

National Air Toxics Trends Study In Grand Junction, Colorado

January through December 2007



January 2011

Prepared by the

**Colorado Department of Public Health & Environment
Air Pollution Control Division
Technical Services Program**

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**National Air Toxics Trends Study
In Grand Junction, Colorado**

January through December 2007

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. Grand Junction was one of the five “rural” sites selected. (The Environmental Protection Agency considers this area “rural” because it is not a major metropolitan area). This report discusses the data collected at the Grand Junction monitors for 2007. Most of the compounds detected 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 vehicular sources. These include formaldehyde, benzene, toluene, ethylbenzene, xylenes, and styrene. Chloroflourocarbons are also present, including chloromethane, dichlorodifluoromethane, trichlorofluoromethane, and trichlorotrifluoroethane.

Section 1: Introduction

Introduction

The Grand Junction Air Toxics monitoring site was established as a part of the United States Environmental Protection Agency's (EPA) National Air Toxic Trends Study. This network of monitors will measure air toxics for a six year period to determine the success of the National Air Toxics Strategy in reducing 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, versus the mean concentrations for the last three years. This report discusses the results from the Grand Junction site from January 2007 through December 2007.

This report is separated into sections. Sections 2 through 5 discuss the compounds monitored as a part of this study. 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. Sections 6, 7 and 8 compare the carbon monoxide, PM₁₀ and PM_{2.5} 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). Attachment 1 discusses sources and health effects for certain compounds that have been of potential health significance on a national or local basis. This Attachment gives a brief summary of each chemical's use, its air emission sources, and its concentrations in typical urban air.

Site Information

The National Air Toxics Trends Study at Grand Junction sampled at two separate locations. These are in close proximity to one another. However, the particulate samplers are located on a roof-top, while the other parameters are monitored at a shelter at ground level. 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. The particulate samplers are located on the roof of the Powell Building at 650 South Avenue. The other monitor is located at an adjacent site at 645¼ Pitkin Avenue. This site contains the carbon monoxide monitor, meteorological tower and the gaseous air toxic monitors. Documentation regarding these sites, including maps, photographs, and aerial views, is available in Attachment 2. The sites are located on the southern end of the city in an area of commercial/light industrial land use.

Section 2: Carbonyls at Grand Junction – Powell Site

Summary Statistics – Carbonyls

Maximum and Mean – All Samples

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-based compound. Twelve compounds were measured for this study. The list of these compounds and the summary of the collected data are shown in Table 2.1 and Table 2.2.

Carbonyls were sampled on an every-sixth-day basis for the year, with 3 extra samples in June, for a total of 65 samples attempted. One sample was not valid, for a total of 64 valid samples. The site met the EPA goal for over 85 percent sample recovery.

Table 2.1 summarizes the annual maximum and mean concentrations for each carbonyl compound measured during the study. 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 carbonyl compounds measured in this study occurred at concentration levels significantly below those of these top three compounds.

All of the carbonyls, except for isovaleraldehyde and 2, 5-dimethylbenzaldehyde, were present 100 percent of the time. The isovaleraldehyde detection percentage of 32.8% was a decrease from 2006, when it was detected 78% of the time. Note that the true annual mean of 2,5-dimethylbenzaldehyde may be well below the number reported in Table 2.2. 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.

Percentage of Samples For Which Compound Was Detected

Table 2.1 shows that most of these carbonyl compounds were present in air all of the time. However, 2,5-dimethylbenzaldehyde was seen much less frequently, with no detections in 2007. 2,5-dimethylbenzaldehyde was detected 34 percent of the time in the 2001 – 2002 pilot study, while it was only detected 4.8 percent of the time in 2005, and not at all in 2006 or 2007. This is a sizable reduction in detection frequency from the Pilot study.

Isovaleraldehyde was detected about 33 percent of the time. This is a significant change from the 2006 detection frequency of 78%. The decreased detection frequency is likely due to higher detection limits for 2007, versus 2006.

Table 2.1 Carbonyl Compounds Sample Summary - 2007

Grand Junction – Powell Site	CAS Number	60 Samples	
		Number of Samples Above Detection	Percentage of Samples Detected
Acetaldehyde	75-07-0	64	100
Formaldehyde	50-00-0	64	100
Acetone	67-64-1	64	100
Valeraldehyde	110-62-3	64	100
Butyraldehyde	123-72-8	64	100
Propionaldehyde	123-38-6	64	100
Crotonaldehyde	123-73-9	64	100
Hexaldehyde	66-25-1	64	100
Tolualdehydes	NA	64	100
Benzaldehyde	100-52-7	64	100
Isovaleraldehyde	590-86-3	21	32.8
2,5-Dimethylbenzaldehyde	5779-94-2	0	0

Graphs - Carbonyls

The summary data for carbonyl compounds measured during 2007 are graphed in Figure 2.1. These compounds in these graphs are ordered by ranking their maximum concentration. The graphs show that acetaldehyde, acetone, and formaldehyde generally had the highest maxima. The maximums observed in 2007 were very similar to those in 2006. The means for the compounds during the two years were fairly close, with no consistent trend across compounds.

Table 2.2 Carbonyl Compounds Data Summary Comparisons – 2006 – 2007

Grand Junction – Powell Site	2007 Statistics (µg/m ³)			2006 Statistics (µg/m ³)		
	Maximum	Mean	Average MDL*	Maximum	Mean	Average MDL*
Acetaldehyde	5.495	2.794	0.007	4.162	2.358	0.008
Formaldehyde	6.317	4.020	0.012	7.522	4.017	0.006
Acetone	9.621	5.242	0.017	8.385	4.079	0.017
Valeraldehyde	0.419	0.016	0.007	0.409	0.167	0.004
Butyraldehyde	0.761	0.359	0.006	0.640	0.339	0.004
Propionaldehyde	0.620	0.309	0.005	0.670	0.313	0.005
Crotonaldehyde	0.530	0.198	0.006	0.628	0.176	0.003
Hexaldehyde	0.213	0.104	0.004	0.385	0.113	0.008
Tolualdehydes	0.487	0.199	0.018	0.442	0.225	0.015
Benzaldehyde	0.655	0.325	0.004	0.768	0.334	0.009
Isovaleraldehyde	0.120	0.023	0.007	0.088	0.042	0.004
2,5-Dimethylbenzaldehyde	ND	ND	0.011	ND	ND	0.005

*- Average MDL – average minimum detectable level

Figure 2.2 shows the concentrations for the compounds during the year. Unlike past years, the compounds did not show much seasonal variation. 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. In 2008, the Air Pollution Control Division started a new ozone monitor near Grand Junction, in Palisade. It will be interesting to see if ozone trends here follow those in the rest of the state.

Field Blanks – Carbonyls

Field blanks were collected twelve times a 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 small amounts of formaldehyde, acetaldehyde, and acetone. Detailed information regarding field blank results is available upon request.

Precision of Sample Results – Carbonyls

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. Detailed information regarding precision results is available upon request.

Figure 2.1 Maximum and Annual Mean Carbonyls 2007

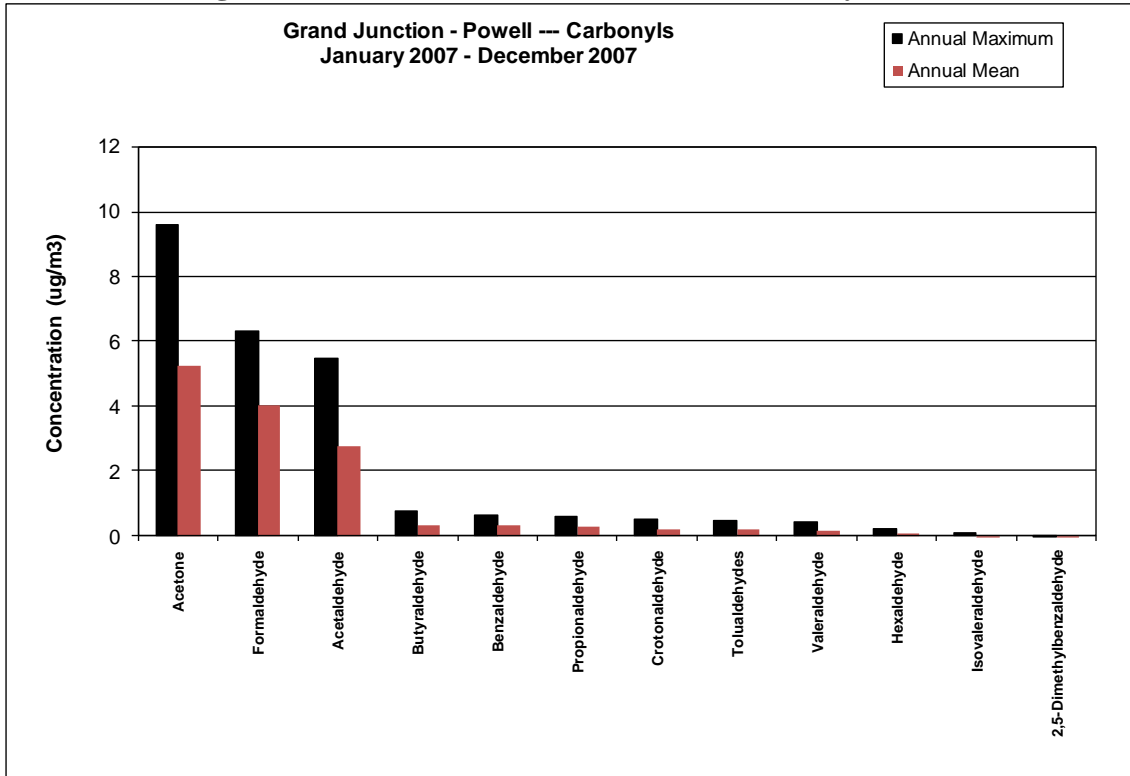
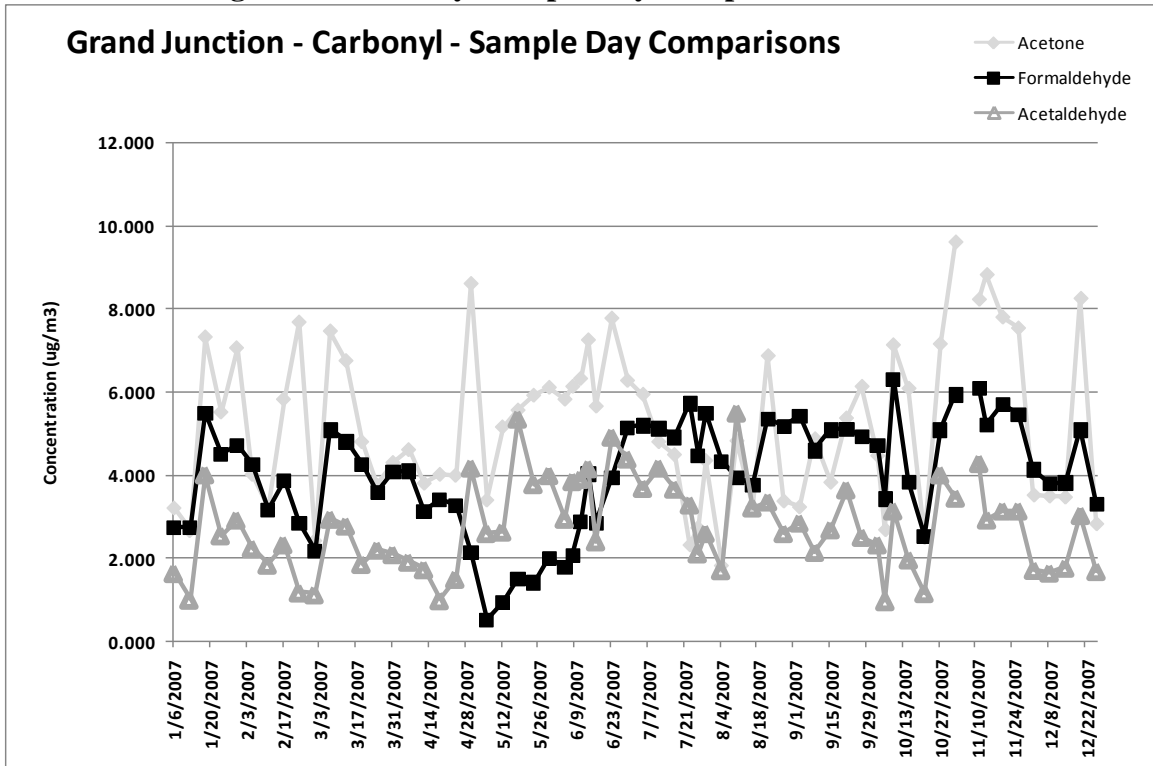


Figure 2.2 Carbonyl Sample Day Comparisons for 2007



Section 3: Volatile Organic Compounds at Grand Junction – Powell Site

Summary Statistics – Volatile Organic Compounds

Maximum and Mean – All Samples

Volatile organic compound (VOC) data collected at the Grand Junction - Powell station from January through December 2007 are presented in this section. There were 60 VOCs analyzed for this study. The list of these VOCs is on Table 3.1. These are the same VOCs collected by all of the sites participating in the national air toxics study.

Volatile organic compounds were sampled on an every-sixth-day basis, with one additional daily sample in the months of June, July, and November, for a total of 65 possible days. Three samples were not valid, giving 62 samples for the year (95.4% recovery).

Table 3.2 summarizes the annual maximum and mean concentrations for each of the 60 volatile organic compounds 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 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.

Table 3.1 VOC Detection Summary - 2007

Grand Junction - Powell Site	CAS Number*	62 Samples Taken	
		Number of Samples Detected	Percentage of Samples Detected
1,1,1-Trichloroethane	71-55-6	62	100.0%
1,1,1,2-Tetrachloroethane	79-34-5	0	0.0%
1,1,2-Trichloroethane	79-00-5	0	0.0%
1,1-Dichloroethane	75-34-3	0	0.0%
1,1-Dichloroethene	75-35-4	0	0.0%
1,2,4-Trichlorobenzene	120-82-1	0	0.0%
1,2,4-Trimethylbenzene	95-63-6	62	100.0%
1,2-Dibromoethane	106-93-4	1	1.6%
1,2-Dichloroethane	107-06-2	2	3.2%
1,2-Dichloropropane	78-87-5	0	0.0%
1,3,5-Trimethylbenzene	108-67-8	62	100.0%
1,3-Butadiene	106-99-0	62	100.0%
Acetonitrile	75-05-8	59	95.2%
Acetylene	74-86-2	62	100.0%
Acrolein	107-02-8	61	98.4%
Acrylonitrile	107-13-1	6	9.7%
Benzene	71-43-2	62	100.0%
Bromochloromethane	74-97-5	0	0.0%
Bromodichloromethane	75-27-4	1	1.6%
Bromoform	75-25-2	0	0.0%
Bromomethane	74-83-9	60	96.8%
Carbon Disulfide	75-15-0	62	100.0%
Carbon Tetrachloride	56-23-5	62	100.0%
Chlorobenzene	108-90-7	1	1.6%
Chloroethane	75-00-3	47	75.8%
Chloroform	67-66-3	54	87.1%
Chloromethane	74-87-3	62	100.0%
Chloromethylbenzene	100-44-7	0	0.0%
Chloroprene	126-99-8	1	1.6%
cis-1,2-Dichloroethylene	156-59-4	1	1.6%
cis-1,3-Dichloropropene	10061-01-5	0	0.0%
Dibromochloromethane	124-48-1	0	0.0%
Dichlorodifluoromethane	75-71-8	62	100.0%
Dichloromethane	75-09-2	62	100.0%
Dichlorotetrafluoroethane	76-14-2	62	100.0%
Ethyl Acrylate	140-88-5	0	0.0%
Ethyl tert-Butyl Ether	637-92-3	0	0.0%
Ethylbenzene	100-41-4	62	0.0%
Hexachloro-1,3-butadiene	87-68-3	1	1.6%
m,p-Xylene	100-01-6	62	100.0%
m-Dichlorobenzene	541-73-1	1	1.6%
Methyl Ethyl Ketone	78-93-3	61	98.4%
Methyl Isobutyl Ketone	108-10-1	55	88.7%
Methyl Methacrylate	80-62-6	47	75.8%
Methyl tert-Butyl Ether	1634-04-4	1	1.6%
n-Octane	111-65-9	62	100.0%
o-Dichlorobenzene	95-50-1	0	0.0%
o-Xylene	95-47-6	62	100.0%
p-Dichlorobenzene	106-46-7	57	91.9%
Propylene	115-07-1	62	100.0%
Styrene	100-42-5	62	100.0%
tert-Amyl Methyl Ether	994-05-8	1	1.6%
Tetrachloroethylene	127-18-4	62	100.0%
Toluene	108-88-3	62	100.0%
trans-1,2-Dichloroethylene	156-60-5	0	0.0%
trans-1,3-Dichloropropene	10061-02-6	0	0.0%
Trichloroethylene	79-01-6	13	21.0%
Trichlorofluoromethane	75-69-4	62	100.0%
Trichlorotrifluoroethane	76-13-1	62	100.0%
Vinyl chloride	75-01-4	5	8.1%

* "CAS Number" refers to the Chemical Abstract System Number. This is an alternate way of referencing organic chemicals, which can have multiple names.

Table 3.2 VOC Data Summary Comparisons - 2006 – 2007

Grand Junction - Powell Site	CAS Number*	2007 Statistics (µg/m ³)			2006 Statistics (µg/m ³)		
		Maximum**	Mean**	Average MDL	Maximum**	Mean**	Average MDL
1,1,1-Trichloroethane	71-55-6	0.18	0.09	0.09	0.27	0.12	0.02
1,1,2,2-Tetrachloroethane	79-34-5	ND	ND	0.11	ND	ND	0.09
1,1,2-Trichloroethane	79-00-5	ND	ND	0.10	ND	ND	0.03
1,1-Dichloroethane	75-34-3	ND	ND	0.07	ND	ND	0.02
1,1-Dichloroethene	75-35-4	ND	ND	0.09	ND	ND	0.06
1,2,4-Trichlorobenzene	120-82-1	ND	ND	0.31	0.15 #	0.06 #	0.11
1,2,4-Trimethylbenzene	95-63-6	1.78	0.64	0.06	5.21	0.81	0.01
1,2-Dibromoethane	106-93-4	0.08 #	0.05 #	0.11	ND	ND	0.14
1,2-Dichloroethane	107-06-2	0.07 #	0.04 #	0.09	ND	ND	0.06
1,2-Dichloropropane	78-87-5	ND	ND	0.09	ND	ND	0.15
1,3,5-Trimethylbenzene	108-67-8	0.54	0.21	0.06	1.08	0.25	0.02
1,3-Butadiene	106-99-0	0.58	0.16	0.04	0.55	0.20	0.01
Acetonitrile	75-05-8	42.31	1.7	0.06	6.18	0.59	0.17
Acetylene	74-86-2	6.48	1.46	0.03	6.72	1.80	0.02
Acrolein	107-02-8	2.48	0.63	0.06	3.23	0.62	0.25
Acrylonitrile	107-13-1	0.22	0.04	0.06	0.65	0.09	0.12
Benzene	71-43-2	4.22	1.46	0.08	3.87	1.85	0.02
Bromochloromethane	74-97-5	ND	ND	0.10	ND	ND	0.10
Bromodichloromethane	75-27-4	0.13 #	0.06 #	0.12	ND	ND	0.05
Bromoform	75-25-2	ND	ND	0.16	ND	ND	0.18
Bromomethane	74-83-9	0.12	0.05	0.10	0.08	0.04	0.04
Carbon Disulfide	75-15-0	17.16	8.71	0.07	23.57	8.51	0.03
Carbon Tetrachloride	56-23-5	0.84	0.53	0.09	1.20	0.59	0.06
Chlorobenzene	108-90-7	0.06 #	0.03 #	0.06	0.05 #	0.01 #	0.02
Chloroethane	75-00-3	0.11	0.03	0.05	0.11	0.03	0.02
Chloroform	67-66-3	0.17	0.09	0.09	0.39	0.08	0.02
Chloromethane	74-87-3	1.56	1.22	0.05	1.71	1.21	0.03
Chloromethylbenzene	100-44-7	ND	ND	0.07	ND	ND	0.03
Chloroprene	126-99-8	0.11 #	0.03 #	0.05	0.07 #	0.04 #	0.08
cis-1,2-Dichloroethylene	156-59-4	0.16 #	0.04 #	0.07	ND	ND	0.06
cis-1,3-Dichloropropene	10061-01-5	ND	ND	0.08	ND	ND	0.06
Dibromochloromethane	124-48-1	ND	ND	0.13	ND	ND	0.09
Dichlorodifluoromethane	75-71-8	3.50	2.70	0.09	4.65	2.78	0.02
Dichloromethane	75-09-2	1.39	0.38	0.05	2.26	0.41	0.06
Dichlorotetrafluoroethane	76-14-2	0.18	0.12	0.14	0.14	0.12	0.02
Ethyl Acrylate	140-88-5	ND	ND	0.07	ND	ND	0.05
Ethyl tert-Butyl Ether	637-92-3	ND	ND	0.04	0.04 #	0.02 #	0.03
Ethylbenzene	100-41-4	1.53	0.61	0.06	1.91	0.66	0.02
Hexachloro-1,3-butadiene	87-68-3	0.26 #	0.19 #	0.38	0.21 #	0.07 #	0.14
m,p-Xylene	100-01-6	5.47	2.05	0.10	6.56	2.29	0.04
m-Dichlorobenzene	541-73-1	0.12 #	0.05 #	0.10	ND	ND	0.02
Methyl Ethyl Ketone	78-93-3	2.61	0.99	0.12	9.35	1.23	0.13
Methyl Isobutyl Ketone	108-10-1	0.56	0.17	0.07	1.35	0.21	0.03
Methyl Methacrylate	80-62-6	10.16	1.34	0.06	9.30	0.26	0.02
Methyl tert-Butyl Ether	1634-04-4	0.05 #	0.02 #	0.04	0.25 #	0.01 #	0.01
n-Octane	111-65-9	0.65	0.24	0.04	0.70	0.24	0.03
o-Dichlorobenzene	95-50-1	ND	ND	0.11	ND	ND	0.03
o-Xylene	95-47-6	1.88	0.73	0.06	2.65	0.83	0.02
p-Dichlorobenzene	106-46-7	0.30	0.07	0.10	0.54	0.09	0.04
Propylene	115-07-1	5.25	0.91	0.06	7.11	1.11	0.02
Styrene	100-42-5	2.88	0.58	0.06	1.75	0.37	0.04
tert-Amyl Methyl Ether	994-05-8	0.05 #	0.02 #	0.05	ND	ND	0.05
Tetrachloroethylene	127-18-4	1.20	0.32	0.08	2.31	0.34	0.07
Toluene	108-88-3	29.10	4.22	0.07	8.56	4.06	0.02
trans-1,2-Dichloroethylene	156-60-5	ND	ND	0.07	ND	ND	0.07
trans-1,3-Dichloropropene	10061-02-6	ND	ND	0.08	ND	ND	0.04
Trichloroethylene	79-01-6	0.14	0.06	0.10	.27	0.05	0.05
Trichlorofluoromethane	75-69-4	1.99	1.46	0.12	2.53	1.52	0.04
Trichlorotrifluoroethane	76-13-1	5.06	0.83	0.16	1.23	0.76	0.09
Vinyl chloride	75-01-4	0.04	0.03	0.06	0.03 #	0.01 #	0.02

* "CAS Number" refers to the Chemical Abstract System Number. This is an alternate way of referencing organic chemicals, which can have multiple names.

