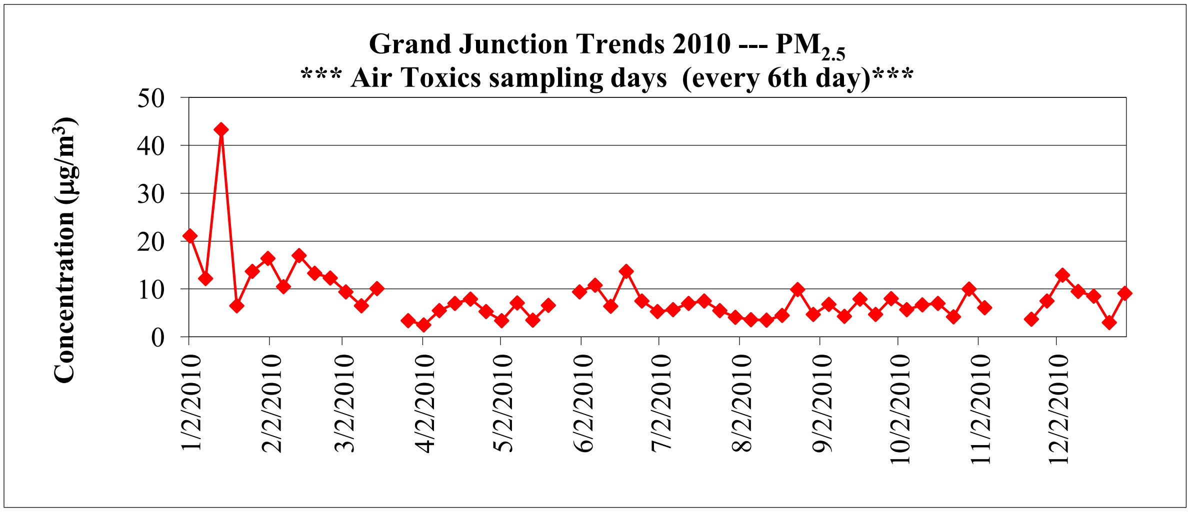

Figure 40. **$PM_{2.5}$ Concentration by Date, Every 6th Day Sampling 2010**

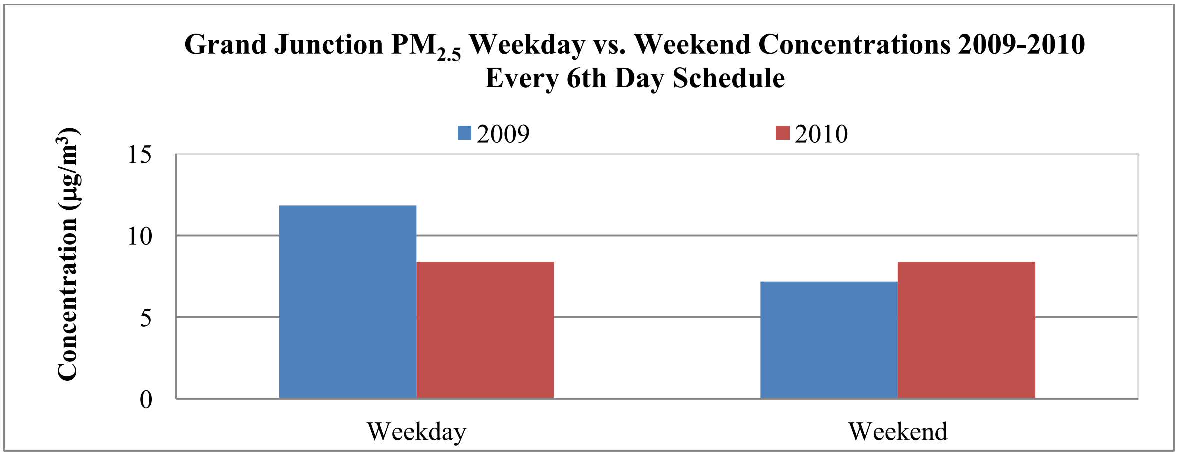

Figure 41. **$PM_{2.5}$ Weekend vs. Weekday Comparison 2009-10, every 6th day**

Figure 41 shows how the weekend versus weekday average concentrations compare for 2009-2010, for both the every 3rd day, and every 6th day sampling schedules. In both cases, the 2009 weekday averages were larger than the 2010 weekday averages, and the 2009 weekend averages were smaller than the 2010 weekend averages. Figure 42 shows the annual average concentrations for $PM_{2.5}$ for 2005 through 2010. The overall average trend seems to be staying quite similar from year to year.

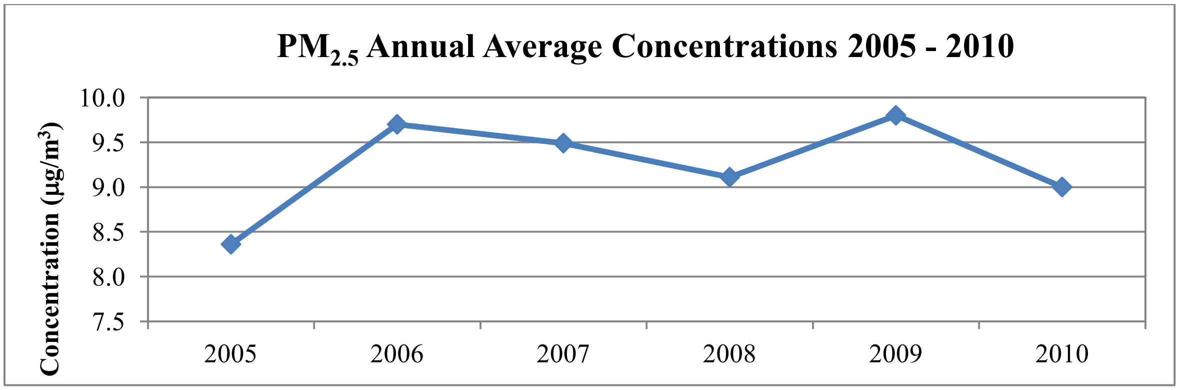

Figure 42. **$PM_{2.5}$ Annual Average Concentrations 2005 – 2010**

Quality Assurance/Quality Control

Field Blanks

There were no field blanks taken for $PM_{2.5}$.

Precision of Sample Results

No collocated samples were run for $PM_{2.5}$.

IX. POLYCYCLIC AROMATIC HYDROCARBONS

Summary Statistics

In April 2008, the Grand Junction National Air Toxics Trends Site added a sampler for polycyclic aromatic hydrocarbon (PAH) compounds. A good definition of these chemicals is:

> *Polycyclic aromatic hydrocarbons (also known as polynuclear aromatic hydrocarbons) are composed of two or more aromatic (benzene) rings which are fused together when a pair of carbon atoms is shared between them. The resulting structure is a molecule where all carbon and hydrogen atoms lie in one plane. Naphthalene ($C_{10}H_8$, MW = 128.16 g), formed from two benzene rings fused together, has the lowest molecular weight of all PAHs. The environmentally significant PAHs are those molecules which contain two (e.g., naphthalene) to seven benzene rings (e.g., coronene with a chemical formula $C_{24}H_{12}$; MW = 300.36 g). In this range, there are a large number of PAHs which differ in number of aromatic rings, position at which aromatic rings are fused to one another, and number, chemistry, and position of substituents on the basic ring system.* (Source: Ambient Water Quality Criteria for Polycyclic Aromatic Hydrocarbons (PHAs) Ministry of Environment, Lands and Parks, Province of British Columbia. By N. K. Nagpal, Ph.D., Water Quality Branch, Water Management Division, British Columbia, Canada, Ministry of Environment, February, 1993).

In all, 61 PAH samples were attempted, and 57 were collected for analysis (93.4% sample recovery rate). Twenty-two compounds were measured for this study. The list of these compounds and the summary of the collected data are shown in Table 13 and Table 14. Twelve of the 22 compounds analyzed for were detected in greater than 90% of the samples, and 19 were detected in greater than 50% of the samples. Eight compounds were detected in every sample taken. These are: 9-fluorenone, acenaphthene, chrysene, fluoranthene, fluorene, naphthalene, phenanthrene, and pyrene.

