

National Air Toxics Trends Study In Grand Junction, Colorado

January through December 2005



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 2005

Executive Summary

The Grand Junction air toxics monitors were originally established as a part of the Pilot Study for National Air Toxics Trends Sites. It 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 2005. There are several important aspects of this report. They are: the improved, lower, detection limits for the carbonyl compounds; the development of a chromium-six detection method and the measured reduction in concentrations of acetone and acetaldehyde.

The acetonitrile data for the first four months of 2005 had to be invalidated because of problems in the sampling procedure. Although these problems were corrected, the maximum and second maximum values are outliers from the rest of the data set and are as yet unexplained.

In January 2005 the collection method for metals was changed from a high volume PM₁₀ sampler to a low volume PM₁₀ sampler. This change was implemented because the high volume PM₁₀ filters had shown contamination from chromium and nickel.

In January of 2005 a new hexavalent chromium sampler was added to the network. The previous method was only able to measure total chromium and could not distinguish between the toxic hexavalent and the non-toxic trivalent forms of chromium. The new sampling method showed that in general the hexavalent form accounted for less than one-thousandth of the total chromium concentration.

Section 1: Introduction

Introduction

The Grand Junction Air Toxics monitoring site was established as a part of the United States Environmental Protection Agency's 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 2005 through December 2005.

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 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, 645¼ Pitkin Avenue. This site contained 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 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 most of the year, with a few one-in-three day samples during the summer, for a total of 68 samples attempted. Two samples were not valid, and four were missed (not taken), for a total of 62 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 at least 85 percent of the time. However, the true annual means of isovaleraldehyde and 2,5-dimethylbenzaldehyde may be well below the numbers reported here. Due to the fact that these were rarely detected, one-half of the detection limit was used for the estimated concentration of many of the non-detects. Actual concentrations could have been at lower levels than these estimates.

The 2005 sample detection limits were about a third lower than the 2004 limits because of improved analytical methodology.

Percentage of Samples For Which Compound Was Detected

Table 2.1 shows that most of these compounds were present in air over 85 percent of the time. However 2,5-dimethylbenzaldehyde was seen much less frequently, with detections in less than five percent of the air samples taken. Isovaleraldehyde was detected about 30 percent of the time. The isovaleraldehyde frequency of occurrence is similar to that noted during the 2001 - 2002 Pilot project study in Grand Junction. In that study isovaleraldehyde was detected 29 percent of the time. 2,5-dimethylbenzaldehyde was detected 34 percent of the time in 2001 - 2002, while it was only detected 4 percent of the time in 2004 and 4.8 percent of the time in 2005. This is a sizable reduction in detection frequency from the Pilot study.

Table 2.1 Carbonyl Compounds Sample Summary - 2005

Grand Junction – Powell Site	CAS Number	62 Samples	
		Number of Samples Above Detection	Percentage of Samples Detected
Acetaldehyde	75-07-0	62	100
Formaldehyde	50-00-0	62	100
Acetone	67-64-1	62	100
Valeraldehyde	110-62-3	59	95.2
Butyraldehyde	123-72-8	62	100
Propionaldehyde	123-38-6	55	88.7
Crotonaldehyde	123-73-9	61	98.4
Hexaldehyde	66-25-1	59	95.2
Tolualdehydes	NA	54	87.1
Benzaldehyde	100-52-7	61	98.4
Isovaleraldehyde	590-86-3	19	30.6
2,5-Dimethylbenzaldehyde	5779-94-2	3	4.8

Graphs - Carbonyls

The summary data for carbonyl compounds measured during 2005 are graphed in Figure 2.1. The compounds in these graphs are ordered by ranking their maximum concentration. The graphs show that acetaldehyde, acetone, and formaldehyde generally had the highest maxima. However, both the maximum and the annual mean concentrations of these three compounds were lower in 2005 than in 2004 (Table 2.2). The formaldehyde means for the two years were nearly identical.