** ND – Non-Detect. All samples were less than the detection limit for this compound.

- Compound detected only once or twice during the year.

Percentage of Samples For Which Compound Was Detected

Table 3.1 shows the percentage of the samples in which each VOC was detected. Twenty-seven of the compounds were detected in over 90 percent of the samples. These compounds, that are almost always present, are listed in Table 3.3. Twenty-two of these compounds were detected over 90 percent of the time in 2006, as well. Of the five “new” compounds seen for greater than 90% of the time in 2007, two had significantly lower detection limits in 2007 than they had in 2006. Thus, the increasing number of ubiquitous compounds seen in Grand Junction air is likely due to better laboratory methodology, not to an actual change in ambient levels.

Fourteen VOCs were not detected at all during the years 2006 or 2007. Eight other compounds were very rare – they were detected once or twice during the years 2006 and 2007 (Table 3.4). The fuel additive tert-amyl methyl ether (TAME), was detected only a few times in 2007. Ethyl tert-butyl ether (ETBE), a fuel additive, was detected two or three times in the two year period. The list of compounds in Table 3.4 includes many compounds that are chiefly emitted by stationary sources. Evidently, these source types are not present in the immediate vicinity of the station.

Table 3.3 Compounds Detected in Over 90 Percent of the VOC Air Samples – 2007

<p>Compounds Detected Over 90 % of the Time in 2007 and 2006 (22)</p>	<p>1,1,1-Trichloroethane 1,3,5 - Trimethylbenzene 1,2,4 – Trimethylbenzene 1,3 - Butadiene Acetylene Benzene Carbon Disulfide Carbon Tetrachloride Chloromethane Dichloromethane Dichlorodifluoromethane</p>	<p>Dichlorotetrafluoroethane Methyl Ethyl Ketone n-Octane Ethylbenzene m,p - xylene o - xylene Propylene Styrene Toluene Trichlorofluoromethane Trichlorotrifluoroethane</p>
<p>Compounds Detected Over 90% of the Time in 2007, that Were Not Detected This Often in 2006 (5)</p>	<p>Acetonitrile Acrolein Bromomethane</p>	<p>p –Dichlorobenzene Tetrachloroethylene</p>

Table 3.4 Volatile Organic Compounds Rarely Detected in the VOC Air Samples

<p>Compounds Not Seen In 2007 or 2006 (14)</p>	<p>1,1,1,2 - Tetrachloroethane 1,1,2-Trichloroethane 1,1-Dichloroethane 1,1-Dichloroethene 1,2-Dichloropropane</p>	<p>Bromochloromethane Bromoform Chloromethylbenzene cis – 1,3-Dichloropropene</p>	<p>Dibromochloromethane Ethyl Acrylate o-Dichlorobenzene trans – 1,2-Dichloroethylene trans – 1,3-Dichloropropene</p>
<p>Compounds Not Seen In 2006, but Seen Once Or Twice in 2007 (6)</p>	<p>1,2 – Dibromoethane 1,2 – Dichloroethane Bromodichloromethane</p>	<p>cis – 1,2 - Dichloroethylene</p>	<p>m-Dichlorobenzene tert-Amyl Methyl Ether</p>
<p>Compounds Not Seen In 2007, but Seen Once or Twice In 2006 (2)</p>	<p>1,2,4 – Trichlorobenzene Ethyl tert-butyl Ether</p>		

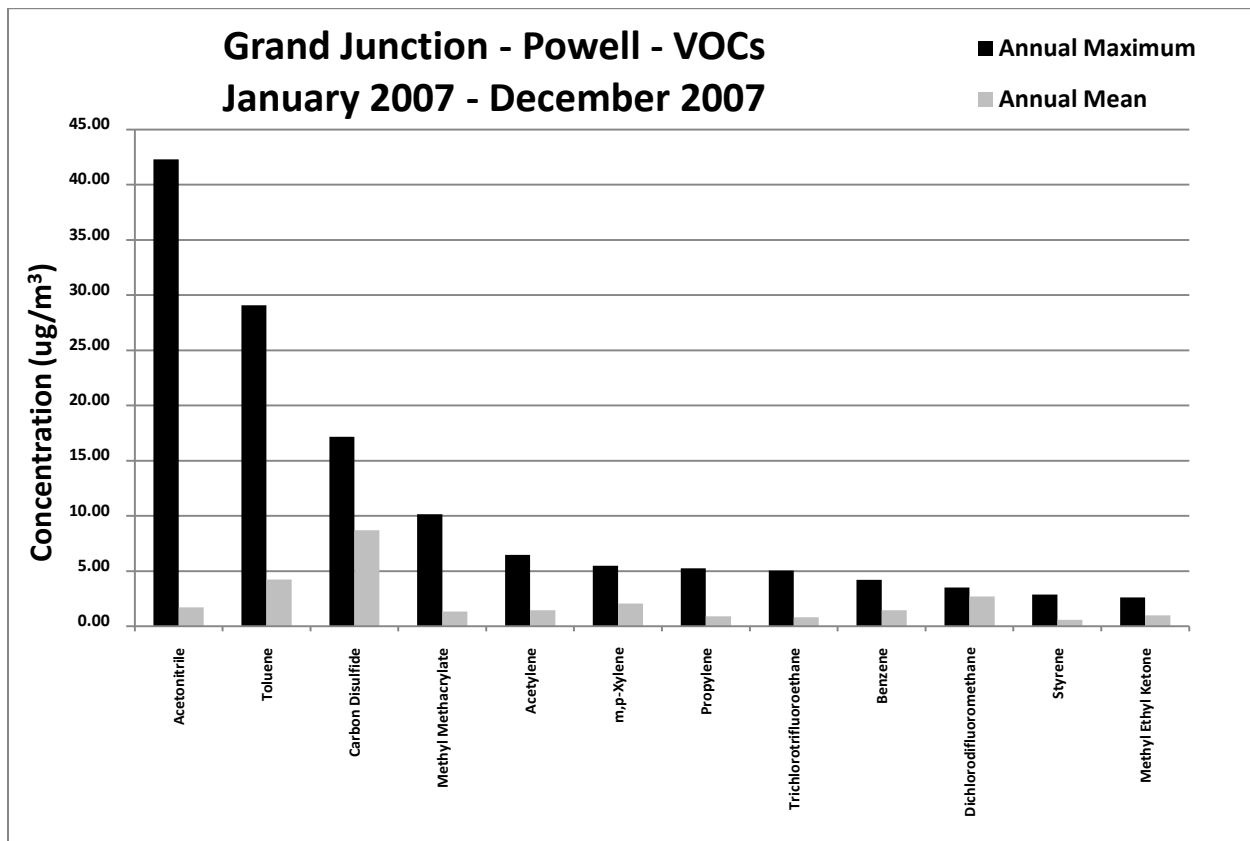
Graphs – Volatile Organic Compounds

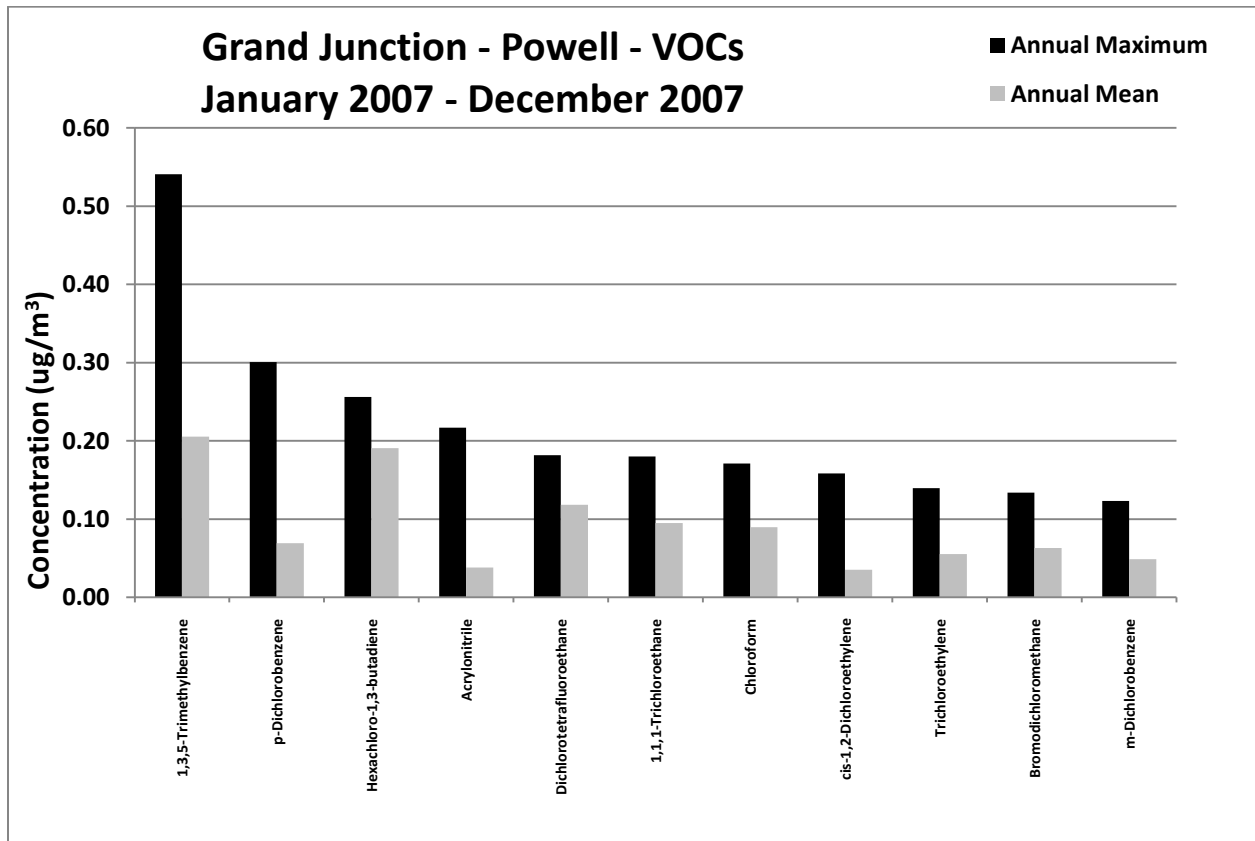
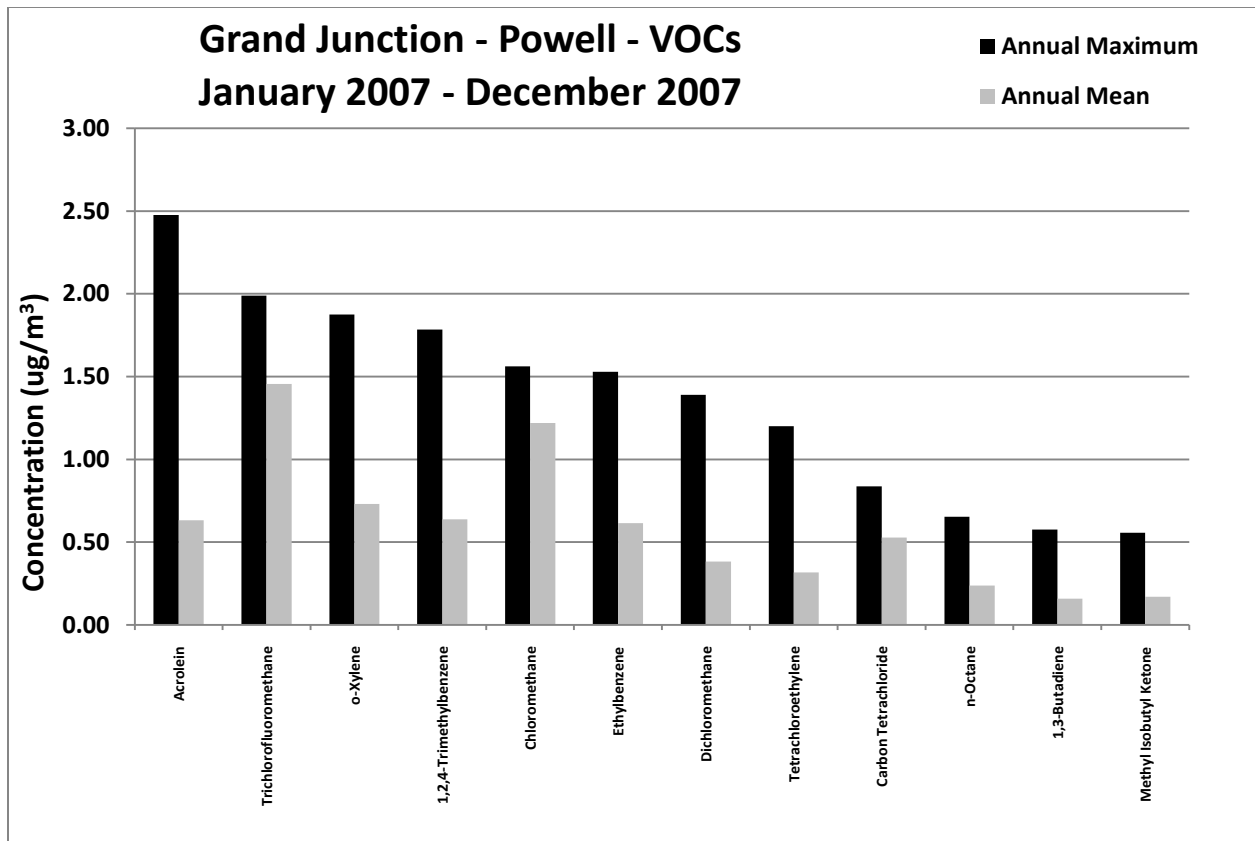
Figure 3.1 has four graphs showing the 24-hour maximum and annual mean concentrations for each of the 38 compounds that were detected during the year. These graphs are ordered from highest to lowest 24-hour maximum. Note that the graphs scales vary from a full-scale level of 45 ug/m³, to a full-scale value of 0.6 ug/m³.

Figures 3.2 and 3.3 show that benzene, toluene, ethylbenzene, the three xylenes, styrene, and 1,2,4-trimethylbenzene show a close relationship with similar peaks and valleys. These compounds are all present in petroleum. Figure 3.4 shows that three chlorofluorocarbon compounds tend to trend together. In Figure 3.5, acetylene and propylene trend together. This similarity is due to a similar source, probably automotive emissions.

Figure 3.6 shows 1,3-butadiene and acetonitrile. They do not trend together. These are both used in chemical production. 1,3-butadiene is also emitted in vehicle exhaust. Although present in very small amounts, 1,3-butadiene is believed to be a significant component of the total cancer risk from airborne toxic compounds.