Table 13. PAH Sample Summary Data 2010

Compound	CAS Number	# of ND's	% ND
9-Fluorenone	486-25-9	0	0%
Acenaphthene	83-32-9	0	0%
Chrysene	218-01-9	0	0%
Fluoranthene	206-44-0	0	0%
Fluorene	86-73-7	0	0%
Naphthalene	91-20-3	0	0%
Phenanthrene	85-01-8	0	0%
Pyrene	129-00-0	0	0%
Anthracene	120-12-7	1	2%
Retene	483-65-8	1	2%
Benzo (g,h,i) perylene	191-24-2	2	4%
Benzo (b) fluoranthene	205-99-2	4	7%
Benzo (e) pyrene	192-97-2	8	14%
Coronene	191-07-1	10	18%
Indeno(1,2,3-cd)pyrene	193-39-5	14	25%
Acenaphthylene	208-96-8	16	28%
Benzo (k) fluoranthene	207-08-9	20	35%
Benzo (a) anthracene	56-55-3	23	40%
Benzo (a) pyrene	50-32-8	28	49%
Perylene	198-55-0	36	63%
Cyclopenta[cd]pyrene	27208-37-3	40	70%
Dibenz (a,h) anthracene	53-70-3	50	88%

ND = Not Detected

Table 14 summarizes the annual mean concentrations for each PAH measured during the study, from 2008 through 2010. The compounds that were detected in less than 90% of the samples taken are italicized to show that their averages are dependent upon their respective MDL values. The annual means were calculated by replacing all "non-detect" values with one-half of the sample minimum detection limit. This is an accepted conservative technique for calculating annual values when some of the samples were less than the laboratory's ability to detect. Naphthalene had the largest annual average of the PAH compounds with a value of 147.04 nanograms per meter cubed in 2010. This is over ten times greater than the next closest average concentration, which is phenanthrene, with 13.92 nanograms per meter cubed. Naphthalene is found in tobacco smoke, mothballs, coal tar production, and from the combustion of coal and oil. The 2010 annual averages are smaller than the 2009 annual averages.

Table 14. PAH Annual Average Values 2008 - 2010

Analyte	**2008 Average (ng/m^3)**	**2009 Average (ng/m^3)**	**2010 Average (ng/m^3)**
Naphthalene	**111.88**	**189.13**	**147.04**
Phenanthrene	11.98	17.91	13.92
Acenaphthene	8.41	11.34	7.30
Fluorene	5.15	9.20	6.44
Fluoranthene	2.52	3.79	3.30
Acenaphthylene	*2.12*	*3.68*	*2.50*
9-Fluorenone	1.53	2.67	2.34
Pyrene	1.81	2.87	2.28
Retene	0.67	1.37	1.04
Anthracene	0.63	1.65	0.89
Benzo (b) fluoranthene	0.36	0.72	0.50
Chrysene	0.35	0.68	0.49
Benzo (g,h,i) perylene	0.26	0.43	0.28
Benzo (a) anthracene	*0.20*	*0.39*	*0.25*
Benzo (e) pyrene	*0.19*	*0.39*	*0.24*
Indeno(1,2,3-cd)pyrene	*0.21*	*0.37*	*0.24*
Benzo (a) pyrene	***0.18***	***0.33***	***0.20***
Benzo (k) fluoranthene	*0.10*	*0.21*	*0.14*
Coronene	*0.15*	*0.23*	*0.13*
Cyclopenta[cd]pyrene	*0.16*	*0.19*	*0.10*
Perylene	*0.07*	*0.08*	*0.09*
Dibenz (a,h) anthracene	*0.06*	*0.06*	*0.03*

Bold = MQO Core Analyte, *Italic = Detection rate of less than 90%*

Graphs

Graphs of the concentration data from the twelve PAH compounds that were detected in greater than 90% of the samples taken are shown in Figure 43 through Figure 46. Naphthalene is the most variable, with concentrations ranging from 10.4 to 390 nanograms per meter cubed, and an average value of 147.0 nanograms per meter cubed. In comparison, the NMP national average naphthalene concentration was 95.3 nanograms per meter cubed.[13] The phenanthrene, fluorene, and fluoranthene concentrations tended to follow the same general trend that naphthalene did. Grand Junction recorded average concentrations of 13.92, 7.30, and 6.44 nanograms per meter cubed for phenanthrene, acenaphthene, and fluorene, respectively. The NMP national averages for these compounds were 9.63, 0.872, and 4.82 nanograms per meter cubed, respectively.[14]

Acenaphthylene, pyrene, retene, benzo (b) fluoranthene, and benzo (g,h,i) perylene exhibited a seasonal variation, with larger concentrations in the winter months, and lower concentrations in the summer months. This makes sense, since the primary source of many PAHs in air is the incomplete combustion of wood and

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[13] "2010 National Monitoring Programs Annual Report (UATMP, NATTS, CSATAM). US EPA. November 2012. http://www.epa.gov/ttnamti1/files/ambient/airtox/2010NMPAnnualReportVol1.pdf.

[14] *Ibid.*

fuel.[15] PAHs are a product of combustion from common sources like automobiles, wood-burning stoves and furnaces, cigarette smoke, etc. The natural sources of PAHs include volcanoes, forest fires, crude oil, and shale oil.[6]

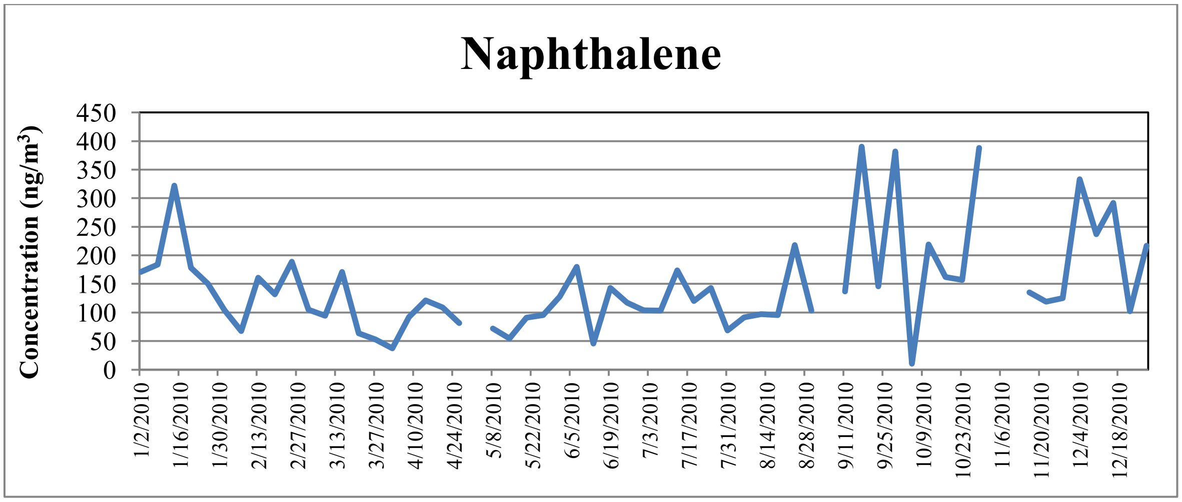

Figure 43. **Naphthalene Concentration by Date 2010**

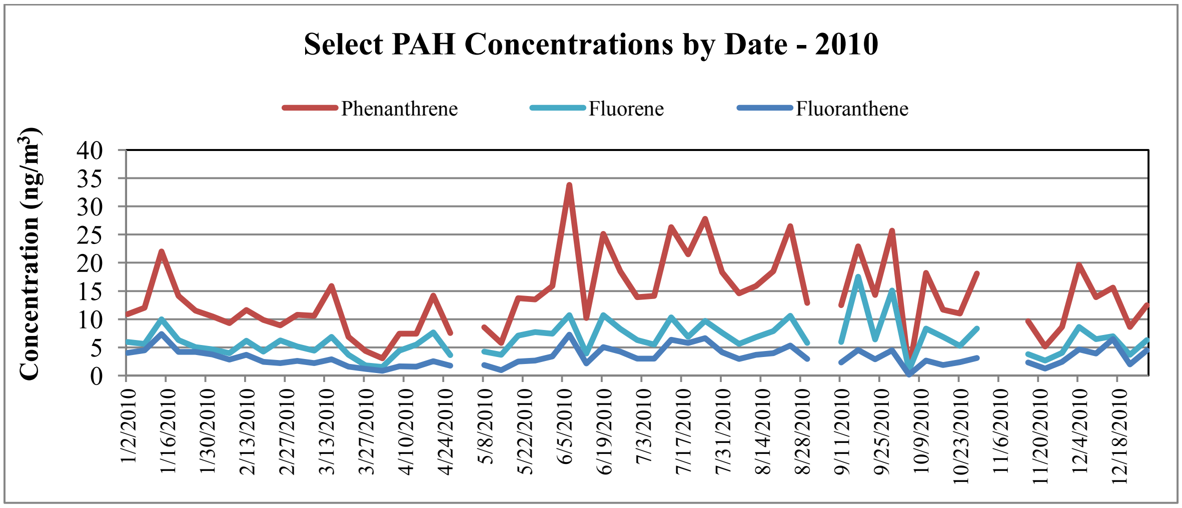

Figure 44. **Select PAH Concentrations by Date 2010**

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[15] "Toxicological Profile for Polycyclic Aromatic Hydrocabons." US Department of Health and Human Services, Agency for Toxic Substances and Disease Resigtry. August 1995. http://www.atsdr.cdc.gov/ToxProfiles/tp69.pdf

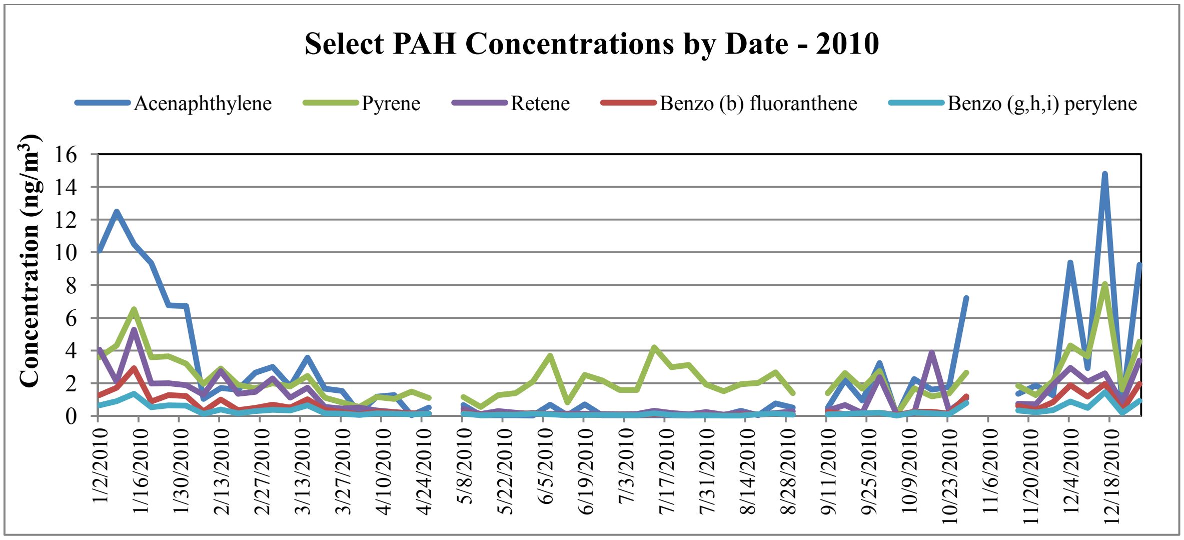

Figure 45. **Select PAH Concentrations by Date 2010, ctd.**

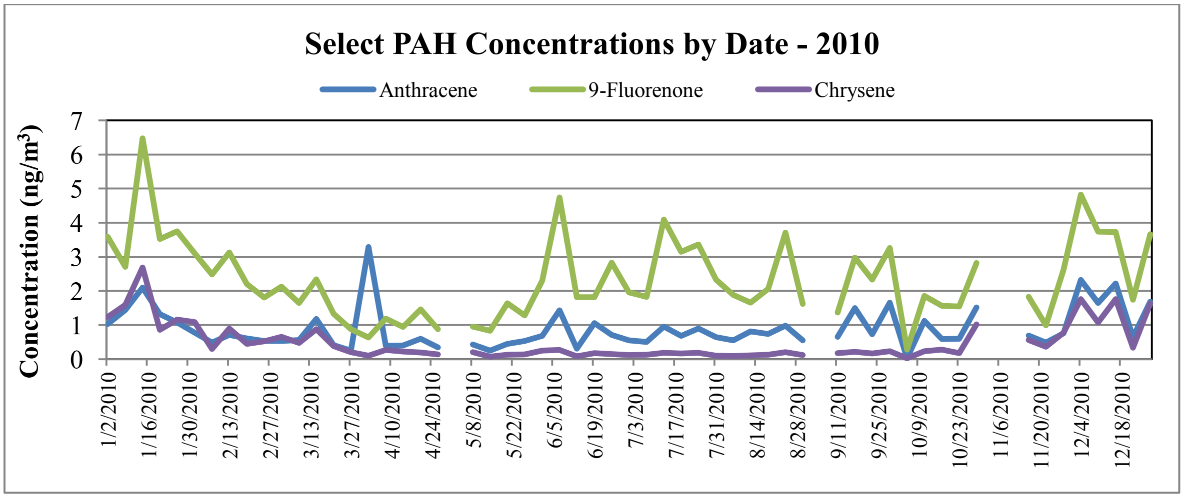

Figure 46. **Select PAH Concentrations by Date 2010, ctd.**

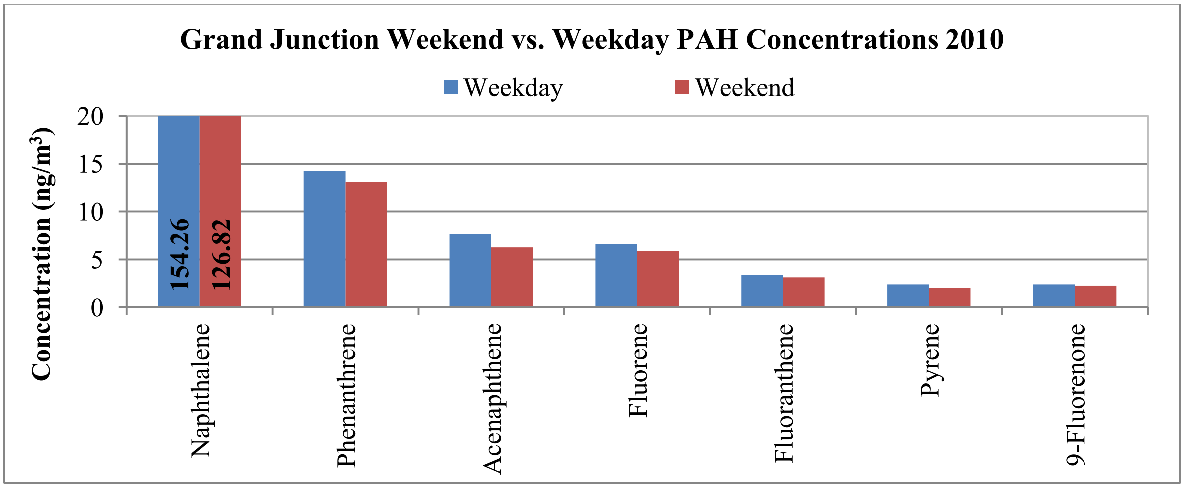

Figure 47. **PAH Weekend vs. Weekday Concentrations 2010**

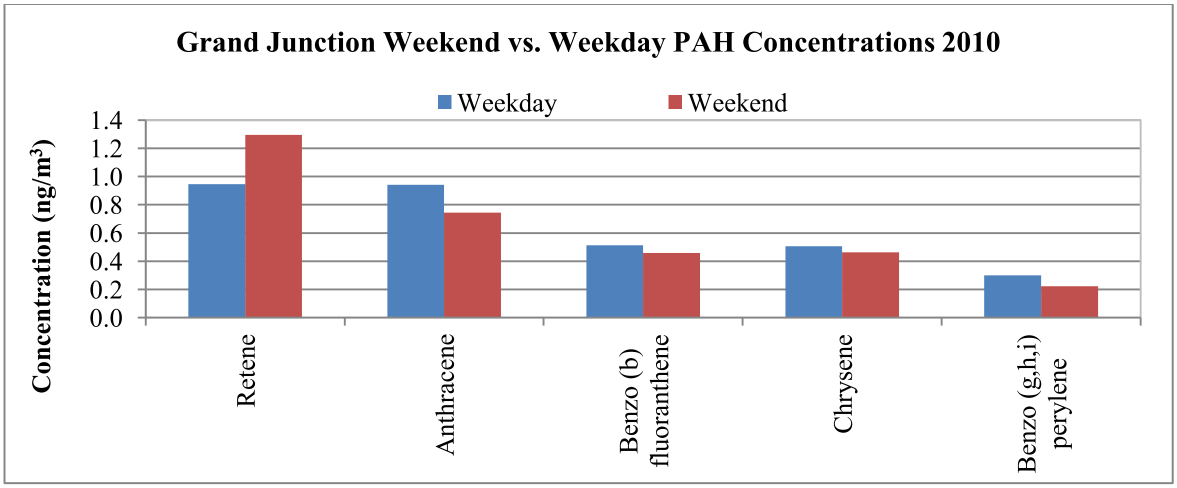

Figure 48. **PAH Weekend vs. Weekday Concentrations 2010, ctd.**

Figure 47 and Figure 48 are graphs of the weekend and weekday concentrations for the PAH compounds that were detected in greater than 90% of the samples taken in 2010. The weekday averages were larger than the weekend values for all compounds except retene. This compound had larger weekend values than weekday values. The values for naphthalene are off the chart with a weekday average of 154 nanograms per meter cubed, and a weekend average of 124 nanograms per meter cubed in 2010. Figure 49 through Figure 51 are graphs of the annual average concentrations for the twelve compounds detected in greater than 90% of the samples taken in 2009 and 2010. The graphs show that from 2008 to 2009 there was an increase in all the annual averages for those compounds, and from 2009 to 2010 there was a decrease. All twelve compounds followed this trend.