Figure 3.1 Annual Mean and 24 Hour Maximum VOCs





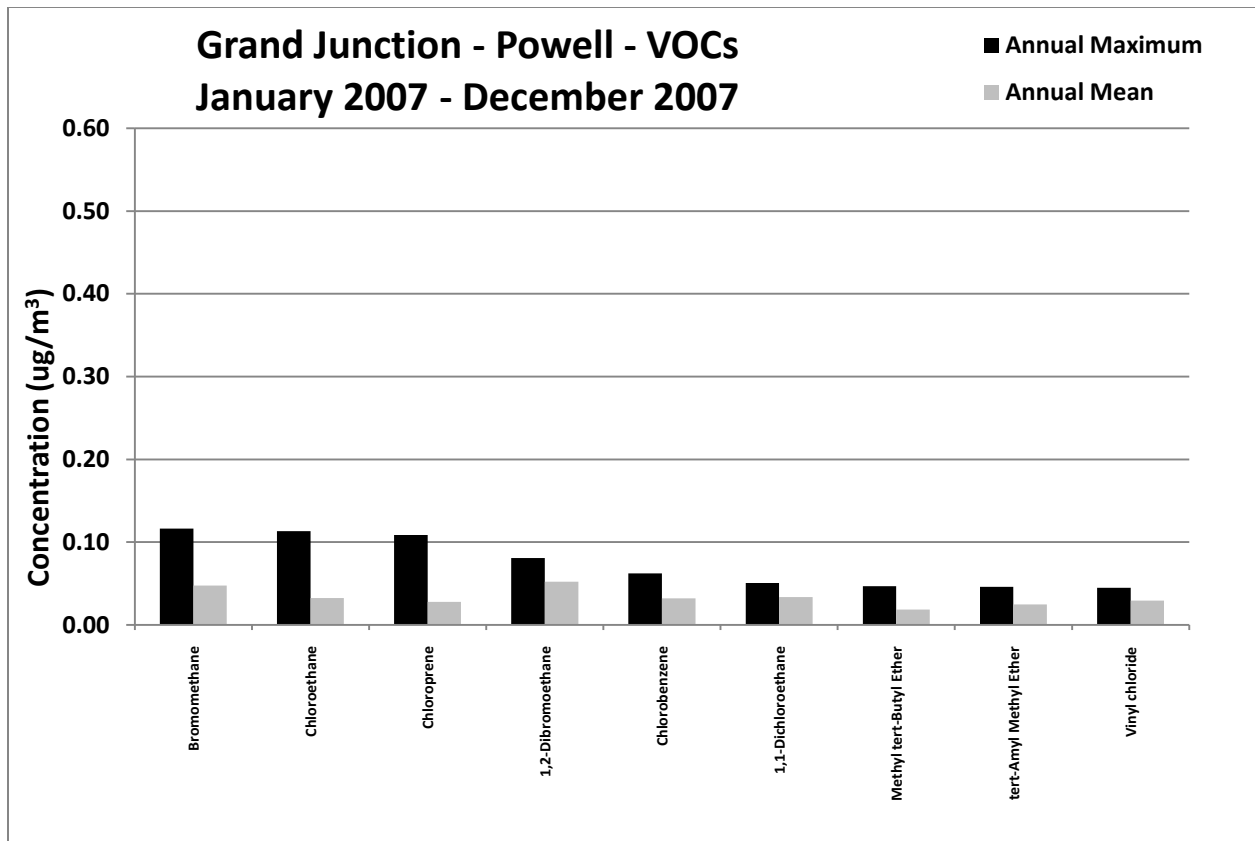


Figure 3.2 Toluene, Benzene and Ethylbenzene Concentrations

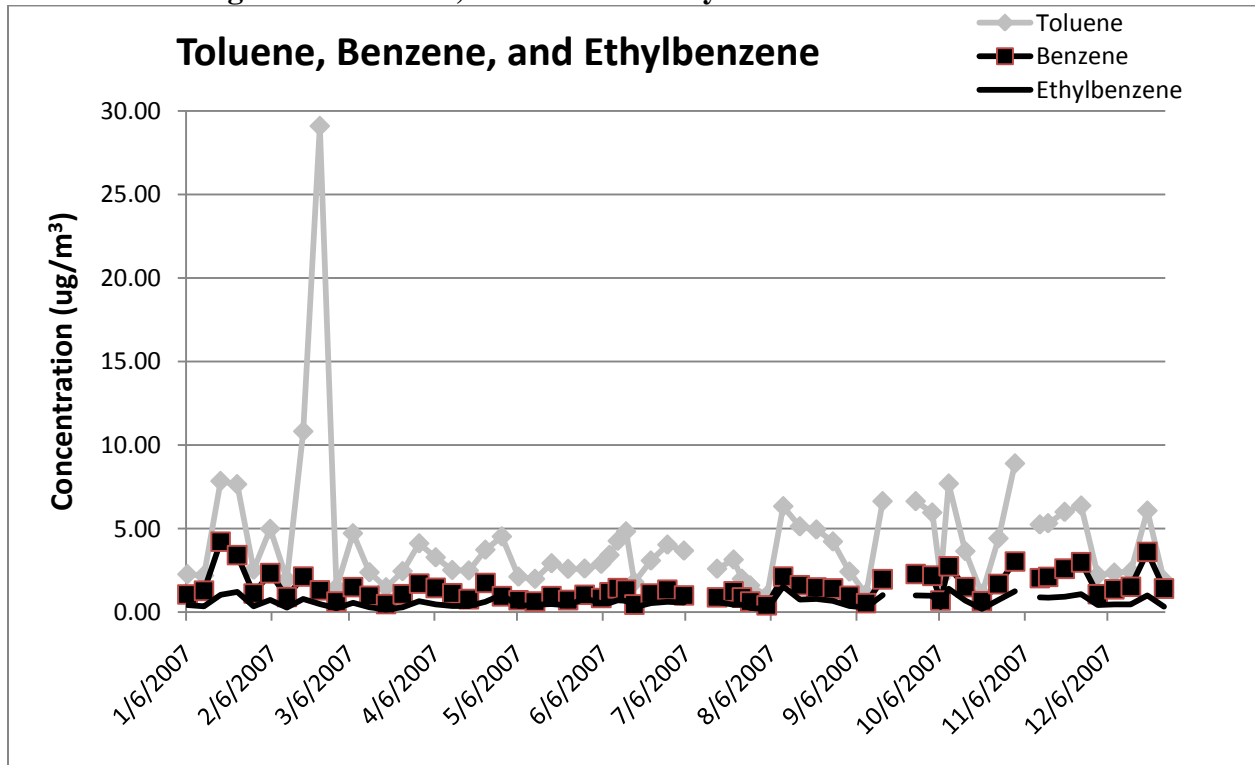


Figure 3.3 Styrene, Xylenes and 1,2,4-Trimethylbenzene Concentrations

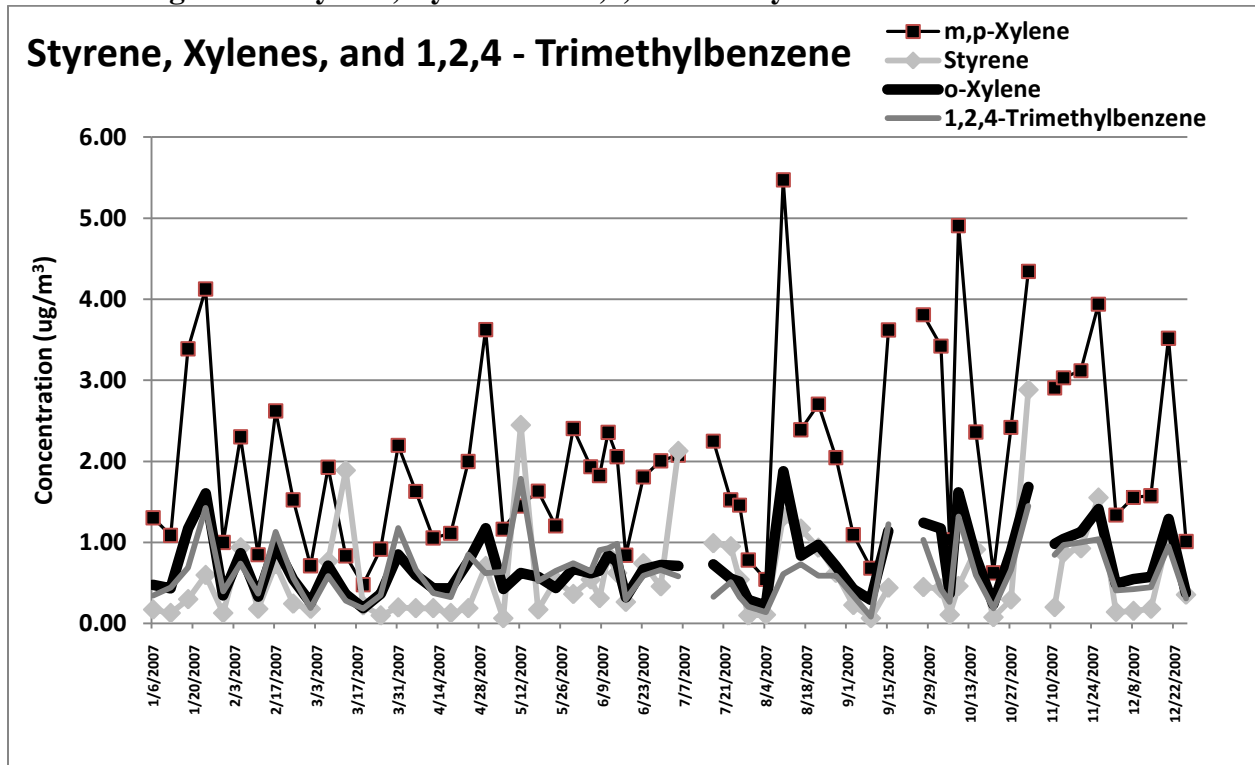


Figure 3.4 Trichlorofluoromethane, Chloromethane, and Dichloromethane Concentrations

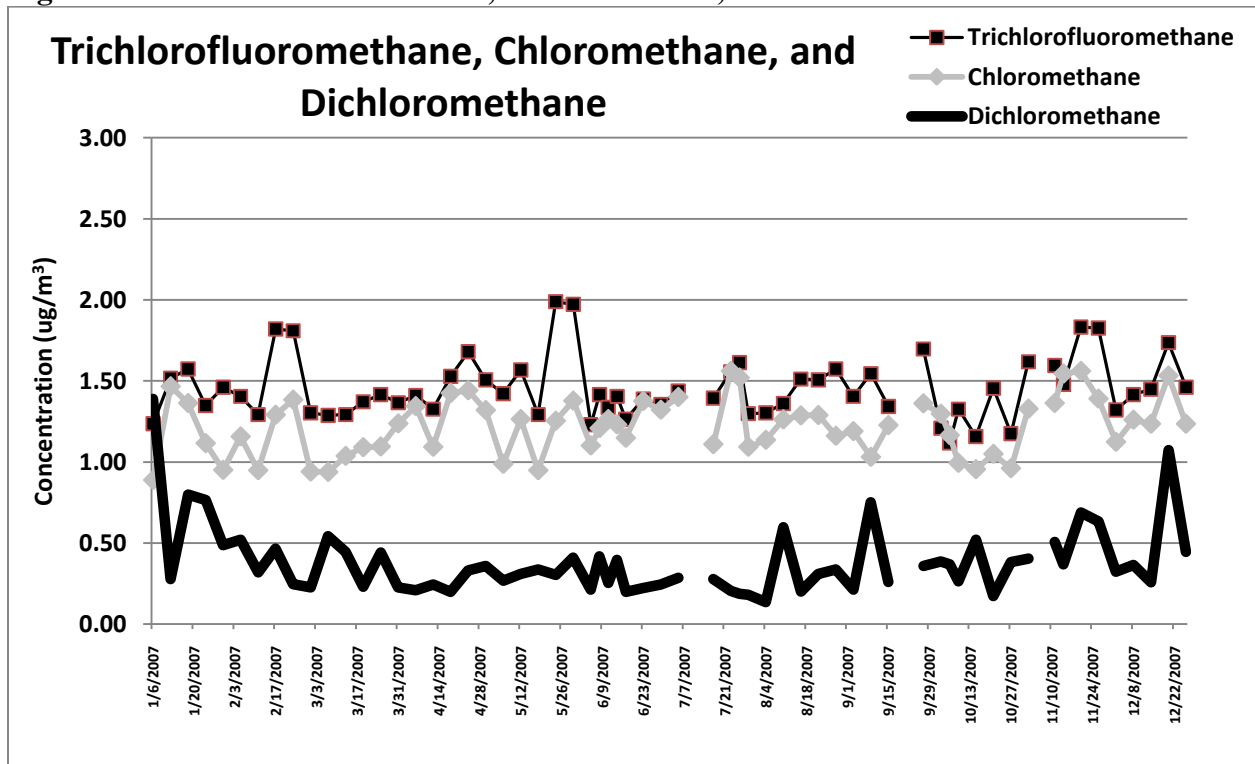


Figure 3.5 Acetylene and Propylene Concentrations

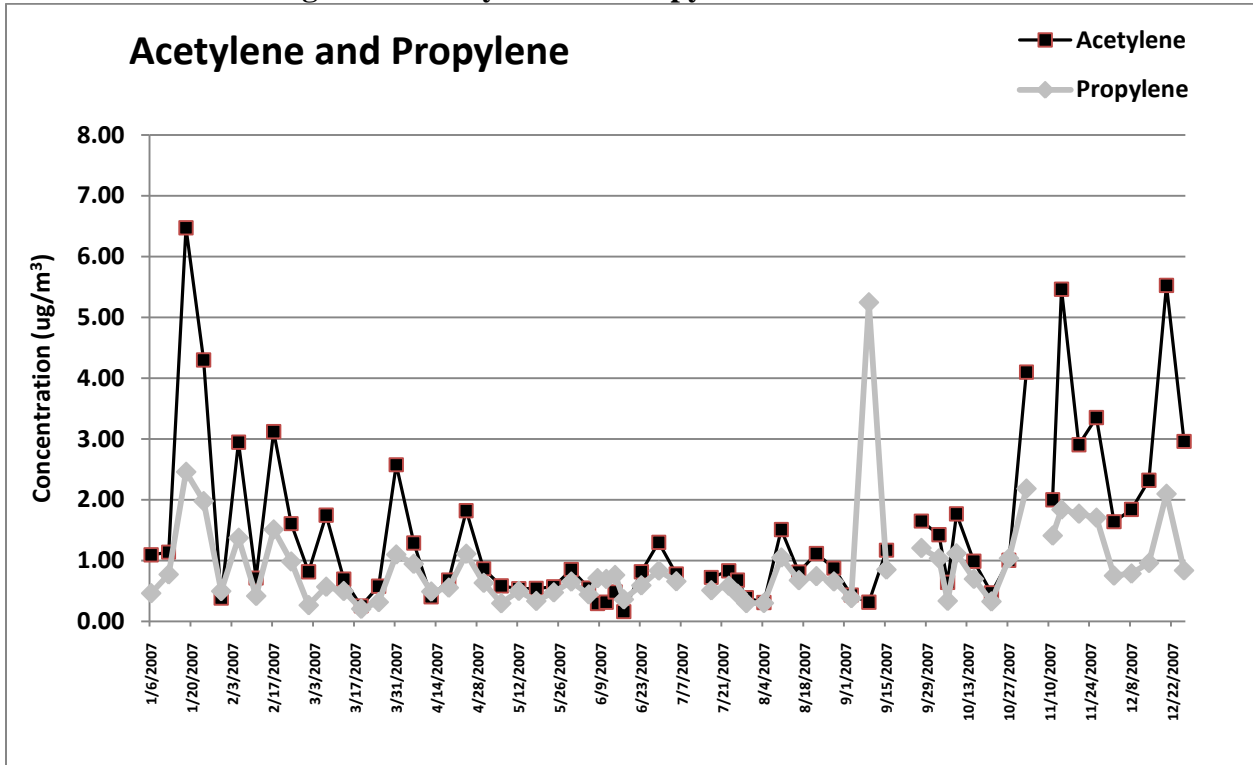
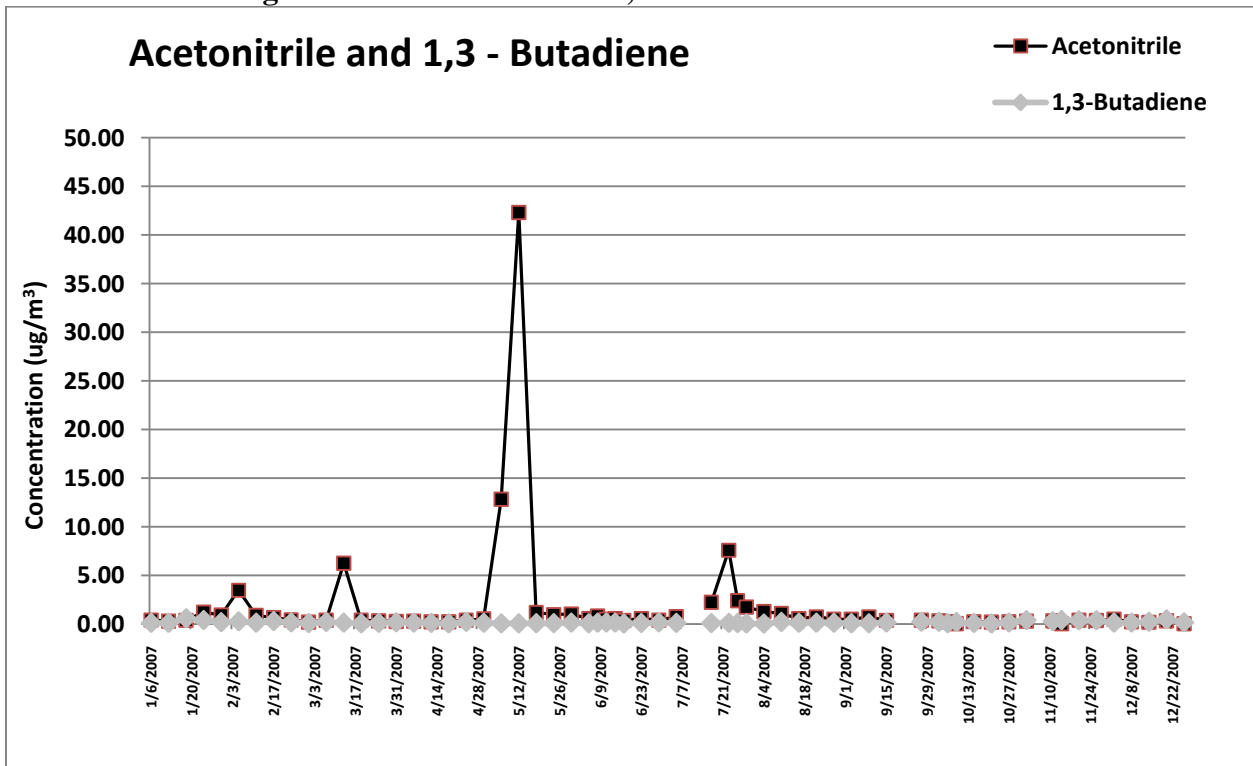


Figure 3.6 Acetonitrile and 1,3-Butadiene Concentrations



Precision of Sample Results – Volatile Organic Compounds

On six sampling dates, 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.

Field Blanks – Volatile Organic Compounds

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 20 to 30 inches of vacuum. Therefore, field blanks are not used in this method. The canisters are “blanked” at the laboratory prior to shipping to the field.

Section 4: Metals at Grand Junction – Powell Site

Summary Statistics – Metals

Percentage of Samples For Which Compound Was Detected

During the study, metals were sampled on the every-sixth-day schedule, for a total of 60 samples attempted. Of these, 49 were recovered, for a percentage data recovery of 81.7. This is a bit less than the EPA’s goal of 85 % annual data recovery for this study. Table 4.1 shows the percentage of the samples in which each metal was detected. Chromium (total), lead and manganese were detected in about 90% or more of the samples. Antimony was detected in less than half of all samples. Arsenic was never detected. Nickel, cadmium and beryllium were seen less than 20% of the time. Percentages of detection are down slightly from 2006. However, this is likely due to higher detection limits for the 2007 samples, and is probably not a true reduction in ambient air concentrations.

Table 4.1 Metals Detection Summary - 2007

Grand Junction – Powell Site	CAS Number	49 Samples Taken	
		Number of Samples Above Detection Limit	Percentage of Samples Above Detection Limit
Antimony	7440-36-0	21	42.9
Arsenic	7440-38-2	0	0.0
Beryllium	7440-41-7	9	18.4
Cadmium	7440-43-9	4	8.2
Chromium (total)	7440-47-3	49	100.0
Lead	7439-92-1	44	89.8
Manganese	7439-96-5	47	95.9
Nickel	7440-02-0	7	14.3

Maximum and Mean – All Samples

Table 4.2 summarizes the annual maximum and mean concentrations for each of the metals measured during the study. Annual means were calculated by using one-half of the 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. Results show that manganese, lead, and total chromium were the compounds with the highest mean concentrations in ambient air. The other metals were present at lower concentrations. The 2007 annual mean levels are similar to 2006, except for the mean antimony level, which was lower in 2007, and the total chromium level, which was higher in 2007.

Table 4.2 Metals Data Summary Comparisons 2006 - 2007

Grand Junction – Powell Site	CAS Number	2007 Statistics (µg/m ³)			2006 Statistics (µg/m ³)		
		Maximum	Mean	Average MDL	Maximum	Mean	Average MDL
Antimony	7440-36-0	0.00355	0.00099	0.00071	0.00402	0.00147	0.00037
Arsenic	7440-38-2	ND	ND	0.00845	ND	ND	0.00575
Beryllium	7440-41-7	0.00197	0.00068	0.00103	0.00126	0.00059	0.00079
Cadmium	7440-43-9	0.00103	0.00024	0.00041	0.00201	0.00026	0.00030
Chromium (total)	7440-47-3	0.03590	0.01683	0.00402	0.04701	0.01308	0.00176
Lead	7439-92-1	0.02568	0.00426	0.00026	0.01363	0.00433	0.00040
Manganese	7439-96-5	0.03511	0.01523	0.00060	0.04016	0.01504	0.00054
Nickel	7440-02-0	0.00386	0.00144	0.00234	0.01244	0.00119	0.00154

ND - Not Detected

Note that arsenic, beryllium, cadmium, and nickel have means that are less than the MDL. These values are a function of the method of calculating the annual mean using one-half of the minimum detectable limit for “non-detect” samples. Table 4.1 shows that arsenic was never detected in the 49 samples. Beryllium was detected only 9 times out of 49 samples. Cadmium was detected only 4 times and nickel was detected only 7 times out of 49 samples.

Graphs – Metals

The metal compounds measured during the study are graphed in Figure 4.1. This figure shows that total chromium and manganese were the metals at highest concentration. Total chromium was a bit higher in 2007 than in 2006. Figure 4.2 shows that lead was at a low level for most of the year. Chromium and manganese peaked in late May / early June.

Precision of Sample Results – Metals Compounds

Precision samples run every sixth day in 2007 and show good agreement for all compounds. Detailed information regarding precision results is available upon request.

Field and Filter Blanks – Metals Compounds

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 2007, the laboratory analyzed 7 “field blanks”, filters which were placed on the sampler, and then returned to the laboratory. Seventeen “filter blanks”, filters which never left the laboratory, were also analyzed in 2007.

Chromium showed up consistently in all blanks. In 2004, total chromium contamination was a problem for 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 PM₁₀ samplers, in early 2005. Unfortunately, chromium continues to show up in the blanks of the 2006 and 2007 filters, along with lesser amounts of antimony and manganese. Blank amounts are subtracted, but the chromium variability is still a problem, with blanks as high as 0.629 µg/filter.

Manganese was present in approximately one-half of the blanks. Antimony was present in a little over one-third of the blanks. Beryllium was present in a little less than one-third of the blanks. Lead was present in 17 % of the blanks. Nickel was detected in 8% of the blanks. Arsenic and cadmium were never detected in any of the blanks.