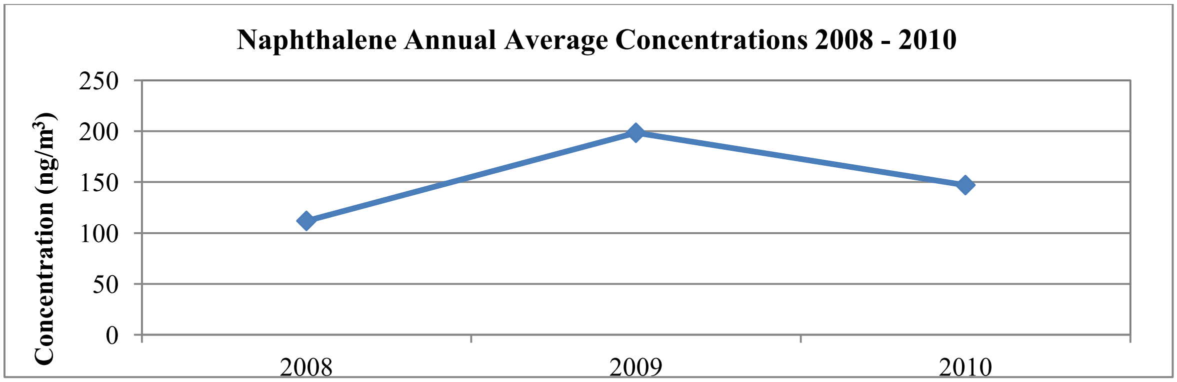

Figure 49. **Naphthalene Annual Average Concentrations 2008 – 2010**

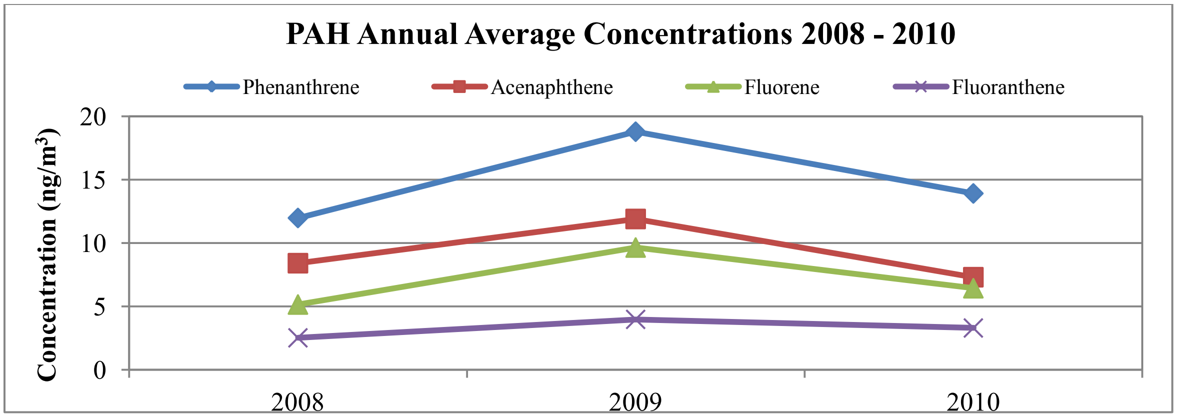

Figure 50. **Select PAH Annual Average Concentrations 2008 – 2010**

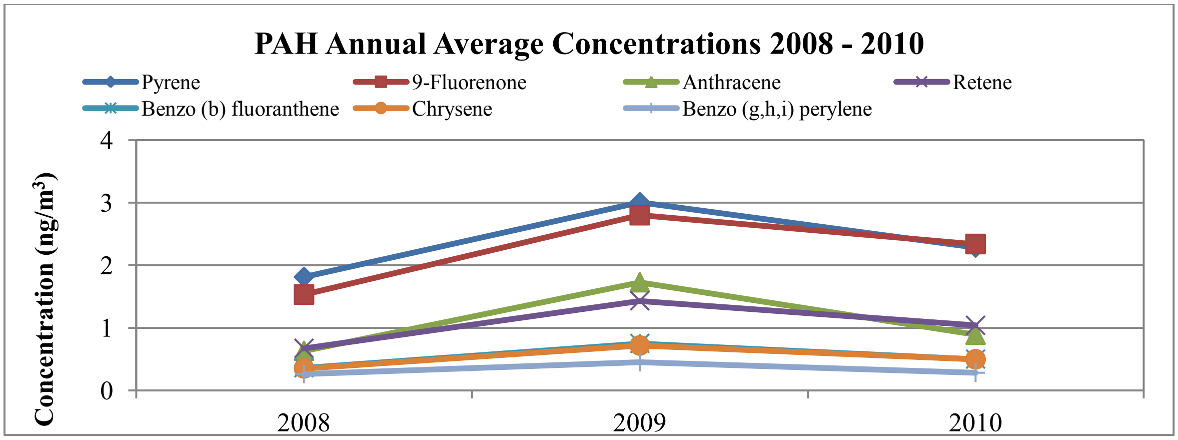

Figure 51. **Select PAH Annual Average Concentrations 2008 – 2010, ctd.**

Quality Assurance/Quality Control

Field Blanks

Periodically, the laboratory analyzes a "blank," or unused, filter for PAH compounds. The purpose of this extra analysis is to determine if there was any contamination of the filter during manufacturing, or during laboratory processing. In 2010, the laboratory analyzed 11 "filter blanks," filters which never left the lab. Several compounds were detected at low levels in many of the filter blanks.

Precision of Sample Results

Precision air samples were not run in 2010. Assessing precision requires a collocated sampler at the site, and the NATTS group chose to take precision samples at other locations in the nationwide network.

X. METEOROLOGY

A meteorological tower at the Pitkin shelter site measures wind speed, wind direction, relative humidity, and temperature. The year 2010 wind rose is shown below. The "arms" of this diagram show the percentage of the time that the wind blew from each direction. The shading on each arm indicates the wind speeds associated with each direction. Each of the concentric rings, moving outward, signifies an additional two percent of the time. For example, just below 8% of the winds are from the west-northwest. Wind speeds in the ranges of 0.5 to 2.1 meters per second (m/s) or 2.1 to 3.6 m/s are the most frequent. It should be noted here that the legend lists the wind speeds in units of meters per second, and not miles per hour (mph). All wind speeds were converted from mph to m/s.

The wind rose shows that winds follow a daily pattern typical of river valleys. At night, the winds come from the southeast quarter, flowing down river. During the day, heating of the air causes flow reversals, and flow comes from the northwest.

A look at the highest concentrations days for each pollutant indicated that some days showed maxima for more than one air pollutant. Many of these dates are in the fall or winter period, which indicates possible local temperature inversions and limited air mixing, thus allowing pollutants of all types to build up in the area.

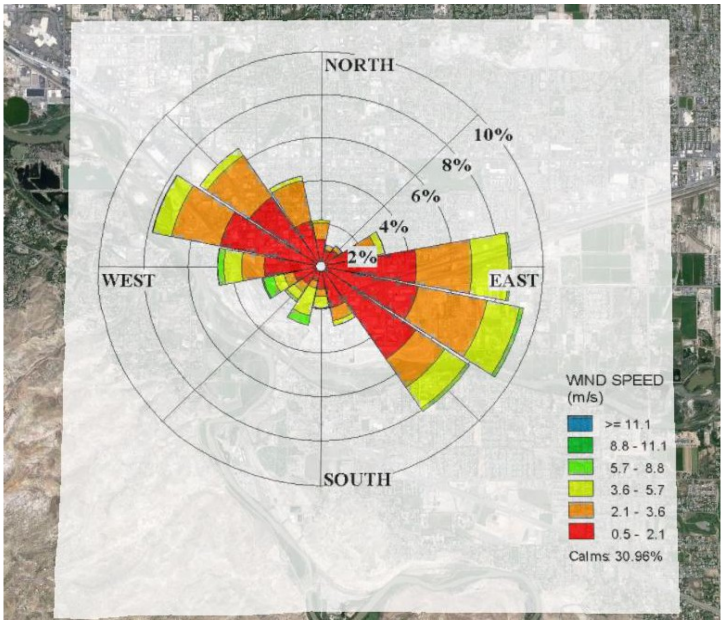

Figure 52. **Wind Rose for Grand Junction 2010**

XI. DATA CORRELATIONS AND DISCUSSION

The data presented below are the results of several correlation comparisons between the particulate concentrations, and various other air toxics compound concentrations.

Carbonyl Correlations and Sample Composition

Carbonyl compounds are known to have adverse effects on human health. They can be emitted directly from primary sources (motor vehicle emissions, and incomplete combustion), or can be formed secondarily via atmospheric photooxidation reactions .[16] They play an important role in the formation of ozone in the atmosphere, and are of great interest to atmospheric researchers, as is particulate matter. Particulates are a mixture of solid particles and liquid droplets found in the air. Of particular interest to researchers are two different classes of particulates: course (having a diameter of 10 micrometers or less), and fine (having a diameter of 2.5 micrometers or less). These particles are small enough to be inhaled deep into the lungs, and cause serious health problems. Fine particulates are the major cause of visibility issues in many parts of the U.S. A correlation of the annual average carbonyl concentration data was performed with both the PM_{10}, and $PM_{2.5}$ annual average data sets. The results of the correlation are presented in Table 15.

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[16] Wang et al., "Seasonal Variation and Source Apportionment of Atmospheric Carbonyl Compounds in Urban Kaohsiung, Taiwan." *Aerosol and Air Quality Research,* 10: 559–570, 2010. http://aaqr.org/VOL10_No6_December2010/5_AAQR-10-07-OA-0059_559-570.pdf

Table 15. Correlation Coefficient Values for Carbonyls-Particulates

Correlations	r - PM_{10}	r-$PM_{2.5}$
Acetone	0.706	-0.237
Acetaldehyde	0.544	-0.294
Formaldehyde	0.773	0.405
Butyraldehyde	0.719	-0.341
Benzaldehyde	0.939	0.075
Crotonaldehyde	0.746	-0.357
Propionaldehyde	0.579	-0.215
Hexaldehyde	0.836	-0.208
Tolualdehydes	0.896	0.138
Valeraldehyde	0.210	-0.477

Several of the carbonyl compounds tended to correlate fairly well with the PM_{10} data. It should be noted here that the correlation was performed only for the carbonyl compounds that were detected in 90% or more of the samples taken. Benzaldehyde shows the strongest correlation with an "r" value of 0.939. The "big three" carbonyls, formaldehyde, acetaldehyde, and acetone, did not show a strong correlation with the course particulate concentrations. There was little correlation between any of the carbonyls and the fine particulate concentrations, with many of the carbonyls exhibiting a slightly negative correlation. A graph of the three carbonyls with the highest "r" value for the PM_{10} correlation is shown in Figure 53.

The final graph presented in this section is a snapshot of the chemical make-up of the carbonyls group from 2004 through 2010. Figure 54 shows the percentage each carbonyl compound contributed to the overall total carbonyl concentration from year to year. Clearly, acetone, acetaldehyde, and formaldehyde dominate the carbonyl concentrations yearly.

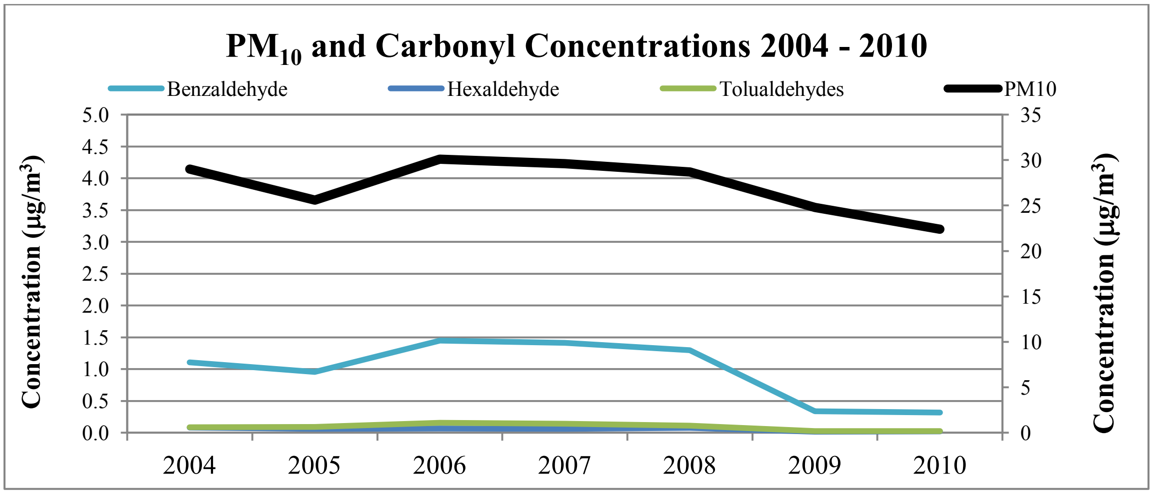

Figure 53. **PM_{10} – Carbonyl Concentration Comparison**

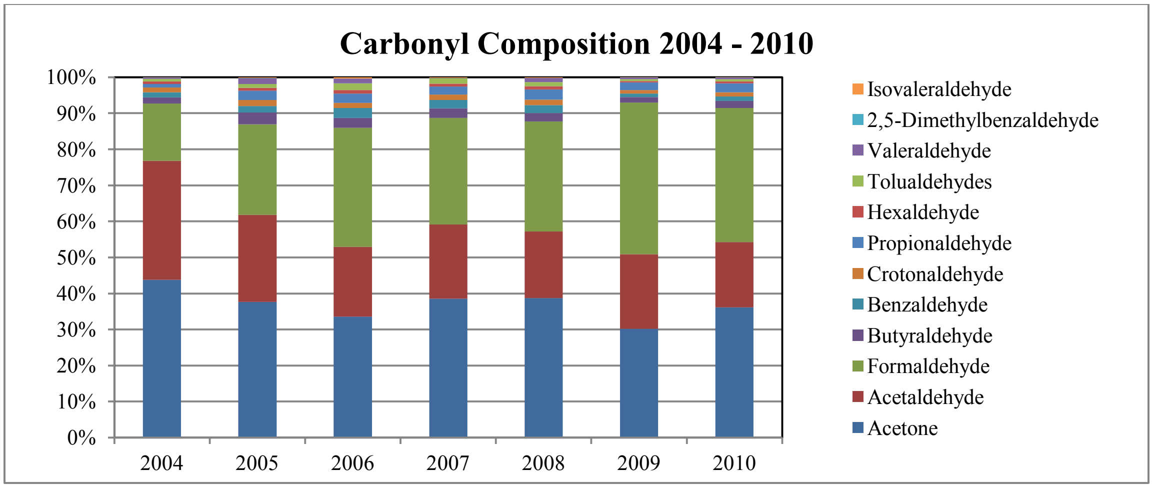

Figure 54. **Annual Carbonyl Composition**

VOC Correlations and Sample Composition

VOCs are organic compounds which have a high vapor pressure at room temperature. Because of this high vapor pressure, which is the result of a low boiling point, large numbers of VOC molecules can evaporate, or sublimate, from a liquid, or solid form and enter the ambient air. The NATTS program monitors for 60 of these compounds, many of which are never detected in any samples. The VOC correlation data used and discussed in this section is based upon the subset of 24 compounds that were detected in greater than 90% of the samples taken. It does not include three of the eight mandatory monitoring compounds (chloroform, trichloroethylene, and vinyl chloride), because they were not detected in enough samples. The other five mandatory compounds (1,3-butadiene, acrolein, benzene, carbon tetrachloride, and tetrachloroethylene) are included as they were detected in greater than 90% of the samples taken.

Table 16 is a listing of the correlation coefficients (r) for each of the 24 VOC compounds data sets, with both $PM_{2.5}$ and PM_{10} data sets. For the VOC - PM_{10} correlation, there were two VOC compounds that correlated fairly well with the particulate concentrations. Acrolein exhibited a strong, negative correlation with the particulates, while benzene showed the strongest positive correlation. Figure 55 is a graph of the benzene and acrolein concentrations, comparing them to the PM_{10} concentrations.