Figure 4.1 Maximum and Annual Mean Metal Concentrations - 2007

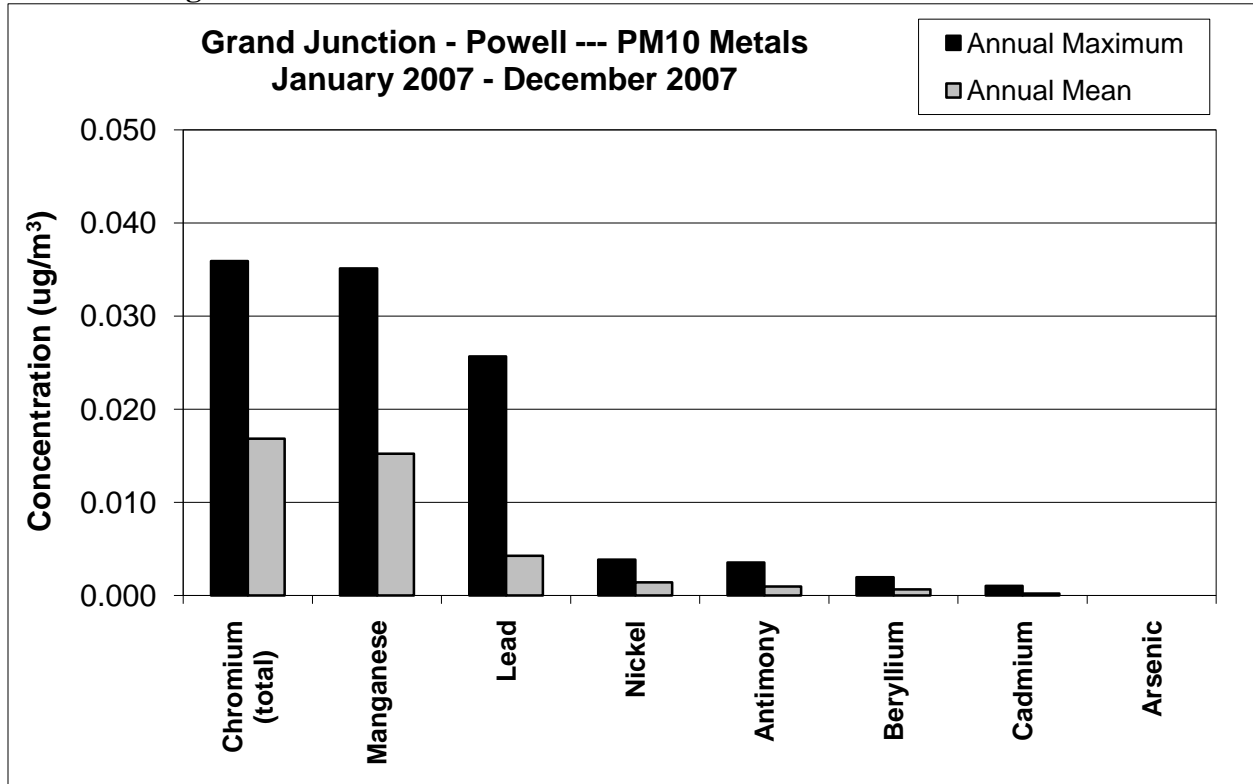
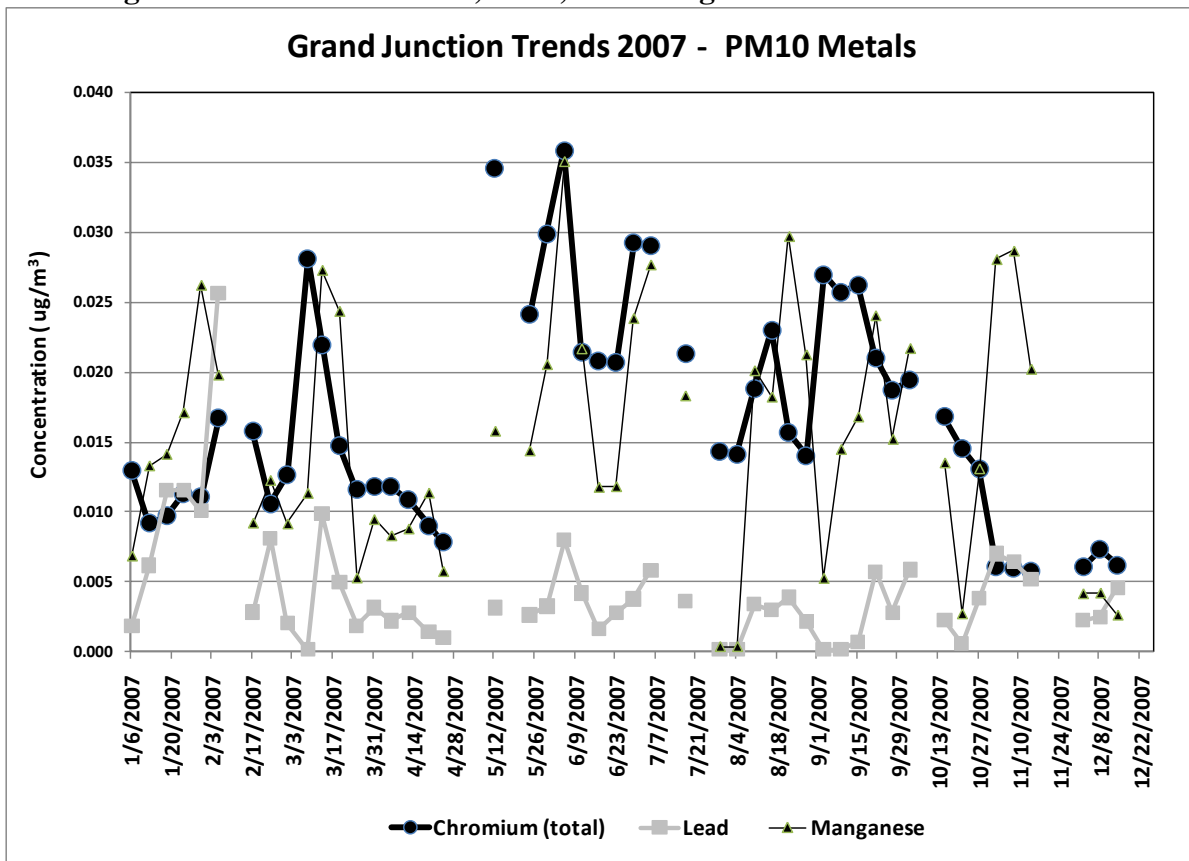


Figure 4.2 Total Chromium, Lead, and Manganese Concentrations – 2007



Section 5: Hexavalent Chromium at Grand Junction – Powell Site

Summary Statistics – Hexavalent Chromium

Maximum and Mean – All Samples

Hexavalent chromium data collected at the Grand Junction – Powell station from January 2007 through December 2007 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 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, Morrisville, North Carolina, 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 (ug/m^3) used elsewhere in this report.

During the year-long period, hexavalent chromium was sampled on an every-sixth-day basis, with one extra sample in June, and one in October, for a total of 62 samples attempted. Of these, 60 were recovered, for a percentage data recovery of 96.8. Table 5.1 summarizes the annual maximum and mean concentrations for hexavalent chromium during 2006 and 2007. 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.

Table 5.1 24 Hr Maximum and Annual Mean Concentrations for Hexavalent and Total Chromium – 2006 and 2007

Grand Junction – Powell Site	CAS Number	Maximum ng/m^3	Mean ng/m^3	Cr ⁶⁺ 59 Samples Taken – 2005 Cr ⁶⁺ 60 Samples Taken – 2006		Minimum Detection Level ng/m^3
				Number Above Detection	Percentage Above Detection	
Hexavalent Chromium - 2006	1854-02-99	0.1130	0.0300	49	81.7	0.0111
Total Chromium - 2006	7440-43-3	47.01	13.08	59	100.0	1.76
Hexavalent Chromium - 2007	1854-02-99	0.0928	0.0155	43	72.9	0.0074
Total Chromium - 2007	7440-43-3	35.90	16.83	49	100.0	4.02

Percentage of Samples For Which Compound Was Detected

Hexavalent chromium was at detectable levels for seventy-three percent of the time. Total chromium (measured from the PM_{10} filters) was always present.

Graphs – Hexavalent Chromium

Figure 5.1 shows annual maximum and mean hexavalent chromium concentrations for 2007. Figure 5.2 shows hexavalent chromium concentrations during the calendar year. Most concentrations were less than $0.060 \text{ ng}/\text{m}^3$ for the year. The maximum concentration occurred in November.

Precision of Sample Results – Hexavalent Chromium

Six times during the year, a second hexavalent chromium sample was run simultaneously with the main one, in order to assess the precision (repeatability) of the sampling method. In general, all duplicate dates showed good agreement.

Figure 5.1 Average and Maximum Hexavalent Chromium Concentration - 2007

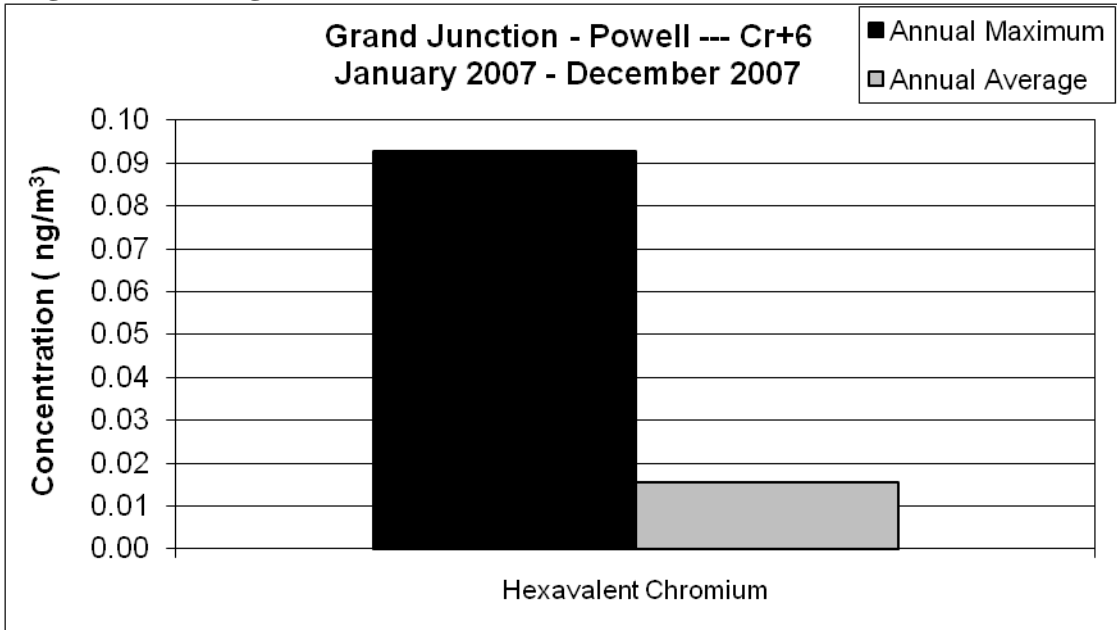
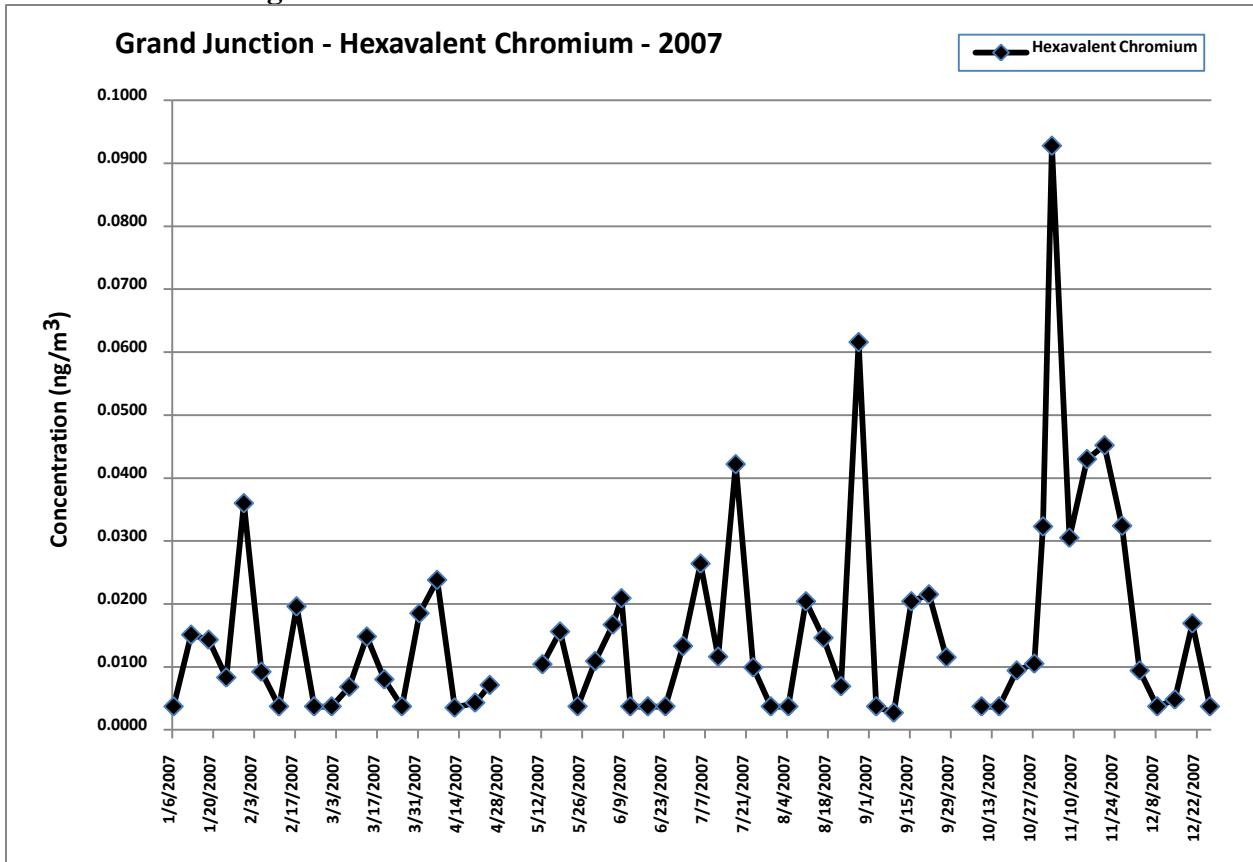


Figure 5.2 Hexavalent Chromium Concentrations – 2007



Field Blanks – Hexavalent Chromium

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 field blanks taken, none showed detectable levels of hexavalent chromium. Unlike the total chromium samples discussed in Section 4, hexavalent chromium samples are not potentially compromised by high blank levels. This is good, because the concentrations of hexavalent chromium are more relevant to risk assessment than the amount of total chromium is.

Section 6: Carbon Monoxide at Grand Junction – Powell Site

Summary Statistics – Carbon Monoxide

Maximum – All Samples

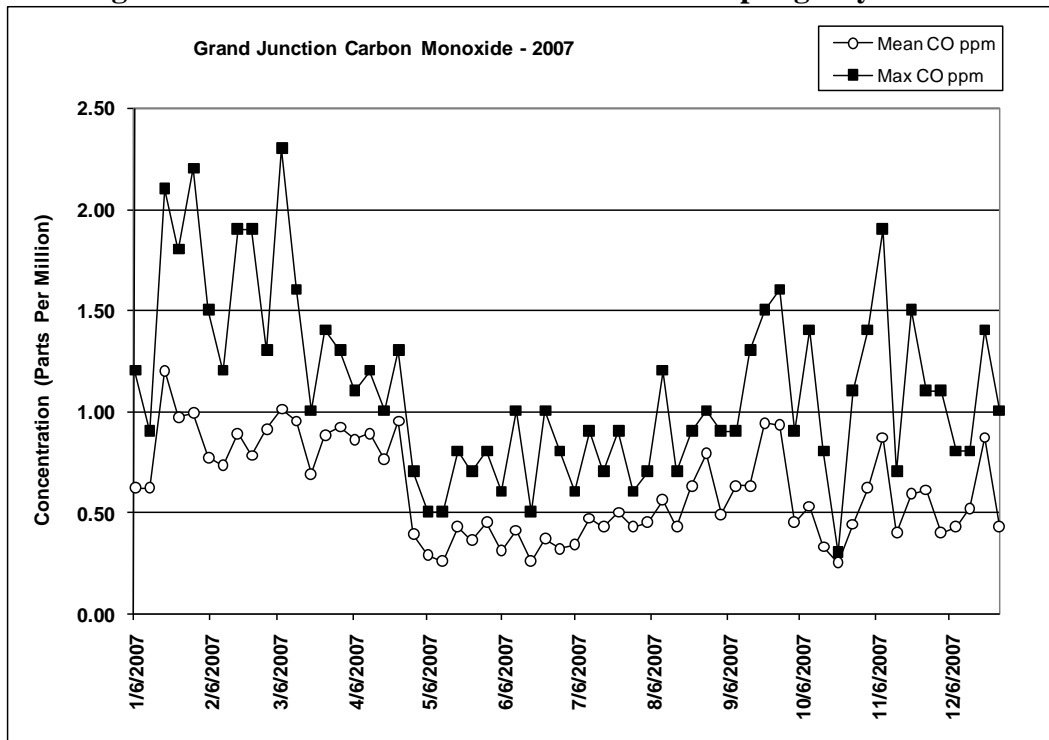
The Colorado Department of Public Health and Environment operates a carbon monoxide monitor at the Grand Junction – Powell station. This monitor was installed on January 29, 2004 as a part of the Colorado Department of Public Health & Environment’s statewide air quality measurement network. Results of the statewide carbon monoxide monitoring network are discussed in “Colorado: 2007 Air Quality Data Report” by the Air Pollution Control Division. Table 6.1 shows the most recent annual NAAQS statistics for this area.

Table 6.1 Carbon Monoxide Data Summary – 2006 and 2007

Grand Junction – Powell Site	1 Hour Average (ppm)			8 Hour Average (ppm)		
	Federal Standard	Maximum	2 nd Maximum	Federal Standard	Maximum	2 nd Maximum
Carbon Monoxide - 2007	35	2.9	2.8	9	1.8	1.8
Carbon Monoxide - 2006	35	3.0	2.8	9	1.9	1.7

Figure 6.1 summarizes daily means and daily one-hour maximum carbon monoxide samples for the dates that air toxics sampling took place. (Air toxics were sampled once every-sixth-day). The national air toxics monitoring network hopes to use contemporaneous carbon monoxide data as an indication of motor vehicle activity. In the future, levels of air toxics compounds that are mobile source-related will be analyzed for increases or decreases over time. The carbon monoxide data should provide some indication of whether overall vehicular emissions are increasing or decreasing over time.

Figure 6.1 Carbon Monoxide on Air Toxics Sampling Days - 2007



Section 7: Particulate Matter at Grand Junction – Powell Site

Particulate Data At Grand Junction - Powell

The Colorado Department of Public Health and Environment operates samplers for particulate matter 10 microns or less in diameter (PM₁₀) and 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 PM₁₀ and PM_{2.5}. Results of the statewide particulate matter monitoring network are discussed in “Colorado: 2007 Air Quality Data Report” by the Air Pollution Control Division. Table 7.1 shows the percentage PM₁₀ data recovery for the year. This table includes both the air toxics network low-volume, filter-based PM₁₀ sampler, and the continuous Beta Attenuation PM₁₀ monitor. The difference is that the low-volume sampler requires that filters be installed manually, and is run midnight-to-midnight every 3 days. The continuous method is always running, but the 24 hour midnight-to-midnight daily value is determined to assess compliance with the National Ambient Air Quality Standards.

Table 7.2 shows the most recent annual PM₁₀ NAAQS statistics for this area. There was not much difference between 2007 and 2006, for the individual methods. The continuous method, which ran all the time, caught higher maximum concentrations than the filter-based method, which ran only one-third of the time. Tables 7.3 and 7.4 give the same information for PM_{2.5}. Note that the PM₁₀ data are at standard conditions, while the PM_{2.5} data are at local conditions. This is because the national version of the PM₁₀ standard requires that “standard” conditions of temperature and pressure be used. This corrects for the fact that air temperatures and pressure is different at various altitudes, by adjusting the air volume to what it would be at sea level. The federal standard for PM_{2.5} does not require this correction, so “local” conditions of temperature and pressure are used (no altitude correction is done). Even though the daily maximum PM₁₀ values on the continuous monitor are greater than 150 ug/m³, Grand Junction is in compliance with the national ambient air quality standards for particulate matter. This is because the PM₁₀ standard is based on exceedances over a three-year period. Therefore, an occasional exceedance does not violate the standard.