Table 16. **VOC – Particulate Correlation Coefficient Values**

Analyte	r-PM_{10}	r-$PM_{2.5}$
1,2,4-Trimethylbenzene	0.348	-0.394
1,3,5-Trimethylbenzene	0.274	-0.491
1,3-Butadiene	0.460	0.104
Acetonitrile	-0.722	-0.891
Acetylene	0.079	0.111
Acrolein	-0.950	-0.272
Benzene	0.747	-0.183
Carbon Disulfide	0.435	0.856
Carbon Tetrachloride	0.073	0.638
Chloromethane	-0.523	0.185
Dichlorodifluoromethane	-0.522	0.061
Dichloromethane	-0.726	-0.510
Dichlorotetrafluoroethane	-0.401	0.289
Ethylbenzene	0.081	-0.466

Analyte	**r-PM$_{10}$**	**r-PM$_{2.5}$**
m,p-Xylene	0.103	-0.442
Methyl Ethyl Ketone	0.184	0.181
n-Octane	-0.502	-0.689
o-Xylene	0.076	-0.468
Propylene	0.364	-0.181
Styrene	-0.475	-0.692
Tetrachloroethylene	-0.525	0.509
Toluene	0.199	-0.185
Trichlorofluoromethane	0.002	0.129
Trichlorotrifluoroethane	-0.036	0.460

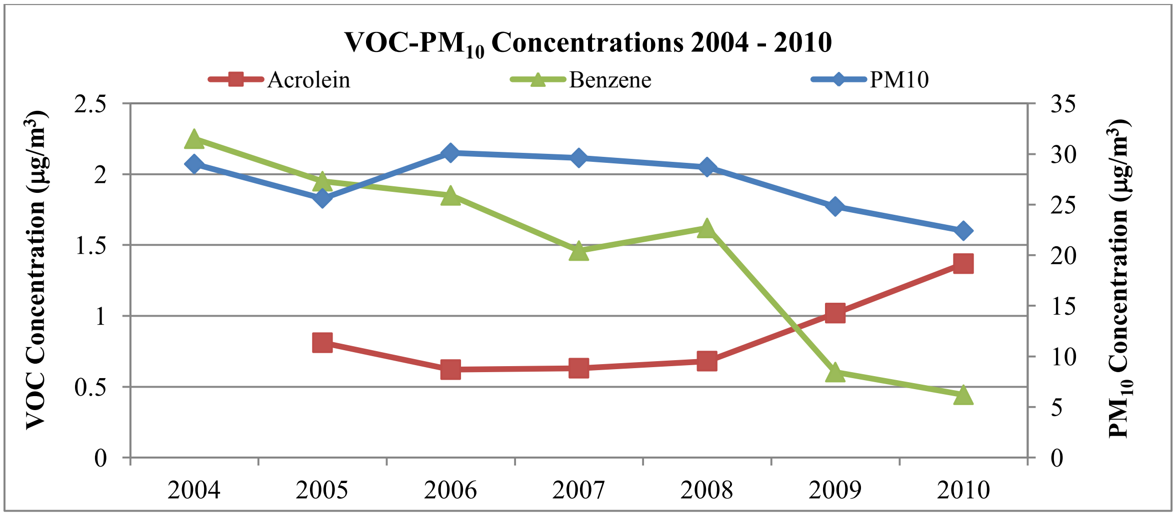

Figure 55. **VOC – PM$_{10}$ Concentration Comparison**

The VOC – PM$_{2.5}$ correlation also showed one compound with a strong negative correlation, and one with a positive correlation. Carbon disulfide correlated well with the fine particulate matter concentrations, showing a positive r-value of 0.856. Acetonitrile, however, showed a negative correlation with the fine particulates, having an r-value of -0.891. Figure 56 shows the concentration graphs for these two compounds, and how they compare to the PM$_{2.5}$ concentrations.

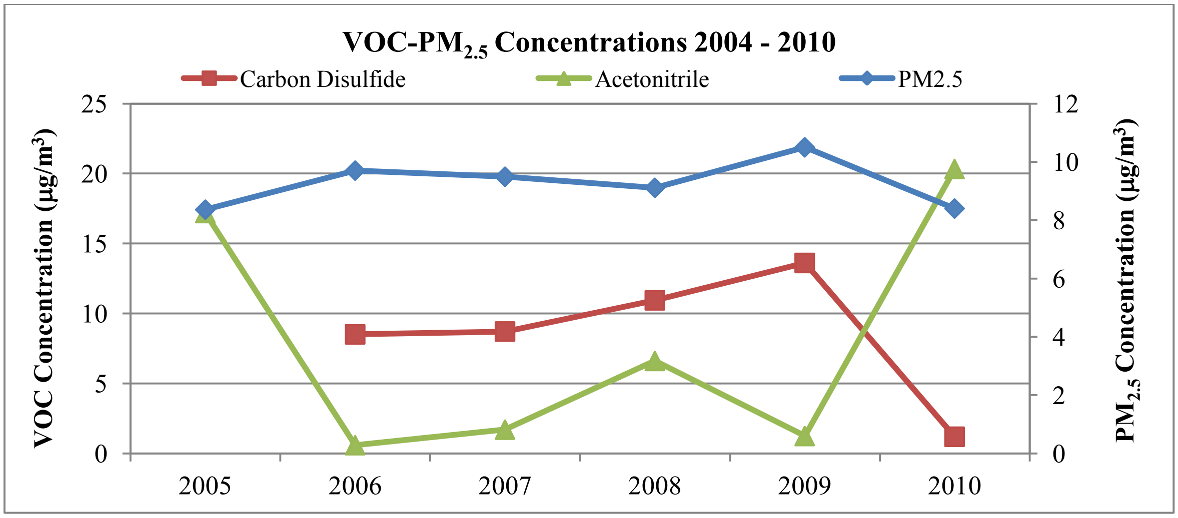

Figure 56. **VOC – PM$_{2.5}$ Concentration Comparison**

The chemical make-up of the VOC compounds tends to be much more variable from year to year than the carbonyl compounds are, for the C1 through C4 carbon chains. This can be seen in Figure 57. Although the graphs only shows data from 2009 and 2010, the year to year variability is easily seen.

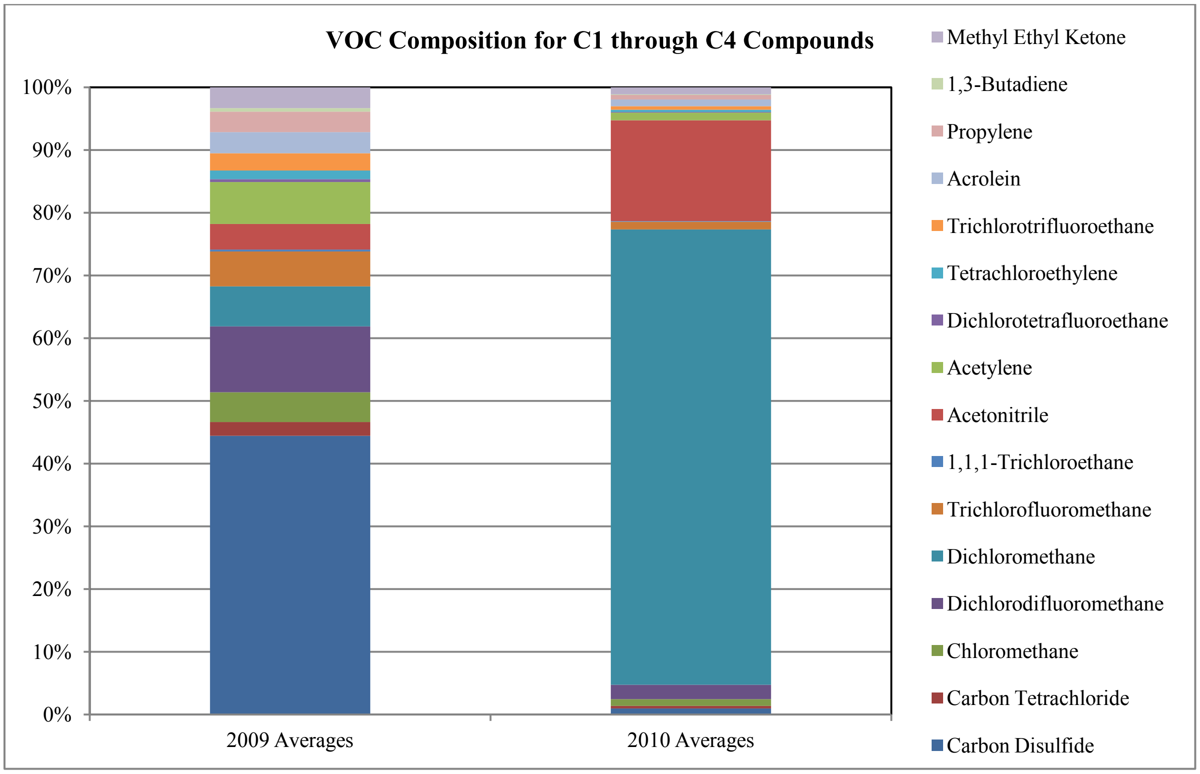

Figure 57. **Total VOC Composition for C1 through C4 Compounds**

Figure 58 shows the chemical composition of the C6 though C8 carbon chain compounds. These compounds tend to show a more consistent make-up from year to year, as opposed to the lighter end alkanes of the C1 through C4 chains. It should be noted that this grouping contains straight chain alkanes, as well as aromatic compounds.