Table 7.1 Percentage Data Recovery for PM₁₀ Samples – 2006 and 2007

Station	Year	Samples Recovered	Samples Scheduled	Percentage Recovered
Grand Junction - Powell Site – Low Volume Sampler	2007	107 Days	123 Days	87.0
Grand Junction - Powell Site – Low Volume Sampler	2006	121 Days	122 Days	99.2
Grand Junction - Powell Site – Continuous Sampler	2007	8553 Hours	8780 Hours	97.6
Grand Junction - Powell Site – Continuous Sampler	2006	8706 Hours	8780 Hours	99.4

Table 7.2 Data Summary for PM₁₀ Samples – 2006 and 2007

Grand Junction – Powell Site	Year	Annual Arithmetic Mean (µg/m ³ at Standard Conditions)		24 Hour Maximum (µg/m ³ at Standard Conditions)		
		Standard	Annual Mean	Standard	Maximum	2 nd Maximum
PM ₁₀ Low Volume Sampler	2007	50	(29.6)	150	84.7	68.8
PM ₁₀ Low Volume Sampler	2006	50	30.1	150	98.3	77.9
PM ₁₀ Continuous Sampler	2007	50	36.8	150	181	124
PM ₁₀ Continuous Sampler	2006	50	34.2	150	174	125

() Indicates less than 75% Data Recovery for Fourth Quarter 2007

Table 7.3 Percentage Data Recovery for PM_{2.5} Samples – 2006 and 2007

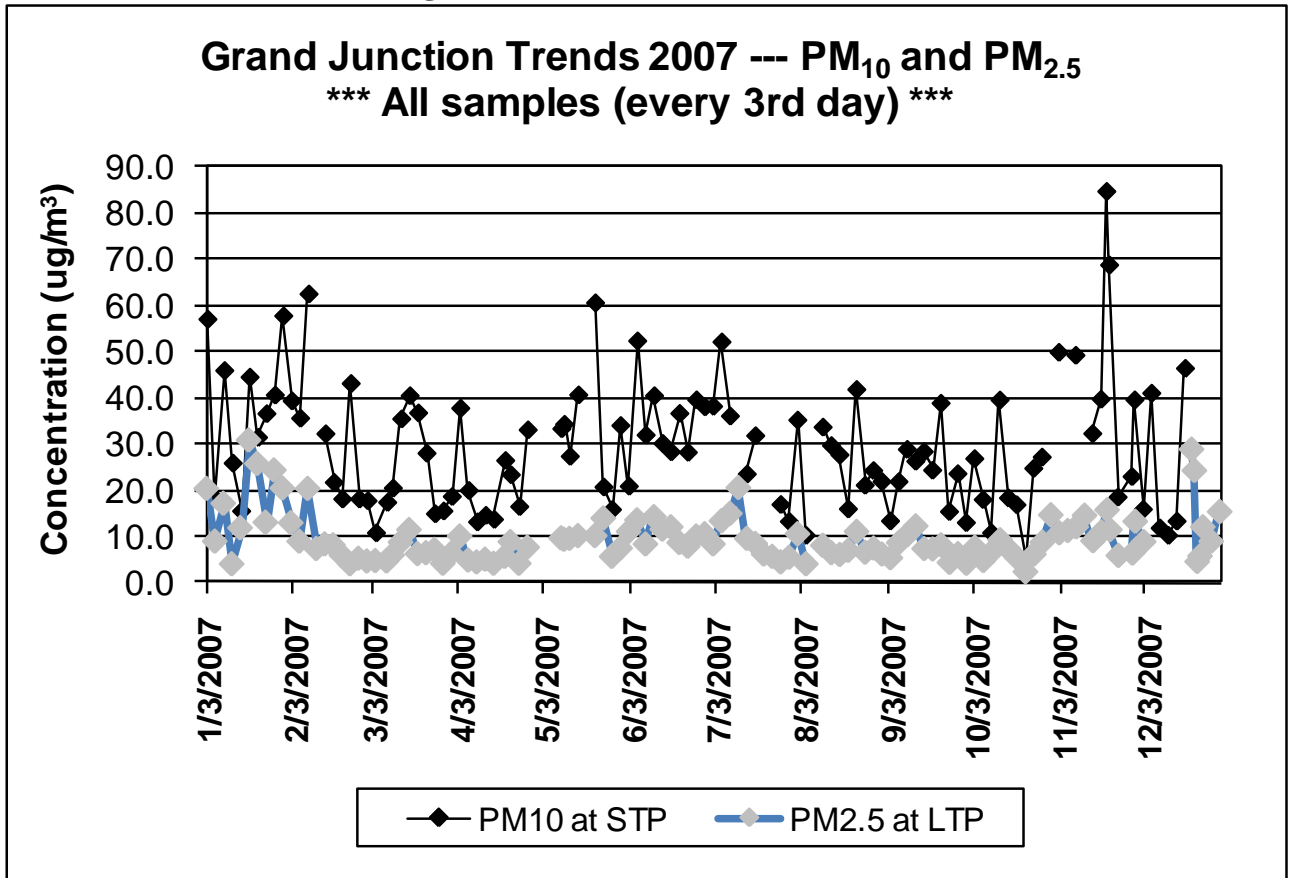
Station	Year	Samples Recovered	Sample Days Scheduled	Percentage Recovered
Grand Junction - Powell Site	2007	116	126	92.1
Grand Junction - Powell Site	2006	122	122	100.0

Table 7.4 Data Summary for PM_{2.5} Samples – 2006 and 2007

Grand Junction – Powell Site	Year	Annual Arithmetic Mean (µg/m ³ at Local Conditions)		98 th Percentile (µg/m ³ at Local Conditions)	
		Standard	Annual Mean	Standard	98 th Percentile
PM _{2.5}	2007	15	9.49	35	25.7
PM _{2.5}	2006	15	9.70	35	24.1

Figure 7.1 is a graph of PM₁₀ from the filter sampler versus PM_{2.5} values, for each day sampled. The two pollutants behaved differently, with PM₁₀ showing peaks and valleys, and PM_{2.5} staying fairly constant. This difference in behavior is likely due to the underlying sources. PM₁₀ is dominated by surface disturbance of earth materials (street sand, windblown dust), while PM_{2.5} particles are generated by combustion (automobile tailpipe emissions, coal burning, etc). The PM₁₀ levels are subject to change due to daily weather conditions, whereas the PM_{2.5} combustion source is more constant.

Figure 7.1 PM₁₀ and PM_{2.5} – 2007



Section 8: PM_{2.5} Speciation at Grand Junction – Powell Site

Summary Statistics – PM_{2.5} Speciation Data

A primary reason for locating the National Air Toxics Trend Station at Grand Junction was the availability of contemporaneous PM_{2.5} sample speciation data. These data are summarized below. A number of elements and ions are detected, at low levels, in the air. Given the low levels observed, the differences between 2007 and 2006 are not very significant.

Table 8.1 Annual Maximum and Mean Concentrations for PM_{2.5} Speciation

Metal/Compound	2007 Maximum ug/m³	2007 Mean ug/m³	2006 Maximum ug/m³	2006 Mean ug/m³
Antimony	0.03500	0.00190	0.05360	0.00202
Aluminum	0.36600	0.08213	0.36800	0.08061
Arsenic	0.00268	0.00046	0.00456	0.00052
Barium	0.19600	0.00434	0.40500	0.01152
Bromine	0.00378	0.00156	0.00758	0.00195
Cadmium	0.00959	0.00050	0.01400	0.00168
Calcium	0.36600	0.10827	0.47300	0.11264
Cerium	0.05120	0.00118	0.08860	0.00548
Cesium	0.05600	0.00131	0.03080	0.00166
Chlorine	0.14700	0.01387	0.17800	0.00961
Chromium (Total)	0.01130	0.00086	0.00720	0.00099
Cobalt	0.00216	0.00017	0.00176	0.00008
Copper	0.01540	0.00299	0.02340	0.00338
Europium	0.01120	0.00025	0.01970	0.00080
Gallium	0.00327	0.00031	0.00619	0.00081
Gold	0.00245	0.00023	0.00385	0.00040
Hafnium	0.00490	0.00018	0.01860	0.00065
Indium	0.04080	0.00215	0.02010	0.00123
Iridium	0.00688	0.00040	0.00409	0.00056
Iron	0.34100	0.12586	0.37400	0.12532
Lanthanum	0.00222	0.00006	0.04390	0.00305
Lead	0.01720	0.00115	0.01360	0.00270
Magnesium	0.08710	0.00868	0.07460	0.00544
Manganese	0.00733	0.00220	0.01010	0.00271
Mercury *	0.00654	0.00040	0.00841	0.00104
Molybdenum	0.00339	0.00020	0.00782	0.00043
Nickel	0.00517	0.00070	0.00521	0.00061
Niobium	0.00245	0.00014	0.00759	0.00041
Phosphorus	0.00922	0.00016	0.01020	0.00030
Potassium	0.28200	0.07442	0.20600	0.08633
Rubidium	0.00215	0.00039	0.00537	0.00044
Samarium	0.00841	0.00062	0.00536	0.00047
Scandium	0.00829	0.00019	0.00291	0.00015
Selenium	0.00402	0.00044	0.00969	0.00095
Silicon	0.99800	0.25895	0.86200	0.27287
Silver	0.01170	0.00072	0.02320	0.00230

Metal/Compound	2007 Maximum ug/m³	2007 Mean ug/m³	2006 Maximum ug/m³	2006 Mean ug/m³
Sodium	0.11800	0.01601	0.11200	0.00781
Strontium	0.00236	0.00039	0.00771	0.00115
Sulfur	0.74100	0.23780	0.57000	0.24487
Tantalum	0.00689	0.00028	0.00793	0.00081
Terbium	0.00643	0.00033	0.01690	0.00045
Tin	0.03850	0.00406	0.02600	0.00233
Titanium	0.06170	0.01012	0.03170	0.00600
Tungsten	0.00909	0.00075	0.00911	0.00092
Vanadium	0.01710	0.00233	0.02140	0.00331
Yttrium	0.00210	0.00016	0.00595	0.00057
Zinc	0.06010	0.01053	0.07300	0.01433
Zirconium	0.00350	0.00031	0.01390	0.00133
Organic Carbon	10.80000	4.33724	12.00000	4.49820
Ammonium	2.96000	0.45840	1.67000	0.44734
Elemental Carbon	4.11000	0.97595	2.97000	0.79450
Nitrate	7.90000	0.91510	5.32000	0.90293
Potassium Ion	0.17700	0.04283	0.18300	0.04003
Sodium Ion	0.17400	0.04950	0.08500	0.03039
Sulfate	1.76000	0.75172	1.75000	0.73630

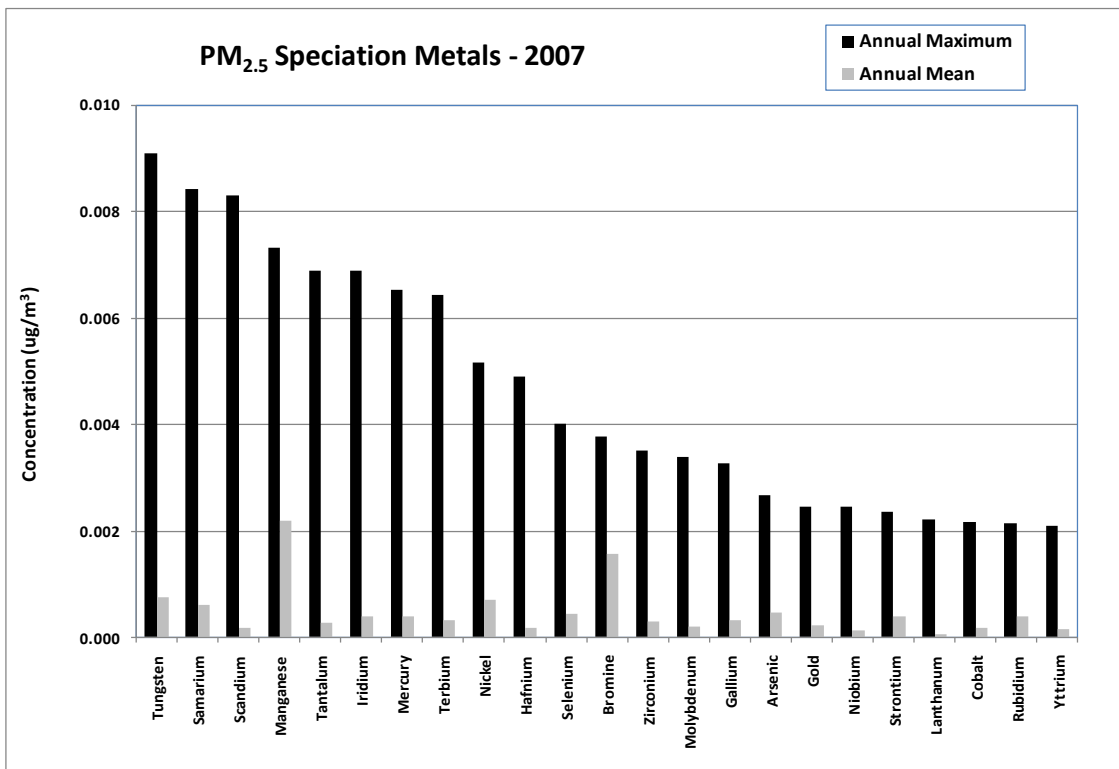
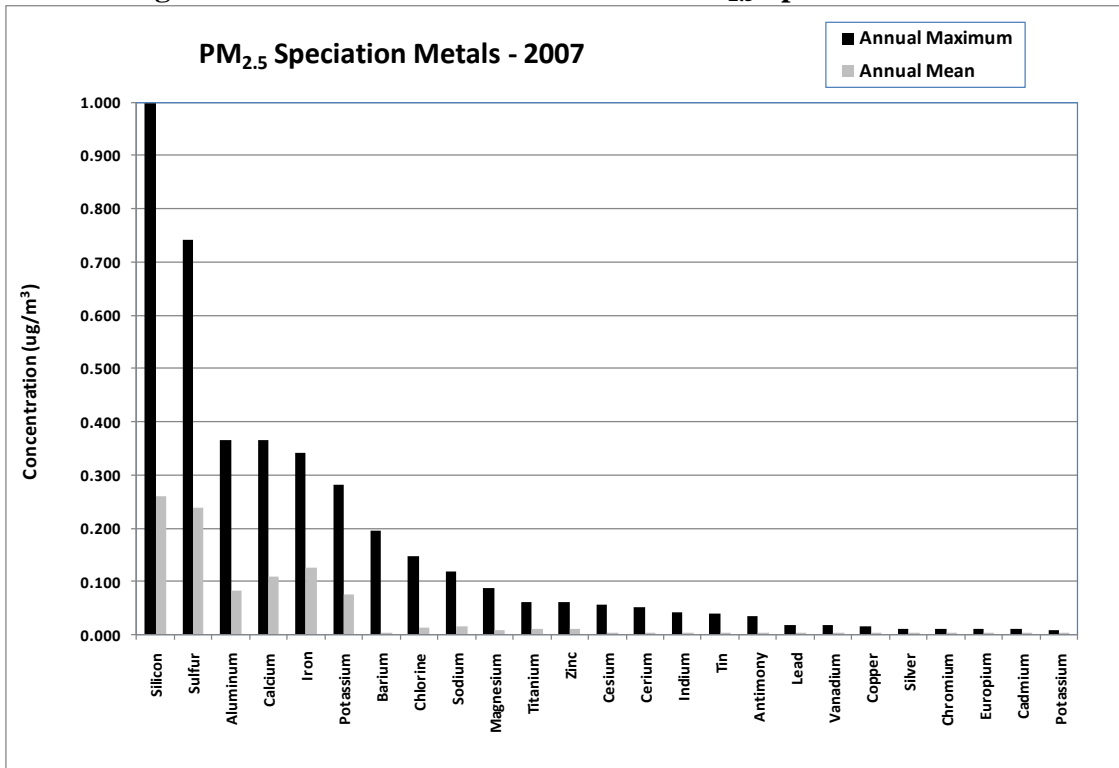
* Mercury is highly volatile. Therefore, the use of filter sampling methods likely underestimates ambient concentrations.

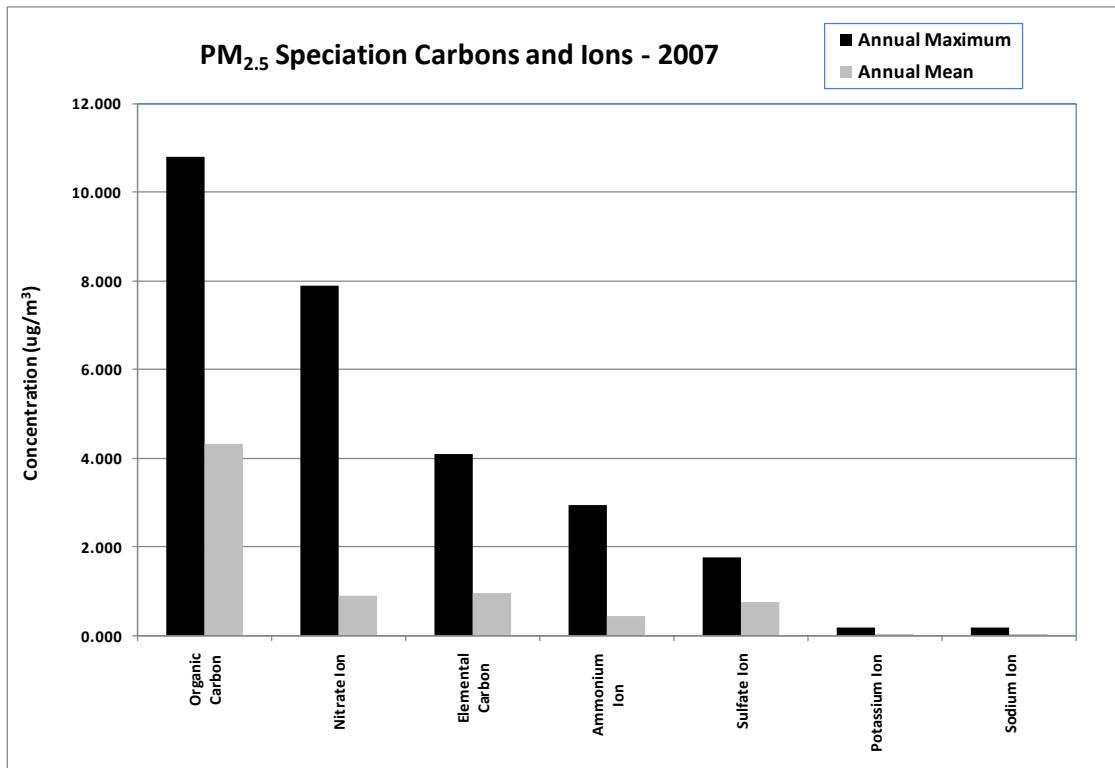
Graphs – PM_{2.5} Speciation Data

Graphs of mean and maximum concentration for various elemental species indicate that those with the highest concentrations were aluminum, barium, calcium, chlorine, iron, potassium, silicon, and sulfur. These elements are all present in the earth's crust, which suggests that geological material is an important component of PM_{2.5} at this location. The crustal material could be from wind-blown dust, street sand, or electric power plant fly ash. Wind-blown dust and street sand are usually in the PM₁₀ particulate matter size fraction, but fly ash occurs in the PM_{2.5} size fraction.

Carbon is present in soot from burning. Nitrate and sulfate form as the gases nitrogen dioxide and sulfur dioxide condense. These components, along with ammonium, play an important role in visibility degradation (visible haze). Ammonium nitrate and ammonium sulfate particulate matter absorbs light, so the view appears hazy when these are in the air.

Figure 8.1 Maximum and Annual Mean PM_{2.5} Speciation – 2007





Section 9: Meteorology

Meteorological Parameters Monitored

A meteorological tower at the Pitkin shelter site measures wind speed, wind direction, relative humidity and temperature. The year 2007 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. For example, about 11% of the winds are from the northwest. Wind speeds in the ranges of 1-4 mph or 4-7 mph are the most frequent.

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 concentration days for each pollutant indicated that often “high” days for each compound were not the “high” days for the other compounds. This is not that surprising, given that the pollutants show such variation. Some are in gaseous form, and some are in particulate matter. Some are from automobiles, and thus ubiquitous, while others are source-specific. Some days did show maxima for more than one type of air pollutant. January 18, January 30, July 5, October 9, November 2, and December 2, 2007 were high for a number of pollutants. The fact that most of these dates are in the fall or winter period indicates that local temperature inversions, which limited air mixing, allowed pollutants of all types to build up in the area.

Figure 9-1 Grand Junction Wind Rose – 2007



Section 10: Summary and Conclusions

The National Air Toxics Trends Study in Grand Junction for 2007 showed similar results to prior years. The highest carbonyls in air were formaldehyde, acetaldehyde, and acetone. Twenty-two volatile organic compounds are ubiquitous, having been detected in 90% of the air samples for 2006 and 2007. These are: acetylene, benzene, 1,3 – butadiene, carbon disulfide, carbon tetrachloride, chloromethane, dichloromethane, dichlorodifluoromethane, dichlorotetrafluoroethane, ethylbenzene, methyl ethyl ketone, n-octane, propylene, styrene, toluene, 1,1,1-trichloroethane, trichlorofluoromethane, trichlorotrifluoroethane, 1,2,4-trimethylbenzene, 1,3,5 – trimethylbenzene, m,p-xylenes, and o-xylene. For the metals, chromium, lead, and manganese showed the highest concentrations. Hexavalent chromium is an extremely small fraction of the chromium in air.

The study will continue in 2008. One of the major goals of this study is to run the site for six years, and then compare the mean concentrations for each pollutant during the first three years to the means for the next three years. The Environmental Protection Agency is conducting this study at a number of locations around the country. The purpose is to assess whether air pollution control strategies aimed at reducing air toxics have succeeded. These interim results, when compared to levels measured during the 2001 – 2002 Pilot study, suggest that levels are decreasing.

ATTACHMENT-1

Compounds Contributing to Cancer and Non-cancer Risks: Overview of Sources and Health Effects

Chemicals can be released to the environment as a result of their use and manufacture. Some chemicals may also form as other chemicals react with sunlight and one another in outdoor air. A brief summary of the potential sources and health effects of some prevalent chemicals in the ambient air is provided below. This information is adopted from the following main sources: EPA Air Toxics Web site, EPA Office of Pollution Prevention and Toxics (OPPT), EPA Integrated Risk Information System (IRIS), Agency for Toxic Substances and Disease Registry (ATSDR), New Jersey Department of Health and Senior Services, Occupational Safety and Health Administration (OSHA), National Institute of Occupational Safety and Health (NIOSH), and the California Air Resources Board (CARB).

Carbonyls

Three of the twelve carbonyl compounds sampled are discussed below. These three are believed to be significant health risk drivers, at the nationwide level.

Acetaldehyde

Acetaldehyde is a hydrocarbon with the formula CH_3CHO . It is closely related to formaldehyde, HCHO . Like formaldehyde, it exists in the atmosphere as a gas with a pungent odor. Acetaldehyde is ubiquitous in the ambient environment. It is mainly used as an intermediate in the synthesis of other chemicals, such as acetic acid, acetic anhydride, chloral, and glyoxal. It is employed in the food processing industry as a food and fish preservative, a flavoring agent, and in gelatin fibers. The tanning and paper industries use acetaldehyde, as do the perfume and dye manufacturers (CARB Acetaldehyde Fact Sheet).