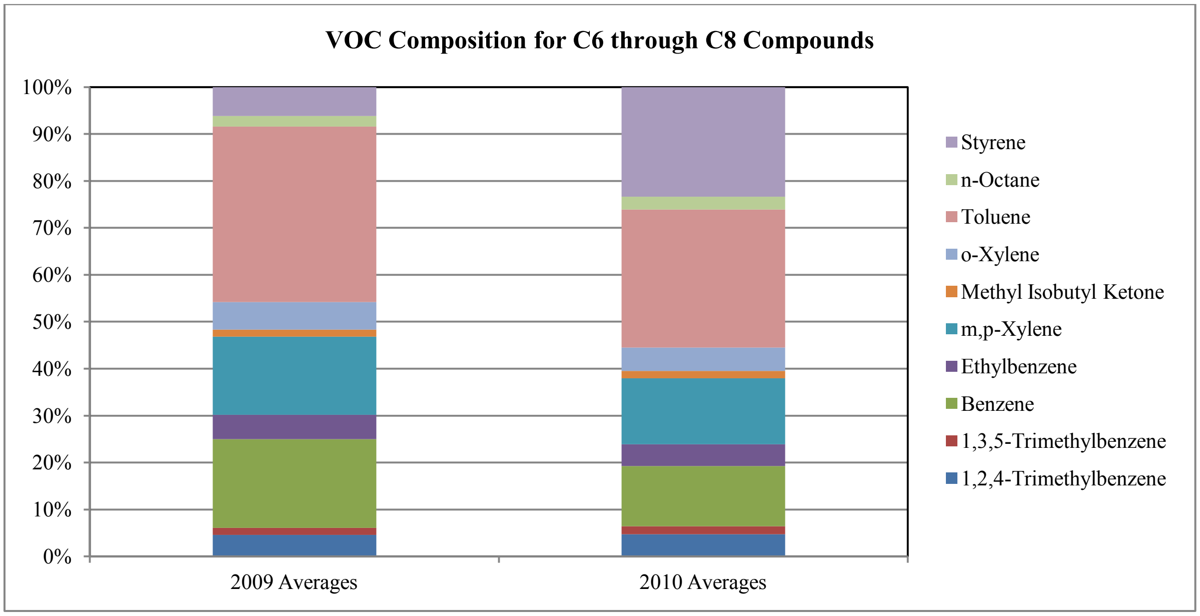

Figure 58. **Total VOC Composition for C6 through C8 Compounds**

PAH Correlations and Sample Composition

Polycyclic Aromatic Hydrocarbons are often found naturally in the environment, but are also man-made. They can enter the air through the incomplete combustion of fuels and garbage. They are a concern because of their persistence in the atmosphere. Because they don't burn completely, they can stay in the environment for long periods of time. Table 17 lists the correlation coefficient values for each of the PAH compounds that were detected in greater than 90% of the samples taken in 2010. Most of the compounds show a negative correlation with the PM_{10} values, with the exception of acenaphthene, which shows very little correlation with an r-value of 0.096.

This particular set of compounds did tend to trend well with the fine particulate matter concentrations. All compounds showed positive correlations with the $PM_{2.5}$ concentrations, with the lowest value being 0.525 for 9-fluorenone. The strongest correlation between the PAH and $PM_{2.5}$ concentrations was seen with acenaphthene. A correlation coefficient of 0.994 was obtained for this compound. Overall, the PAHs appear to correlate well with the $PM_{2.5}$ concentrations. The compounds with the three largest correlation coefficient values are graphed in Figure 59.

Table 17. **PAH – Particulate Correlation Coefficient Values**

PAH correlations	**r - PM_{10}**	**r - $PM_{2.5}$**
9-Fluorenone	-0.728	0.525
Acenaphthene	0.096	0.994
Anthracene	-0.357	0.843
Benzo (b) fluoranthene	-0.475	0.767
Benzo (e) pyrene	-0.305	0.872
Benzo (g,h,i) perylene	-0.229	0.907
Chrysene	-0.514	0.737
Fluoranthene	-0.643	0.621
Fluorene	-0.406	0.814

PAH correlations	r - PM_{10}	r - $PM_{2.5}$
Naphthalene	-0.525	0.729
Phenanthrene	-0.404	0.815
Pyrene	-0.513	0.738
Retene	-0.598	0.665

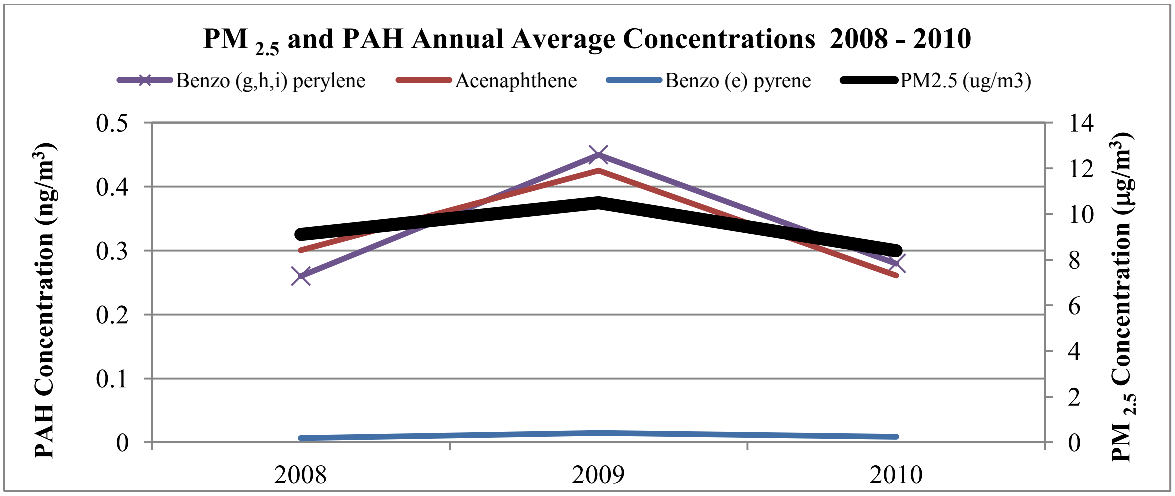

Figure 59. **PAH – $PM_{2.5}$ Concentration Comparison**

Figure 60 is a graph showing the percentage contribution each of the PAH compounds (detected in greater than 90% of the samples taken) to the total PAH concentration. Clearly, naphthalene is the dominant compound of the group. The composition of the PAH group does not appear to vary much from year to year.

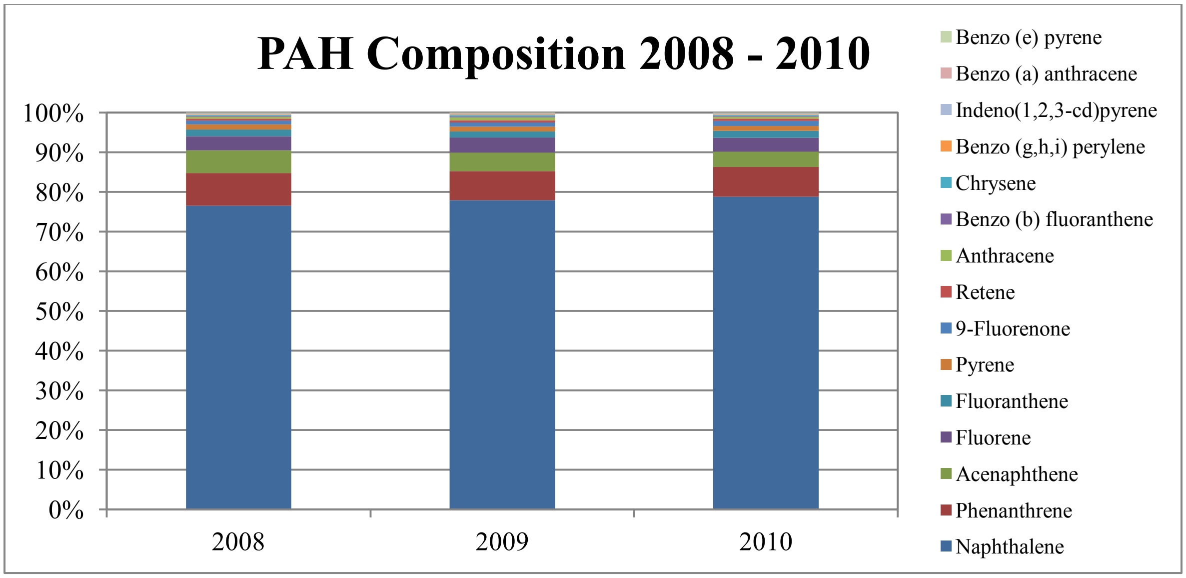

Figure 60. **PAH Chemical Composition 2008 – 2010**

Metals Correlations and Sample Composition

The light metals in this group are analyzed via a PM_{10} filter based monitor. Only four of the six metals analyzed for were detected in at least 90% of the samples taken. The correlation coefficients of these four compounds with the two different particulate classes are shown in Table 18. Manganese concentrations correlated well with the PM_{10} concentrations, having an r-value of 0.846. There were no significant correlations between any of the metals compounds and the $PM_{2.5}$ concentrations. A graph of the PM_{10} and manganese concentrations is seen in Figure 61.

Table 18. Metals – Particulates Correlation Coefficients

Analyte	r-PM_{10}	r-$PM_{2.5}$
Arsenic	0.343	-0.401
Lead	0.590	0.148
Manganese	0.846	0.001
Nickel	-0.442	-0.567

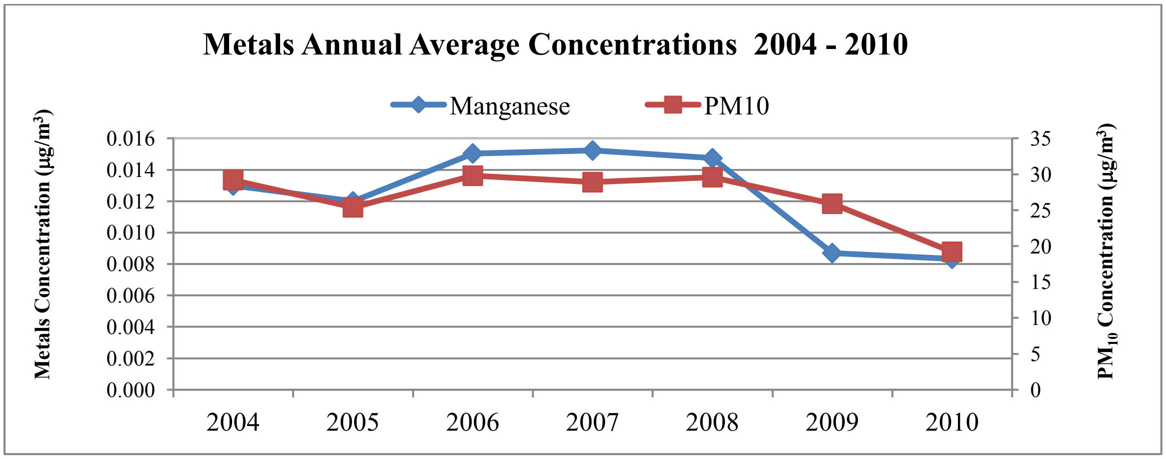

Figure 61. Metals – PM_{10} Concentration Comparison

Figure 62 is a graph showing the percentage contribution of each of the individual metals compounds to the overall total. The concentrations vary somewhat from year to year, but not as much as the C1 through C4 compounds of the VOC section.

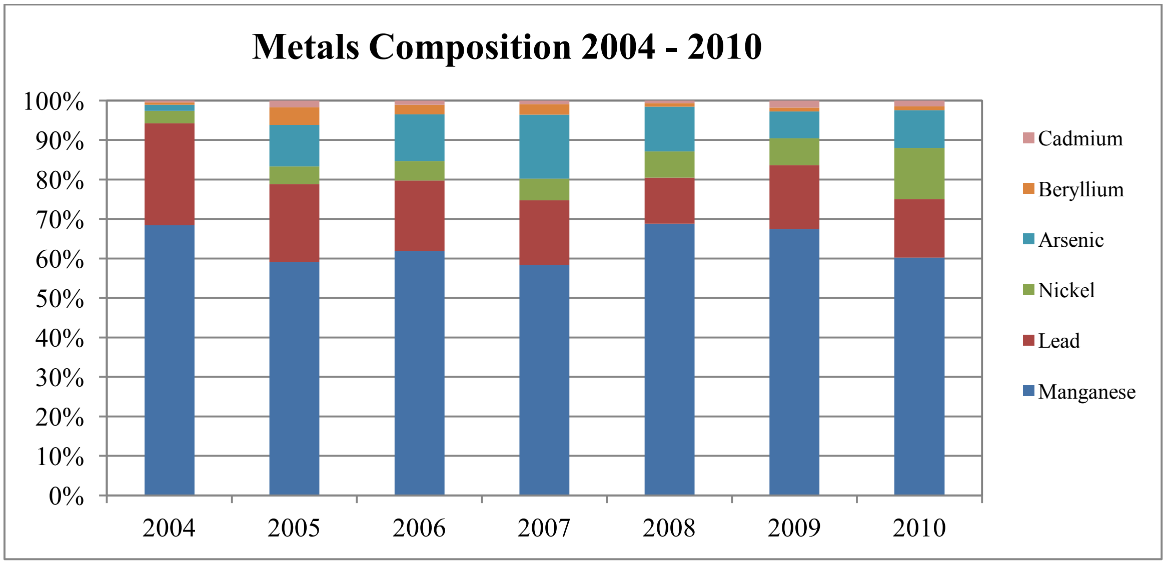

Figure 62. Metals Chemical Composition 2004 – 2010

XII. SUMMARY AND CONCLUSIONS

The National Air Toxics Trends Study in Grand Junction for 2010 showed similar results to prior years. The highest carbonyls in air were formaldehyde, acetaldehyde, and acetone. A correlation analysis was run between the particulate concentrations and the carbonyl concentrations. PM_{10} concentrations tended to correlate with many of the carbonyl compounds. A correlation value (r) of 0.773 was obtained when comparing PM_{10} to formaldehyde concentrations. This value was the highest obtained for the PM_{10}-carbonyl correlation. The lowest value was seen upon a comparison with valeraldehyde, with a correlation coefficient of 0.210. A comparison of the $PM_{2.5}$ concentrations with the carbonyls again showed that formaldehyde correlated the best, but had a low coefficient value of 0.405. Many of the carbonyls showed no correlation at all with the $PM_{2.5}$ values.

Twenty-four volatile organic compounds are ubiquitous, having been detected in 90% of the air samples for 2010. Going back to 2009, there were 26 compounds detected in at least 90% of the samples. From 2009 to 2010, the makeup of the C1 to C4 group was highly variable, with large concentrations of carbon disulfide in 2009, but not in 2010; and also large concentrations of dichloromethane in 2010, but not in 2009. The C6 through C8 group showed more consistency in the constituent concentrations from 2009 to 2010.

For the metals, lead and manganese showed the highest average concentrations. Hexavalent chromium is an extremely small fraction of the chromium in air, comprising less than one percent of the total chromium concentration. The highest polycyclic aromatic hydrocarbons in air were naphthalene, acenaphthene, and phenanthrene, all of which correlated well with $PM_{2.5}$ values. All of the other PAH compounds also correlated rather well with $PM_{2.5}$ values, with correlation coefficients ranging from 0.53 to 0.907.

In general, it appears that the concentrations of many of the compounds of interest are dropping since the inception of the NATTS program in Grand Junction. The study will continue in 2011, as one of the major goals is to run the site long term, for comparison of the mean concentrations for each pollutant during the first three years to the means for successive three year intervals. Calculation of the three year average concentrations to date has shown a decrease in the majority of the concentrations of the compounds of interest. However, only two successive three year averages have been able to be calculated to this point, so it is difficult to draw any real conclusions about concentration trends until further data are collected. Enough data will have been collected by the end of 2012 to calculate a third three year average. At that time, more concrete conclusions may be able to be made.