Acetaldehyde can be released to the environment as a product of incomplete combustion in fireplaces and wood stoves, forest and wild fires, pulp and paper production, stationary internal combustion engines and turbines, vehicle exhaust, and petroleum refineries. Waste water processing is also a source. It is important to note that residential fireplaces and woodstoves are the two highest sources of emissions, followed by various industrial emissions.

Although it is used in industry, the California Air Resource Board believes that the largest sources in outdoor air are combustion and production from photochemical reactions (CARB Acetaldehyde Fact Sheet). Acetaldehyde itself can break down in these complex reactions between air pollutants and sunlight, forming formaldehyde.

The health effects of acetaldehyde are very similar to those of its chemical relative formaldehyde. It irritates the eyes and mucous membranes. It can paralyze the respiratory muscles, act as a narcotic to prevent coughing, and speed up pumping of the heart. Exposure can lead to headaches and sore throat. (Kirk Othmer, Volume 1, page 107). It should be noted that most of these health effects have been observed in factory workers, who are exposed to acetaldehyde concentrations thousands of times greater than those occurring in outdoor air. Acetaldehyde is believed to be a probable human carcinogen, leading to cancer of the nose and throat. Acetaldehyde has been shown to cause birth defects in animals, but no human research is available. (CARB Acetaldehyde Fact Sheet).

EPA's Technology Transfer Network Air Toxic Website provides information on the potential health effects of acetaldehyde. According to this source, the primary acute effects of acetaldehyde are irritation of the eyes, skin, and respiratory tract in humans. At higher exposure levels, erythema, coughing, pulmonary edema, and necrosis may happen. Chronic toxicity symptoms in humans resemble those of alcoholism.

The EPA has established a Reference Concentration (RfC) for inhalation exposure to acetaldehyde based on degeneration of the olfactory epithelium in rats. No information is available on the reproductive and developmental effects of acetaldehyde in humans. Animal studies data indicate that acetaldehyde may be a potential developmental toxin. EPA has classified acetaldehyde as a Group B2, probable human carcinogen, based on increased incidence of nasal tumors in male and female rats and laryngeal tumors in male and female hamsters after inhalation exposure.

The California Air Resources Board observed an annual mean of 1.33 ppb acetaldehyde in its state-wide network during 1996 (CARB Acetaldehyde Fact Sheet). The 2007 mean observed in this Grand Junction study, 1.5 ppb, is right above the California state-wide mean. Acetaldehyde levels are a national problem related primarily to the use of motor vehicles.

Crotonaldehyde

Crotonaldehyde, with the chemical formula of C_4H_6O , is also known as propylene aldehyde, betamethyl-acrolein, crotonin aldehyde and butenal. Crotonaldehyde is a colorless liquid with a pungent, suffocating odor.

Crotonaldehyde can be emitted to the environment from the combustion of gasoline, and the burning of wood, paper, cotton, plastic, and tobacco. It can also be released through industrial use. It is found naturally in emissions of some vegetables and volcanoes.

According to the ATSDR Medical Management Guidelines inhaled crotonaldehyde is highly toxic. It is irritating to the upper respiratory tract even at low concentrations. Crotonaldehyde vapor is heavier than air. Therefore, higher levels of crotonaldehyde vapors would be found nearer to the ground. The mechanism of toxicity of crotonaldehyde is not known, but it is highly reactive. Crotonaldehyde is also a skin irritant and can cause eye irritation and damage to the cornea. After an acute, relatively high concentration exposure, people may become sensitized to crotonaldehyde. Except for rare cases of sensitization, no health effects have been reported in humans exposed to relatively low concentrations of crotonaldehyde. No studies have been found that address reproductive or developmental effects of crotonaldehyde in humans. The compound has been shown to cause degeneration of spermatocytes in mice. No teratogenic effects from acute exposures have been reported.

The Department of Health and Human Services has determined that crotonaldehyde may be a possible carcinogen. The EPA IRIS has classified crotonaldehyde as a possible carcinogen based on the fact that there is no human data, but an increased incidence of hepatic tumors in male rats. The possible carcinogenicity of crotonaldehyde is supported by genotoxic activity and the expected reactivity of croton oil and aldehyde. The EPA IRIS, however, has not derived a cancer toxicity value for the compound. The EPA HEAST (Health Effects Summary Tables) has established an oral cancer toxicity value for crotonaldehyde. The Agency for Research on Cancer has determined that crotonaldehyde is not classifiable as to its carcinogenicity to humans.

Information concerning typical concentrations of crotonaldehydes in air could not be located. The Grand Junction annual mean concentration for 2007 was 0.07 ppb.

Formaldehyde

Formaldehyde is a hydrocarbon compound with the formula $HCHO$. It exists in the atmosphere as a colorless gas with a pungent odor. It is used in the manufacture of urea-formaldehyde resins which are used in particleboard and plywood products. Therefore, high levels of airborne formaldehyde can also be found in indoor air as a result of release from various consumer products such as building materials and home furnishings. Another source of formaldehyde in indoor air is smoking. It is also employed in chemical manufacturing of pharmaceuticals, herbicides, and sealants. Textile finishes, such as used for "permanent press" clothes, contain formaldehyde (Kirk-Othmer, Volume 11, pages 245 - 246).

EPA's Technology Transfer Network Air Toxic Website provides information on the potential sources and health effects of formaldehyde. According to this source, the major sources of formaldehyde emissions to the ambient air include power plants, manufacturing facilities, incinerators, forest and wild fires, stationary internal

combustion engines and turbines, pulp and paper plants, petroleum refineries, and automobile traffic. In urban areas, combustion of automotive fuel is the dominant source for much of the year. However, formaldehyde can also form photochemically in the air, as other hydrocarbons and oxides of nitrogen from automobile traffic break down to form ozone. Complicating the situation is the fact that the complex ozone-producing atmospheric reactions may both create and destroy formaldehyde, as the chains of chemical reactions proceed along various pathways.

The Agency for Toxic Substances and Disease Registry (ATSDR), lists a number of possible health effects that may occur from inhalation of formaldehyde. Formaldehyde is an irritant. The major acute toxic effects via inhalation exposure are eye, nose, and throat irritation and effects on the nasal cavity. At 0.4 – 3 ppm, it may cause the eyes to tear. Other effects observed in humans from exposure to high levels of formaldehyde are coughing, wheezing, chest pain, and bronchitis (EPA's Technology Transfer Network Air Toxic Website). Formaldehyde is believed to be carcinogenic (cancer-causing) to humans. However, the body can quickly break down formaldehyde, so it does not accumulate in fatty tissue. Currently, ATSDR believes that formaldehyde does not cause birth defects in humans (ATSDR Toxicological Profile for Formaldehyde). The main concerns with this compound are its irritant properties and its potential ability to cause cancer of the nose and throat.

Chronic inhalation exposure to formaldehyde in humans has been associated with respiratory symptoms and eye, nose, and throat irritation. EPA has not established an inhalation Reference Concentration (RfC) for formaldehyde. However, the ATSDR has established an inhalation reference concentration called a Minimal Risk Level (MRL) for formaldehyde based on respiratory effects in humans. Developmental effects, such as birth defects, have not been observed in animal studies. EPA has classified formaldehyde as a Group B1, probable human carcinogen, based on limited evidence in humans and sufficient evidence in animals. Occupational studies have shown statistically significant increases in incidence of lung and nasopharyngeal cancer. This evidence is considered limited because of possible exposure to other agents. Animal studies have reported an increased incidence of nasal squamous cell carcinoma by inhalation exposure. Please see the EPA IRIS database for a detailed discussion on the carcinogenicity of formaldehyde.

ATSDR states that typical levels of formaldehyde in urban air are 10 – 20 ppb. ATSDR cites concentrations of 0.2 ppb for rural areas, and 2-6 ppb for suburban areas (ATSDR Toxicological Profile for Formaldehyde). The mean level observed in Grand Junction during 2007, 3.3 ppb, is within the "suburban" range.

Volatile Organic Compounds

Volatile organic compounds that are frequently present include acetonitrile, acetylene, acrolein, benzene, 1,3 – butadiene, carbon tetrachloride, chloromethane, methyl ethyl ketone, 1,4 – dichlorobenzene, propylene, tetrachloroethylene, 1,3,5 – trimethylbenzene and 1,2,4 - trimethylbenzene. Some health summary and source information regarding these compounds is given below.

Acetonitrile

Acetonitrile is a volatile organic compound with the formula CH_3CN . In the atmosphere, it exists as a gas. Acetonitrile is used in the chemical industry for making acrylic fibers, nitrile rubber, perfumes and pharmaceuticals. (CARB Fact Sheet on Acetonitrile). It is often used as a solvent.

Emissions from automobiles and manufacturing operations are the main atmospheric sources of acetonitrile. The California Air Resources Board indicates that coating, engraving, and allied services are the main stationary sources of the compound in California (CARB Fact Sheet on Acetonitrile).

Acetonitrile, also known as methyl cyanide, is metabolized to hydrogen cyanide in the human body (EPA OPPT Chemical Fact Sheet on Acetonitrile). As this metabolism takes time, health reactions to an exposure to acetonitrile may be delayed. Acetonitrile is an irritant to the skin, eyes, and lungs. Very high exposures can affect the nervous system, leading to drooling, nausea, vomiting, confusion, headache, and convulsions. Levels greater than 500 ppm can cause death (New Jersey Hazardous Substance Fact Sheet on Acetonitrile). It should be noted that many of these health effects are observed to occur at concentrations thousands of times higher than those usually found in outdoor air. Studies have indicated that acetonitrile can cause birth defects in animals, but

generally only at levels where the mother is experiencing obvious symptoms. The EPA has established a Reference Concentration for inhalation exposure to acetonitrile based on mortality in mice. It is not known whether acetonitrile can cause cancer. Due to a lack of studies in this area EPA considers it not classifiable as to carcinogenic status.

EPA's OPPT chemical fact sheet on acetonitrile cites air concentration information in the Hazardous Substance Data Bank (HSDB). According to this source, levels in rural and urban US areas range from 2 to 7 ppb. The 2007 annual mean of 1.01 ppb at Grand Junction is a below the normal range.

Acetylene

Acetylene is a hydrocarbon compound with the formula C_2H_2 . It exists in the atmosphere as a colorless and odorless gas. It is used in the production of organic chemicals such as vinyl chloride, vinyl acetate, and acrylates (Kirk-Othmer, Vol. 1, p 240). Another common use is in welding torches used to cut or solder metals.

Acetylene is emitted into the atmosphere from engines (CARB Fact Sheet on Acetylene) and from wood burning. (EPA CHIEF, Residential Wood Stove Chapter). As acetylene is produced by the thermal cracking of hydrocarbons (NIOSH Criteria Document on acetylene), petroleum refineries are another source.

Acetylene is an asphyxiant that can decrease the amount of available oxygen. Thus, the health effects of exposure to large concentrations of this compound involve oxygen deprivation and include headache, dizziness, lightheadedness, unconsciousness, and death. These concerns generally apply to workers using acetylene-powered welding torches in confined spaces. In outdoor air, acetylene is at much lower concentrations. According to the National Institute for Occupational Safety and Health, acetylene is not believed to have any toxic health effects beyond its asphyxiant properties. In fact, during the early twentieth century acetylene was used as an anesthetic for surgical patients (NIOSH Criteria Document on Acetylene). Acetylene has not been investigated for carcinogenic effects, or ability to cause birth defects (New Jersey Hazardous Substance Fact Sheet on Acetylene).

The EPA AIRS system lists data from the state of California. Annual concentrations of acetylene in California typically range from 1 to 5.5 ppbv. The mean of the 2007 Grand Junction data is 1.37 ppbv, within the California range.

Acrolein

Acrolein is a hydrocarbon compound with the formula $CH_2=CH-CHO$. It exists in the atmosphere as a colorless gas with a pungent odor. It is used in the manufacture of plastics, drugs, pesticides, and other chemicals. Acrolein is a strong irritant, and is used in tear gas. Acrolein is a byproduct of burning. It is produced from burning of gasoline or diesel fuels in cars, as well as from wood-burning and forest fires. Coal-burning power plants emit some acrolein. Cigarette smoke is a source of acrolein in indoor air.

In urban areas, combustion of automotive fuel is the dominant source for much of the year. Acrolein can also form photochemically in the air, as other hydrocarbons and oxides of nitrogen from automobile traffic break down to form ozone. However, in outdoor air acrolein itself quickly breaks down to form other compounds, with less than a 24-hour half-life.

The Agency for Toxic Substances and Disease Registry (ATSDR), lists a number of possible health effects that may occur from inhalation of acrolein. It is an irritant. The major acute toxic effects via inhalation exposure are eye, nose, throat and lung irritation, as well as effects on the nasal cavity. It can cause the eyes to tear. Other effects observed in humans from exposure to high levels of acrolein are coughing, wheezing, chest pain, and pulmonary edema. Acrolein has neurological effects such as lightheadedness, headaches, unconsciousness, and death. Acrolein is not believed to be carcinogenic (cancer-causing) to humans. Animal studies suggest that it may be able to cause birth defects, if maternal exposure is high enough to cause severe problems to the mother.

Chronic inhalation exposure to acrolein in humans has been associated with respiratory symptoms and eye, nose, and throat irritation. EPA has established an inhalation Reference Concentration (RfC) for acrolein of .00002

mg/m³. EPA has stated that acrolein's potential carcinogenicity cannot be determined, as the current database is inadequate.

ATSDR states that typical levels of acrolein in urban air are 0.2 ppb, with 0.12 ppb in rural air (ATSDR Public Health Statement for Acrolein). The mean level observed in Grand Junction during 2007, 0.28 ppb, is a bit higher than the urban number.

Benzene

Benzene is a hydrocarbon compound with the formula C₆H₆. It exists in the atmosphere as a colorless gas with a sweet odor. It is used in chemical manufacturing of medicines, detergents, explosives, shoes, dyes, leather, resins, paints, plastics and inks (CARB Fact Sheet on Benzene). It is also present in gasoline.

The largest sources of benzene in ambient air are automobiles, gasoline service stations, refineries, and chemical plants. Burning of vegetative matter in forest fires and woodstoves is also a source. In ambient air, benzene reacts with hydroxyl (OH[•]) radicals within a few hours. Since hydroxyl radicals are common in outdoor air, this chemical transformation prevents the build-up of large concentrations of benzene.

Benzene is a serious concern from a toxicological standpoint. Unlike many of the compounds discussed here, benzene is a proven human carcinogen. It damages the blood-forming capacity of the body, leading to anemia or leukemia. Like the other volatile organic compounds, breathing large amounts can cause lightheadedness, headache, vomiting, convulsions, coma and death. It also irritates the skin and eyes, exerting a drying effect. However, these health effects are usually seen in workplaces, where levels are thousands of times higher than those in outdoor air. Experiments with laboratory animals suggest that benzene exposure may be associated with numerous cancers. It may cause bone marrow damage and bone formation problems for a developing fetus (ATSDR Toxicological Profile for Benzene). EPA has had concern about whether levels of benzene in outdoor air are associated with cancer and leukemia. While no link with outdoor air concentrations has been unequivocally proven, EPA has acted to reduce air concentrations of this pollutant.

The EPA has established a Reference Concentration for inhalation exposure to benzene based on decreased lymphocyte count in an occupational epidemiologic study. Benzene is classified as a "known" human carcinogen for all routes of exposure by the EPA IRIS based on the increased incidence of leukemia in epidemiologic and case studies.

The Agency for Toxic Substances and Disease Registry (ATSDR) cites national 1984 to 1986 data from 300 cities, which indicate an average benzene level of 1.8 ppb for urban and suburban areas (ATSDR Toxicological Profile for Benzene). The Grand Junction – Powell site 2007 mean of 0.46 ppb observed in this study is somewhat lower.

1,3-Butadiene

1,3-Butadiene is a hydrocarbon compound with the formula C₄H₆. It exists in the atmosphere as a colorless gas with an odor similar to gasoline. It is used in making rubber and plastics. The most important use is in tire production. It is also used in the production of chemicals such as 1,4-hexadiene (NIOSH Current Intelligence Bulletin 41).

According to the California Air Resources Board, most emissions of 1,3-butadiene come from combustion of fuels in diesel and gas-powered motor vehicles. Other sources that they list include petroleum refining, tire wear, residential wood heating, and forest fires. Rubber and chemical production plants also have emissions. Breathing of cigarette smoke is another source of 1,3-butadiene exposure (ATSDR Fact Sheet).

1,3-Butadiene is of concern toxicologically because it is characterized as carcinogenic to humans based on the new EPA guidelines for cancer risk assessment and it also has adverse effects on reproduction and fetal development. Exposure to high concentrations can cause irritation and central nervous system effects such as eye irritation, cough, sore throat, headache, drowsiness, nausea, unconsciousness, and death. Rats and mice exposed to this compound in laboratory tests developed multiple cancers within single individuals. The animals had damaged

testes and ovaries, and offspring of the animals had skeletal problems. Other effects seen in animals at low levels of inhalation exposure for one year include kidney and liver disease, and damaged lungs (ATSDR Fact Sheet). Generally, the acute health effects have not been seen at concentrations existing in outdoor air. However, EPA considers that the levels of 1,3-butadiene in air may represent a significant portion of the cancer risk related to ambient airborne chemicals.

The EPA has established a Reference Concentration for inhalation exposure to 1,3-butadiene based on ovarian atrophy in mice. The EPA has characterized 1,3-butadiene as carcinogenic to humans by inhalation based on the following total evidence: sufficient evidence from epidemiologic studies showing increased lymphohematopoietic cancers and leukemia; tumors at multiple sites in animal studies, and strong evidence suggesting that the carcinogenic effects are mediated by genotoxic metabolites of 1,3-butadiene.

ATSDR estimates that urban and suburban areas have an average concentration of 0.3 ppb 1,3-butadiene, while rural areas have 0.1 ppb (ATSDR Toxicological Profile for 1,3-Butadiene). The annual average for 2007 at Grand Junction - Powell is 0.07 ppb.

Carbon Tetrachloride

Carbon tetrachloride, also known as tetrachloromethane or methane tetrachloride, is a chlorinated hydrocarbon with the formula CCl_4 . It exists in the atmosphere as a gas. It has a sweet odor. The primary uses of carbon tetrachloride were as a dry cleaning solvent, a grain fumigant, as a refrigerant, and as an aerosol propellant. Carbon tetrachloride has a long atmospheric half-life, so it can travel to the higher reaches of the atmosphere and damage the earth's ozone layer. Due to its toxicity and ozone-damaging qualities, most uses of carbon tetrachloride have been banned. It is still in use in industrial settings for producing refrigerants.

Carbon tetrachloride is emitted to the air from industrial sources and from petroleum refineries (California Air Resources Board Toxic Air Contaminant Identification List Summary for Carbon Tetrachloride). Carbon tetrachloride is also a common indoor air contaminant due to releases from building materials and products, such as cleaning agents, used in homes (Air Toxic Website). There are no natural sources of carbon tetrachloride; it is produced by man (ATSDR Toxicological Profile for Carbon Tetrachloride).

As is true for many of the chlorinated hydrocarbons, breathing large concentrations of carbon tetrachloride has central nervous system effects including lightheadedness, coma, convulsions, double vision, intoxication, and death. It can also cause vomiting. In animal studies, it had effects on the liver and kidney. Male rats exposed to carbon tetrachloride had lower sperm production. Female rats exposed to it had stunted offspring with birth defects. These health effects are generally observed in occupational settings, where people had exposure to very high levels over a number of years.

EPA has not established a Reference Concentration for carbon tetrachloride. The CalEPA has established a Reference Exposure Level for carbon tetrachloride based on liver effects in guinea pigs. Carbon tetrachloride has been associated with liver and kidney cancer in animals. EPA considers it a Class B2 Carcinogen (probable human carcinogen) based on liver tumors in animals.

The California Air Resources Board has monitored carbon tetrachloride at a number of locations, and found a mean value of 0.078 ppb (California Air Resources Board Toxic Air Contaminant Identification List Summary for Carbon Tetrachloride). The 0.08 ppb annual mean for 2007 observed at Grand Junction – Powell is at the same level.

Chloromethane

Chloromethane, or methyl chloride, is a chlorinated hydrocarbon with the formula CH_3Cl . It exists in the atmosphere as a colorless gas that may have a sweet odor. Chloromethane is used in the chemical production industry to make silicones, amines, rubber, or other hydrocarbons such as methylene chloride, chloroform or carbon tetrachloride (ATSDR Fact Sheet on Chloromethane).

Chloromethane is emitted to the air from sources such as forest fires, burning of vinyl chloride, and outgassing from chlorinated swimming pools and polystyrene insulation. However, natural sources play the overwhelming role, accounting for 99% of the chloromethane in the air (ATSDR Fact Sheet on Chloromethane). Chloromethane is produced by bacteria, and emitted from biomass burning and the oceans.

As is true for many of the hydrocarbons, breathing large concentrations of chloromethane has central nervous system effects including lightheadedness, vomiting, coma, convulsions, double vision, intoxication, and death. In animal studies, chloromethane has had effects on the liver, spleen, and kidney. Male rats exposed to chloromethane had testicular damage and lower sperm production. Female rats exposed to chloromethane had stunted offspring with skeletal and muscle defects. Chloromethane has been associated with liver cancer in animals, but EPA considers it a Class D Carcinogen (cancer status in humans not classifiable from present information).

ATSDR cites chloromethane concentrations of 0.6 to 0.8 ppb for urban and suburban areas. The 2007 annual mean of 0.59 ppb observed in this Grand Junction study is within this range.

Methyl Ethyl Ketone

Methyl Ethyl Ketone is a hydrocarbon compound with the formula C_4H_8O . In the atmosphere, it is a colorless gas with a sweet odor. Methyl Ethyl Ketone is commonly used as a solvent in glues, paints, plastics, printing inks, and cleaning solutions.

The California Air Resources Board states that the primary sources of this chemical in that state are motor vehicle exhaust, wood processing, wood furniture manufacturing operations, and footwear manufacturers (CARB Air Toxics Profile for Methyl Ethyl Ketone). CARB states that the half-life of this chemical in air is 9 to 13 days. Therefore, it can be transported into an area from other places.

Like other volatile organic compounds measured in this study, methyl ethyl ketone has irritant and central nervous system effects. Methyl ethyl ketone can irritate the eyes, skin, and throat. Effects on the brain include headache, dizziness, and blurred vision. It also causes nausea (New Jersey Hazardous Substance Fact Sheet on Methyl Ethyl Ketone). However, these health effects are generally observed in occupational settings, where air concentrations are much higher than those seen outdoors. There is not enough information to determine whether this compound is carcinogenic. Animal testing indicates that high exposures to the mother may be associated with birth defects in the offspring.

In 1996 the average concentration for methyl ethyl ketone within the California Air Resources Board air monitoring network was 0.11 ppb (CARB Air Toxics Profile for Methyl Ethyl Ketone). This compares to a mean concentration of 0.33 ppb for 2007 monitoring at Grand Junction.

1,4-Dichlorobenzene

1,4-Dichlorobenzene, also known as para-dichlorobenzene, is a chlorinated hydrocarbon with the formula $C_6H_4Cl_2$. It exists in the atmosphere as a gas. It has a mothball-like odor. The primary uses of 1,4-dichlorobenzene are for mothballs, insecticide, or as a dry solid room/trash bin/toilet deodorant.

Most emissions of 1,4-dichlorobenzene in air come from its household uses as an insecticide and deodorant, or from factories that produce these household products. Industrial operations producing polyphenylene sulfide may also emit it, as 1,4-dichlorobenzene is used in the production process. There are no natural sources of 1,4-dichlorobenzene; it is produced by man (ATSDR Toxicological Profile for 1,4-Dichlorobenzene).

As is true for many of the chlorinated hydrocarbons, breathing large concentrations of 1,4-dichlorobenzene has central nervous system effects including lightheadedness, coma, convulsions, double vision, intoxication, and death. It also can cause vomiting. In animal studies, it had effects on the liver and kidney. 1,4-dichlorobenzene also affects the blood, leading to anemia and possibly, leukemia (New Jersey Hazardous Substance Fact Sheet for 1,4-Dichlorobenzene). 1,4-dichlorobenzene has been associated with liver and kidney cancer in animals, but EPA considers it a Class C Carcinogen (possible human carcinogen).

The Environmental Protection Agency has monitored 1,4-dichlorobenzene at a number of locations, and found a mean value of 0.17 ppb during 1976 – 1986 (California Air Resources Board Toxic Air Contaminant Identification List Summary for 1,4-Dichlorobenzene). The 0.01 ppb mean observed in this 2007 study is significantly lower.

Propylene

Propylene, also known as propene, is a hydrocarbon compound with the formula C_3H_6 . As a gas, it has a slight odor and is colorless. Propylene is used in the manufacture of chemicals, resins, and plastics.

Propylene is emitted into the air from paper mills, petroleum refining, oil and gas extraction, and motor vehicle exhaust (CARB Air Toxics Profile on Propene). CARB lists an atmospheric half-life of 9 to 13 hours. Thus, propylene is unlikely to be transported for long distances. CARB states that it reacts with OH radicals to form formaldehyde, acetaldehyde, and other compounds.

Propylene is an explosive compound that decreases the amount of available oxygen. These asphyxiant and explosive properties are mainly a concern to workers using propylene in confined spaces. In high concentrations, propylene may cause dizziness, unconsciousness, and death. Propylene is also an irritant to the eyes and lungs. It may also create heart and liver damage. It is not known whether propylene can damage a developing fetus. The cancer-causing potential of this compound is unknown, because there has not been adequate research.

The EPA AIRS system lists data from the state of California. Annual concentrations of propylene in California typically range from 0.3 to 1.7 ppbv. The mean of the 2007 Grand Junction data is 0.53 ppbv, within the California range. Unfortunately, there are no EPA propylene reference concentrations or unit risk factor estimates for cancer or chronic non-cancer health effects.

Tetrachloroethylene

Tetrachloroethylene, also known as perchloroethylene, is a chlorinated hydrocarbon with the formula C_2Cl_4 . It exists in the atmosphere as a gas. It has a “chloroform-like” odor (NIOSH Pocket Guide to Chemical Hazards, Tetrachloroethylene). The primary uses of tetrachloroethylene are as a dry cleaning solvent, metal cleaning solvent, or for chemical production. Tetrachloroethylene is used in paints, inks, aerosols, glues, polishes, silicones and rubber products (CARB Fact Sheet on Tetrachloroethylene and OPPT Chemical Fact Sheet on Tetrachloroethylene).

Most emissions of tetrachloroethylene come from degreasing, dry cleaning, or chemical production facilities. There are microorganisms that can produce tetrachloroethylene (ATSDR Toxicological Profile For Tetrachloroethylene).

As is true for many of the chlorinated hydrocarbons, breathing large concentrations of tetrachloroethylene has central nervous system effects including lightheadedness, coma, convulsions, double vision, intoxication, and death. It also can cause vomiting. In animal studies, it had effects on the liver and kidney. It also is an irritant to eyes, lungs, and skin. However, many of these health effects were observed in occupational settings, where exposure is much higher than in outdoor air. Some animal studies suggest that tetrachloroethylene exposure may lead to leukemia (NIOSH Registry of Toxic Effects of Chemical Substances Information for Tetrachloroethylene). Tetrachloroethylene has been associated with liver and kidney cancer in animals.

The ATSDR has established a Minimal Risk Level (MRL) based on nervous system effects in humans. It is important to note that EPA is currently re-evaluating the toxic potential of tetrachloroethylene, including its carcinogenicity, and therefore no relevant information is available in IRIS. In the interim, EPA recommends the use of CalEPA toxicity values as provisional values. The CalEPA cancer toxicity value is derived by considering data on liver tumors in male and female mice and mononuclear cell leukemia in male and female rats. EPA is currently working to revise the toxicity assessment for tetrachloroethylene.

The California Air Resources Board has monitored tetrachloroethylene at a number of locations within their state, and found a mean value of 0.019 ppb during 1996 (California Air Resources Board Toxic Air Contaminant Identification List Summary for Tetrachloroethylene). The 2007 annual mean at Grand Junction - Powell was 0.05 ppb. These levels are greater than the network-wide mean value for California.

Toluene

Toluene is a hydrocarbon compound with the formula C_7H_8 . It exists in the atmosphere as a gas with an odor similar to that of benzene. Toluene has a number of industrial uses. It is used in high-octane gasoline. Toluene is employed in production processes for paints, resins, glues, and rubber. The printing, plastics, and furniture industries frequently use toluene.

Automotive-related activities are one of the largest sources of toluene in the atmosphere. Toluene is emitted from automobile exhaust, and from gasoline stations and refineries. Toluene is a component of wood smoke. Furniture manufacturers emit toluene, due to its use in paints and coatings. Forest fires are a natural source of toluene emissions.

Toluene is an irritant, has central nervous system effects (both temporary and permanent), and can damage a developing fetus. As an irritant, it causes stinging eyes, coughing, and skin irritation. Toluene can affect the brain. Individuals with exposures to large amounts have experienced slower reflexes, memory loss, hearing loss, and difficulty concentrating. Headache, dizziness, unconsciousness and death may result from exposure to large concentrations. Nausea and appetite loss may also occur. However, many of these health effects were observed in occupational settings, where exposure is much higher than in outdoor air. Mothers who abused toluene as an inhalant had children with brain dysfunction, attention deficits, craniofacial problems, and limb abnormalities. However, the CARB Air Toxics Profile on toluene, which discusses these problems in offspring, notes that the mothers also had exposure to other chemicals. Toluene can cause problems in the liver and kidneys. Due to an inadequate number of studies, it is not known whether toluene can cause cancer.

ATSDR indicates that toluene occurs in polluted air at levels of 0.3 to 7.98 ppb (ATSDR Toxicological Profile on Toluene). Thus, the 2007 Grand Junction mean level of 1.12 ppb is right within a typical US range. The ATSDR Toxicological Profile on Toluene indicates that children living in central urban core areas with large amounts of traffic had 56% more toluene detected in their blood than children living in rural areas. The health significance of this, if any, is not known.

1,3,5-Trimethylbenzene and 1,2,4-Trimethylbenzene

1,3,5-trimethylbenzene and 1,2,4-trimethylbenzene are isomers of the hydrocarbon formula C_9H_{12} . In pure form they are colorless liquids. They are used in chemical manufacturing of medicines, detergents, dyes, paints and inks. Trimethylbenzenes are a large component of distilled petroleum. They are also used as gasoline additives.

The largest sources of trimethylbenzenes in ambient air are likely to be automobiles, gasoline service stations, refineries, and chemical plants. In ambient air, trimethylbenzenes have a half-life of less than a day (EPA OPPT Chemical Summary For 1,2,4-Trimethylbenzene).

Health effects of trimethylbenzenes are similar to those of benzene. They damage the blood-clotting capacity of the body. Like the other volatile organic compounds, breathing large amounts can cause lightheadedness, headache, vomiting, convulsions, coma and death. They also irritate the skin and eyes, exerting a drying effect. Long-term exposure can lead to cough, reduced lung capacity, and bronchitis. However, these health effects are usually seen in workplaces, where levels are thousands of times higher than those in outdoor air. It is not known whether these compounds are carcinogenic. Some animal experiments suggest that they may cause bone formation problems for a developing fetus (EPA OPPT Chemical Summary For 1,2,4-Trimethylbenzene).

The Environmental Protection Agency cites national data indicating that average atmospheric concentrations of 1,2,4-trimethylbenzene are 0.58 ppb in rural areas, and 1.20 ppb in cities (EPA OPPT Chemical Summary For 1,2,4-Trimethylbenzene). The Grand Junction - Powell site had a 2007 mean value of 0.13 ppb. As

the EPA citation is for 1988, it is likely that concentrations have gone down in recent years. The mean for the 1,3,5 – trimethylbenzene isomer in 2007 was 0.04 ppb.

Xylenes

The xylene isomers, also known as the dimethylbenzene isomers, are chlorinated hydrocarbons with the formula C_8H_{10} . They exist in the atmosphere as gas. They have a sweet odor. Xylenes are usually chemically mixed, with the meta, ortho, and para isomers existing together, along with ethylbenzene. For this study, the meta and para isomers were measured as a group, with the ortho isomer separately characterized. Due to the coexistence of the isomers, toxicological data is generally applicable to xylene mixtures.

Xylenes occur naturally in petroleum. They are used as solvents in drug production, in paints, glues, lacquers, varnishes, in rubber production, in plastics, and in many household products. Xylenes are used in the printing industry as well.

Xylenes are emitted from automobiles, from petroleum refineries, and from industrial facilities that use them as solvents. Landfills and wastewater treatment plants may also be emission sources.

As is true for many of the chlorinated hydrocarbons, breathing large concentrations of mixed xylenes has central nervous system effects including lightheadedness, coma, convulsions, double vision, intoxication, and death. They can cause vomiting, and they also are an irritant to eyes, lungs, and skin. In animal studies, they had effects on the central nervous system, liver and kidney. Xylenes have been associated with hearing loss in some animal studies. Tests of rats that were exposed to mixed xylenes in air indicated that they had poorer performance than non-exposed rats on such tasks as finding one's way through a maze. Thus, it has been suggested that xylene exposure may result in learning deficits. Animal studies have also suggested a role in some birth defects, and that young exposed animals have delays in ossification of bone. There is little information on whether xylenes cause cancer. EPA considers mixed xylenes a Class D Carcinogen (not classifiable due to inadequate information).

California has monitored xylenes at a number of locations. In 1996, their network showed a statewide average of 0.97 ppb for m and p-xylenes, and 0.36 ppb for o-xylene (California Air Resources Board Toxic Air Contaminant Identification List Summary for Xylenes). At Grand Junction, the 2007 annual mean concentration for m and p-xylenes was 0.47 ppb, and the mean concentration for o-xylene was 0.17 ppb.

Metals

Arsenic, chromium, and manganese are discussed below. Levels of lead observed in Grand Junction were below the federal standard of $0.15 \mu\text{g}/\text{m}^3$ for a rolling quarterly average.

Arsenic

Arsenic is a metal-like element that occurs naturally in the earth's crust. Its chemical symbol is As. It exists in the atmosphere as particulate matter, in compounds formed from combination with other atoms such as oxygen, chlorine, and sulfur (ATSDR Public Health Statement for Arsenic). In the past, arsenic was used as a pesticide for orchard crops. Today, the chief use is in chromated copper arsenate (CCA) used to "pressure-treat" wood, to preserve it from decay in marine or in-ground usage. It is also used in metal alloy, glass-making, and electrical semi-conductors.

Emission sources of arsenic include smelters, coal-fired power plants, wood-burning, metals operations, mining operations, and incinerators. Arsenic occurs naturally in many soils, so wind-blown dusts from exposed land can contain it. Mine tailings piles generally contain enriched levels of arsenic, resulting in emissions of arsenic in the particulate emissions that occur under windy conditions. Soils contaminated by smelter fall-out can also be a source of emissions during high winds. Burning wood treated with CCA also leads to arsenic emissions.

Arsenic's toxicity has led to its use as a poison. Orally ingesting large amounts can be fatal. The effects of inhalation are similar to the oral effects. Arsenic disturbs the gastro-intestinal system, leading to abdominal pain,

vomiting, and diarrhea. It affects the central nervous system, leading to nerve damage in the legs and arms. It can damage the liver and kidney. Arsenic also has effects on the skin, causing dark patches (hyperpigmentation), and skin cancer. Arsenic also irritates the eyes, lungs, and skin. These effects have been observed in situations of occupational exposure that are significantly higher than concentrations seen in outdoor air. Exposure can lead to effects in the blood, such as anemia.

EPA has not established a Reference Concentration for arsenic. The Cal EPA has established a chronic reference level based on the developmental effects in mice; and other target organs included the cardiovascular system and nervous system. Arsenic exposure is known to cause lung cancer. EPA classifies arsenic in Group A, the known human carcinogens, based on increased lung cancer mortality in multiple human populations exposed primarily through inhalation.

The Agency for Toxic Substances and Disease Registry (ATSDR) states that remote areas have concentrations of 0.001 to 0.003 $\mu\text{g}/\text{m}^3$ arsenic in air, while urban locations range from 0.020 to 0.100 $\mu\text{g}/\text{m}^3$ (ATSDR Toxicological Profile on Arsenic). Arsenic was not detected in the Grand Junction 2007 PM_{10} samples. The annual mean in the $\text{PM}_{2.5}$ speciation samples was 0.0005 $\mu\text{g}/\text{m}^3$. It is likely that national levels of arsenic have decreased in recent years.

Chromium

Chromium is a metal that occurs naturally in the earth's crust. Its chemical symbol is Cr. It exists in the atmosphere as particulate matter, in compounds formed from combination with other atoms. Chromium may exist in several valence states, such as Cr^0 , Cr^{+3} , and Cr^{+6} . The zero valence and trivalent forms are believed to have lower toxicity than the hexavalent form, Cr^{+6} . Chromium is used as an additive in metal processing and steel production, and also as a pigment in paints, rubber products, and plastics (California Air Resources Board Fact Sheet on Chromium). It is also used in leather tanning, and in wood preservatives. In the past, industrial cooling towers employed rust-preventing solutions that contained chromium. These towers were one of the largest chromium emissions sources, until the solutions were changed to formulas that did not contain chromium. The bricks used to line high-temperature furnaces may also contain chromium.

Emission sources of chromium include petroleum refineries, steel producers, chrome production plants, cement producers, coal-fired power plants, wood burning, metals operations, mining operations, and incinerators. Chromium occurs naturally in some soils, so wind-blown dusts from exposed land can contain it. Soils contaminated by smelter fall-out can also be a source of emissions during high winds. Burning wood treated with chromium also leads to emissions. Automobiles may emit small amounts of chromium from catalytic converters or the wearing of brake linings. Most chromium emitted to outdoor air is believed to be of the trivalent form, but some percentage is of the hexavalent form.

Chromium's toxicity varies, depending upon its valence state. Chromium $^{+3}$, the trivalent form, is believed to be an essential micronutrient in the human body. With regard to carcinogenicity, EPA classifies it in Group D, the unclassifiable compounds. This is due to lack of information regarding chromium $^{+3}$ exposures, which occur largely in industrial settings where Chromium $^{+6}$ is also present. Chromium $^{+6}$ has demonstrated health effects including lung cancer, allergic dermatitis, skin ulcers, and irritation of the nasal passages. It has also been shown to create holes in the nasal septum. It irritates the lungs and the gastro-intestinal tract. It can also damage the kidneys, lungs and blood. EPA classifies it in Group A, the known human carcinogens. However, it should be noted that these health effects have been observed in workers with long-term exposure to hexavalent chromium in industrial settings. These exposures were to chromium acid mists occurring at levels hundreds or thousands of times higher than chromium levels in outdoor air. Assessment of the health significance of outdoor levels is complicated by the fact that the monitoring method used in many studies, chemical analysis of chromium in particulate matter collected on filters, is incapable of distinguishing between chromium $^{+3}$ and chromium $^{+6}$. The National Air Toxics Trends Stations, of which Grand Junction is one, have recently started monitoring chromium $^{+6}$ via a new method.

The California Air Resources Board monitored chromium in 1996. They report a network-wide average of 0.0039 $\mu\text{g}/\text{m}^3$ total chromium, of which 0.00013 $\mu\text{g}/\text{m}^3$ was hexavalent chromium. They estimate that the hexavalent form accounts for about 3 to 8 percent of the total chromium measured (CARB Fact Sheet on

Chromium). The 0.001 and 0.0047 annual means measured at two Grand Junction sites in 2000 – 2001 are close to the California results. For 2007, the Grand Junction site had a mean of 0.017 $\mu\text{g}/\text{m}^3$ total chromium, and 0.000016 $\mu\text{g}/\text{m}^3$ hexavalent chromium. This means that hexavalent chromium levels are considerably lower than the 3-8% fraction California estimated. It is also likely that levels have decreased in recent years.

Manganese

Manganese is a metal that occurs naturally in the earth's crust. Its chemical symbol is "Mn". It exists in the atmosphere as particulate matter, in compounds formed from combination with other atoms. Manganese is used as an additive in metal processing and steel production. It is also used in ceramics, matches, glass, dyes, batteries, and as a pigment in paints (California Air Resources Board Fact Sheet on Manganese). It is also employed in wood preservatives. Organic forms of manganese are used as pesticides and for disease prevention in crops such as fruits, vegetables, and cotton.

Emission sources of manganese include petroleum refineries, steel producers, cement producers, coal-fired power plants, wood-burning, metals operations, mining operations, and incinerators. Manganese occurs naturally in some soils, so wind-blown dusts from exposed land can contain it. Soils contaminated by smelter fall-out can also be a source of emissions during high winds.

Manganese is considered an essential micronutrient in the human body. The body tends to regulate manganese concentrations, so oral exposure to small amounts naturally present in food is rarely a problem. Exposure of manganese by inhalation can lead to health effects. Manganese health effects on the respiratory system include lung irritation, chemical pneumonia, cough, and bronchitis. Manganese may damage the central nervous system. The disease known as "manganism", which results from manganese poisoning, includes psychological and nervous system damage. Individuals with manganism have a mask-like face, depression, uncontrollable laughter, and lethargy. The central nervous system effects include trouble with tremors, balance and walking that is similar to that of Parkinson's disease. Central nervous system damage can occur at exposure levels below those that lead to manganism. Examples are decreases in visual reaction time, hand steadiness, and eye-hand coordination. Manganese also affects the gastro-intestinal tract and the kidneys. However, it should be noted that these health effects have been observed in workers with long-term exposure to manganese fumes and dusts in industrial settings. These exposures were at levels hundreds or thousands of times higher than manganese levels in outdoor air.

EPA classifies manganese as Group D, unclassifiable as to carcinogenic potential. This is because there is little evidence to link it to cancer health effects. EPA has established a Reference Concentration for manganese based on an impairment of neurobehavioral function in humans in occupational exposure studies.

The California Air Resources Board monitored manganese in 1996. They report a network-wide average of 0.0212 $\mu\text{g}/\text{m}^3$ total manganese (CARB Fact Sheet on Manganese). The 0.015 $\mu\text{g}/\text{m}^3$ annual mean for 2007 measured at Grand Junction is below the California average.

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ATTACHMENT-2

Documentation for Grand Junction Urban Air Toxics Trends Monitoring Locations

REGIONAL MAP (5 - 30 miles)

AQS ID: **08-077-0017** Site Name: **Grand Junction – Powell Building**

650 South Avenue, Grand Junction, CO 81501

GPS: Zone 12, 710962 E, 4326741 N, elev. 1396m

39° 03' 51" N, 108° 33' 42" W

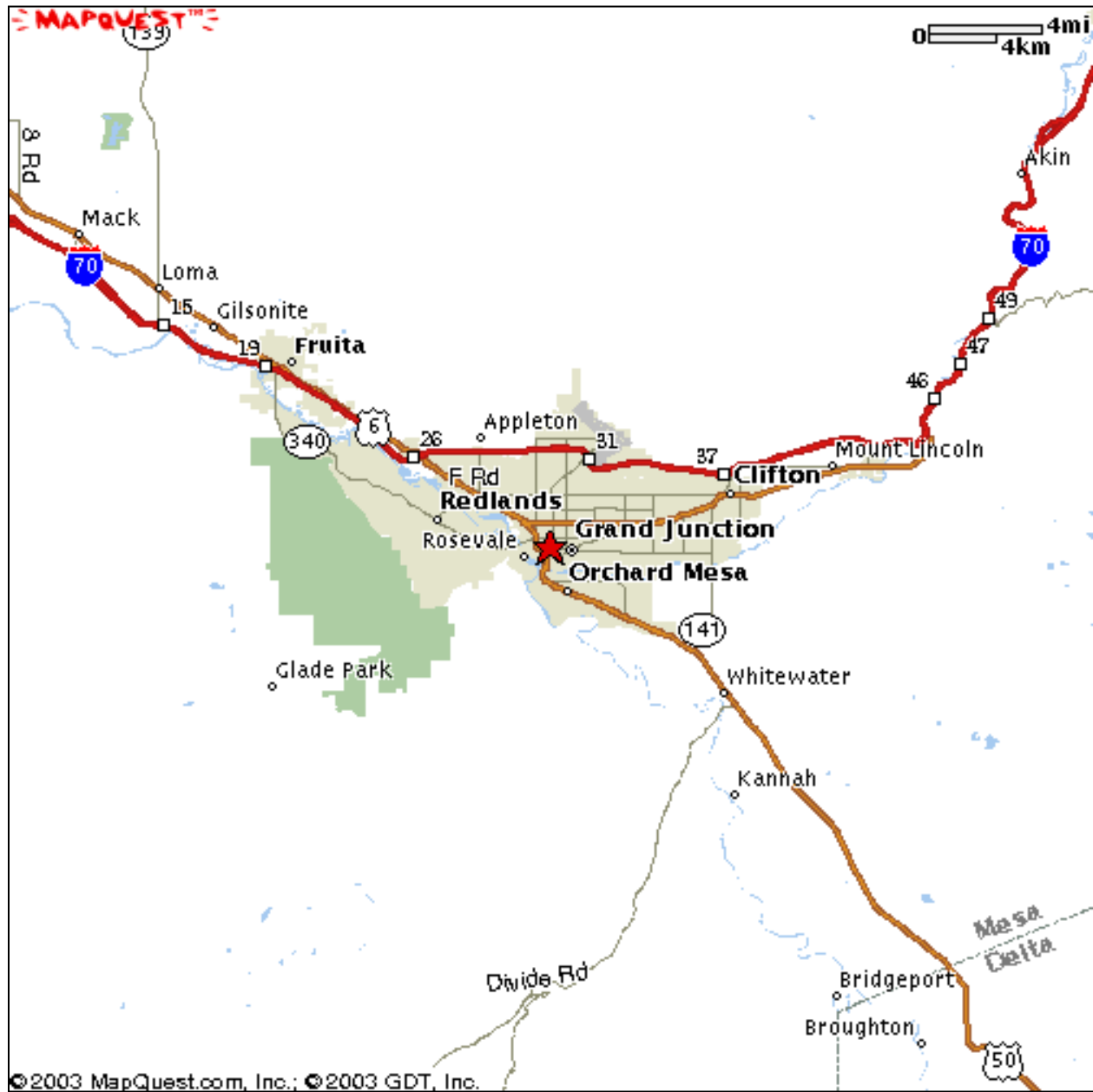
AQS ID: **08-077-0018** Site Name: **Grand Junction – Powell / Pitkin (shelter)**

645 ¼ Pitkin Avenue, Grand Junction, CO 81501

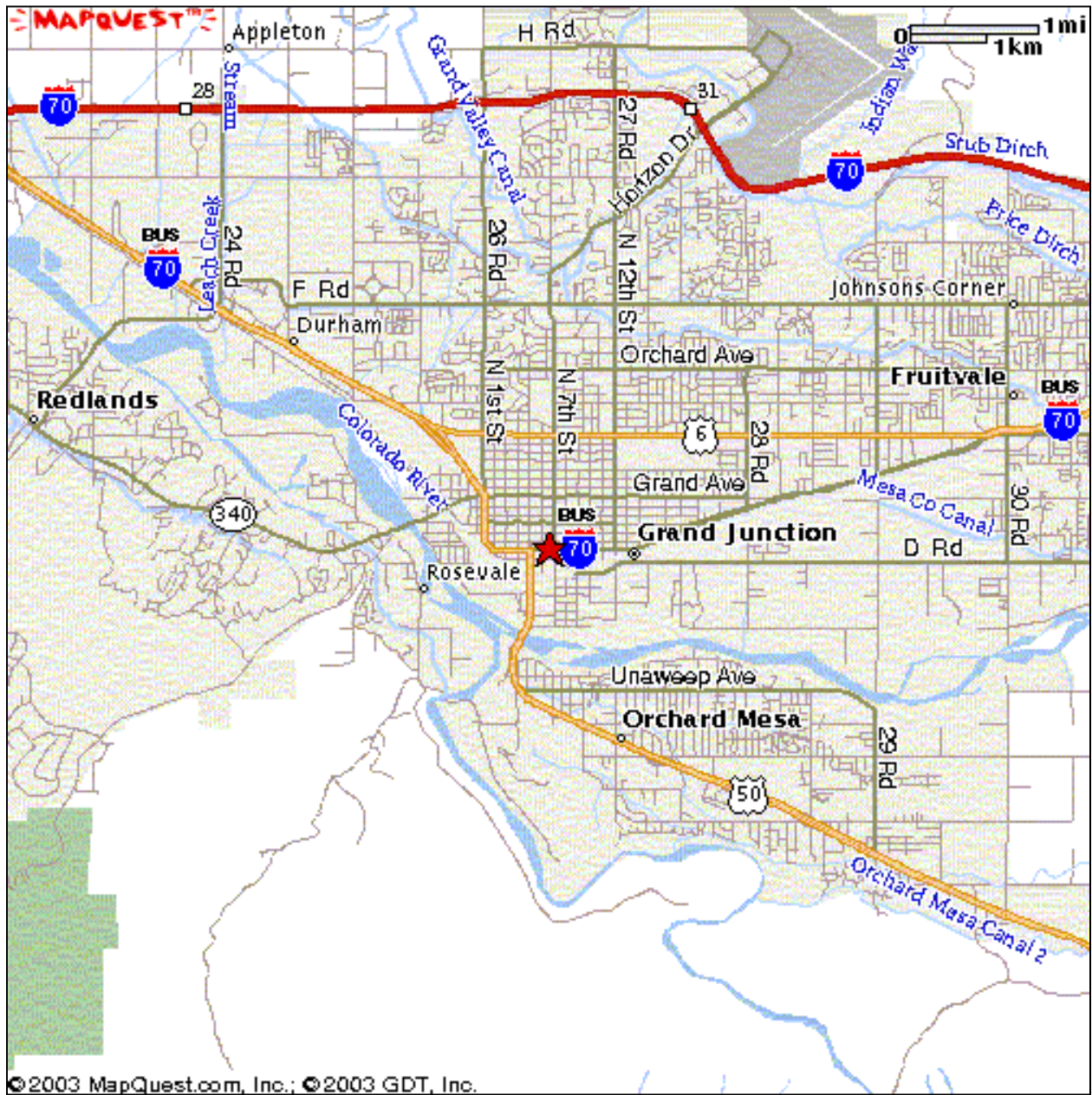
GPS: Zone 12, 710962 E, 4326741 N, elev. 1396m

39° 03' 51" N, 108° 33' 42" W

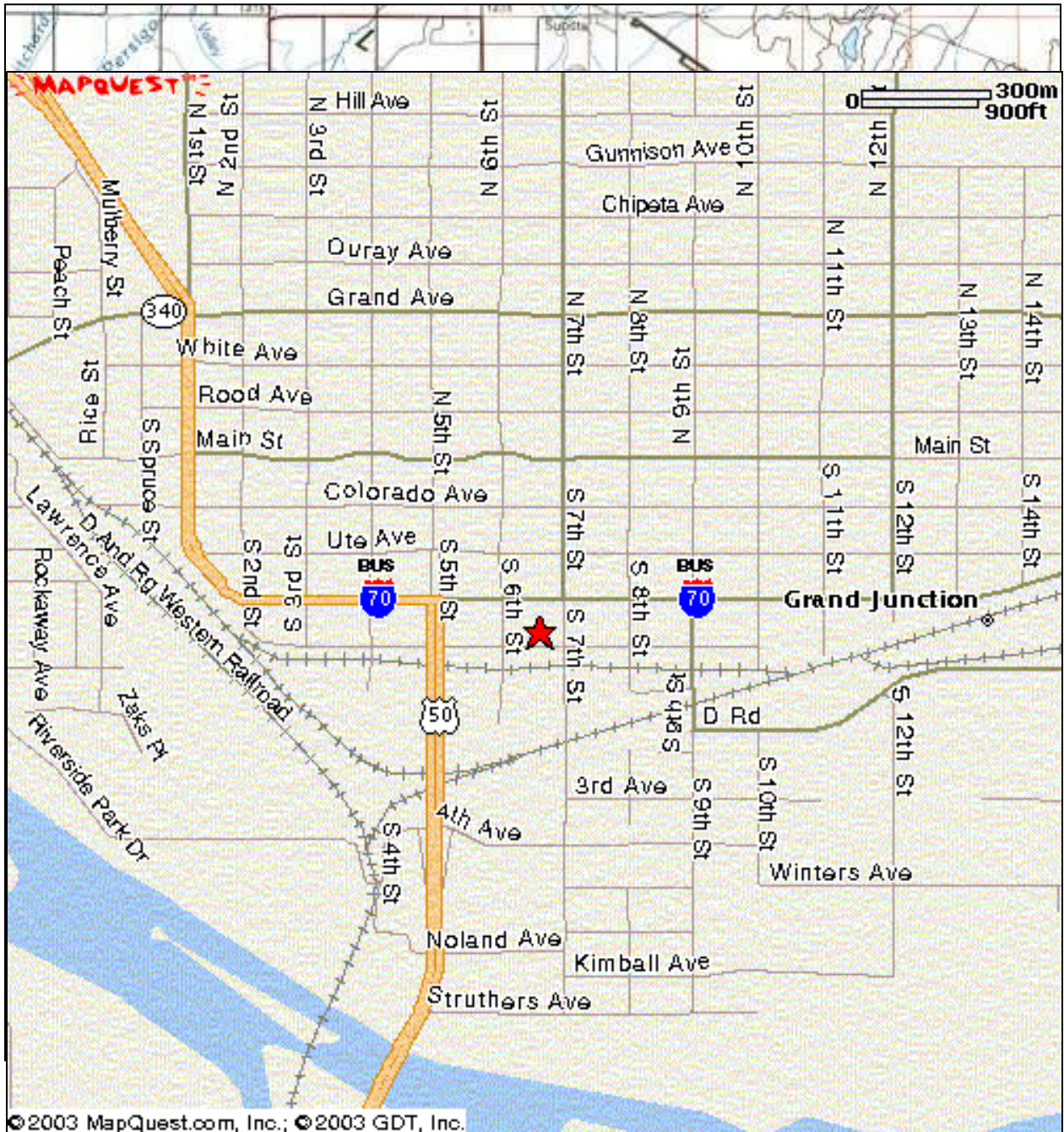
REGIONAL MAP (5 - 30 miles)



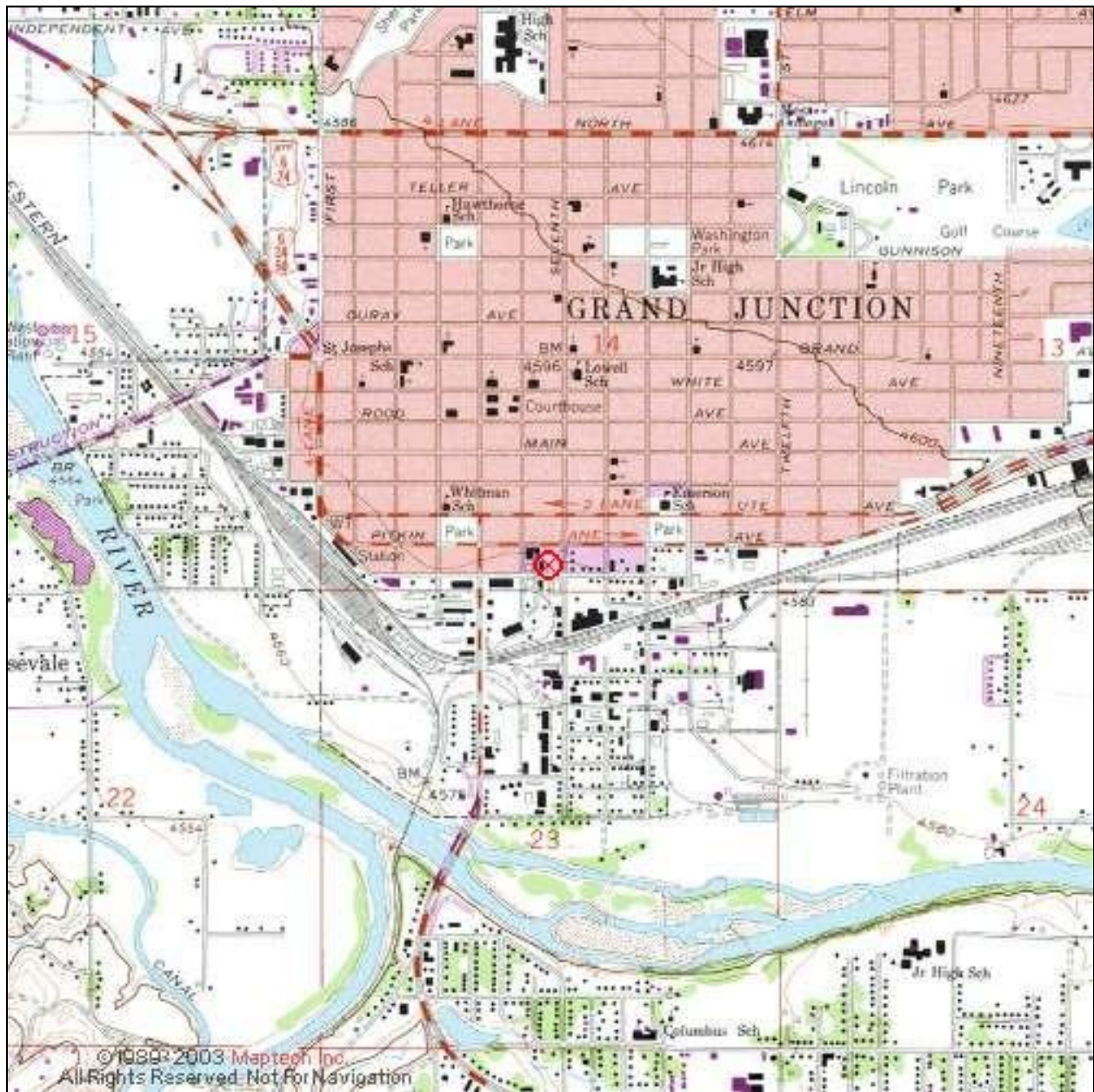
REGIONAL MAP (5 - 30 miles)



SITE MAP (1/4 - 1 mile)



SITE MAP (1/4 - 1 mile)



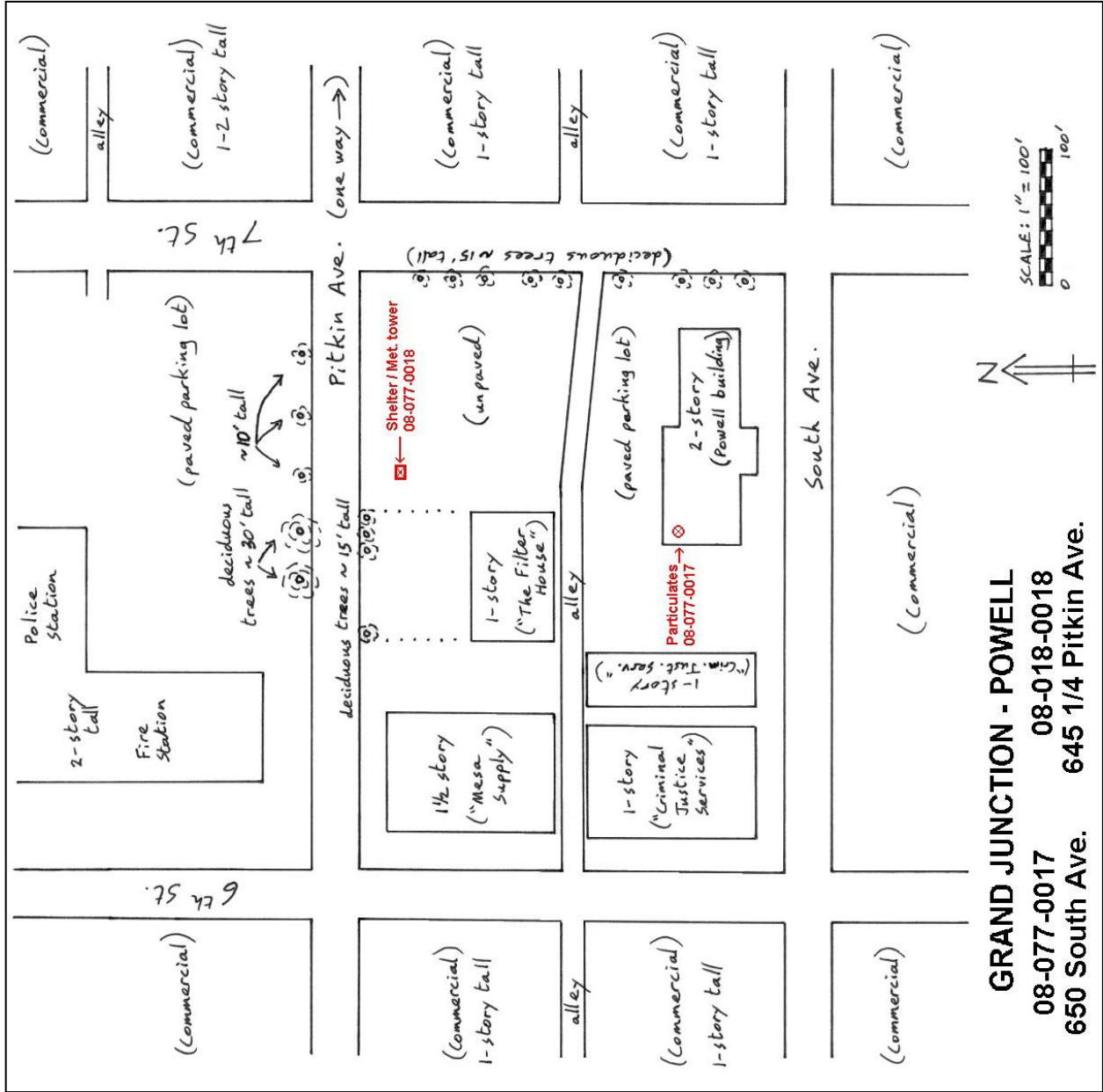


AQS ID: 08-077-0018

Site Name: Grand Junction – Powell (shelter)



SITE MAP (1/4 - 1 mile)



GRAND JUNCTION - POWELL
 08-077-0017 08-018-0018
 650 South Ave. 645 1/4 Pitkin Ave.

AQS ID: 08-077-0017

Site Name: Grand Junction – Powell Building

Photo Date: 01/21/2004

Site Photo: Looking South (from gaseous shelter)



Site Photo: Looking Northwest



Looking NORTH



Looking NORTHEAST



Looking EAST



Looking SOUTHEAST



Looking SOUTH



Looking SOUTHWEST



Looking WEST



Looking NORTHWEST



AQS ID: 08-077-0018

Site Name: Grand Junction – Powell (shelter)

Photo Date: 01/21/2004

Site Photo: Looking North (from particulate samplers)



Site Photo: Looking Northwest



Looking NORTH



Looking NORTHEAST



Looking EAST



Looking SOUTHEAST



Looking SOUTH



Looking SOUTHWEST



Looking WEST



Looking NORTHWEST





**Colorado Department
of Public Health
and Environment**