Table 2.2 Carbonyl Compounds Data Summary Comparisons – 2004 – 2005

Grand Junction – Powell Site	2005 Statistics (µg/m ³)			2004 Statistics (µg/m ³)		
	Maximum	Mean	Average MDL*	Maximum	Mean	Average MDL*
Acetaldehyde	17.188	2.991	0.026	92.785	5.843	0.040
Formaldehyde	11.418	3.118	0.020	40.436	2.81	0.032
Acetone	10.215	4.664	0.020	91.218	7.741	0.031
Valeraldehyde	6.306	0.202	0.013	0.565	0.051	0.021
Butyraldehyde	6.223	0.400	0.015	3.244	0.308	0.023
Propionaldehyde	4.798	0.315	0.013	2.399	0.164	0.020
Crotonaldehyde	3.755	0.217	0.012	3.440	0.233	0.018
Hexaldehyde	1.520	0.105	0.010	1.573	0.137	0.017
Tolualdehydes	0.457	0.128	0.022	0.894	0.124	0.035
Benzaldehyde	0.412	0.220	0.014	4.067	0.255	0.021
Isovaleraldehyde	0.127	0.020	0.013	0.150	0.012	0.021
2,5-Dimethylbenzaldehyde	0.099	0.011	0.016	0.181	0.015	0.025

*- Average MDL – average minimum detectable level

Figure 2.2 shows a spike in formaldehyde in August 2005. Acetaldehyde peaked at the same time. Acetone showed several peaks, at different times. Other than the peaks, none of the compounds showed any definite seasonal variation.

Field Blanks – Carbonyls

Field blanks were collected twice a month 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 two types of precision data in order to assess both sampling and analytical procedures. Every two months, 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. The laboratory also conducted a test of the precision of the analytical process by injecting two samples of each cartridge's liquid extract into the liquid chromatograph/ mass spectrometer. Detailed information regarding precision and laboratory replicate results is available upon request.

Figure 2.1 Maximum and Annual Mean Carbonyls 2005

**Grand Junction - Powell --- Carbonyls
January 2005 - December 2005**

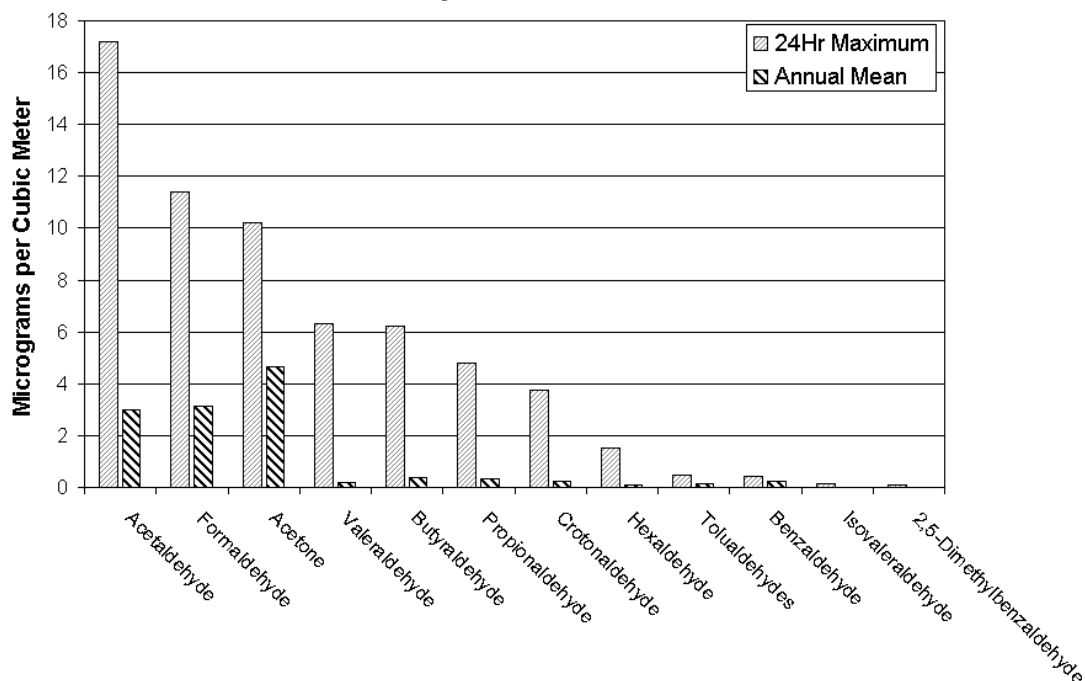
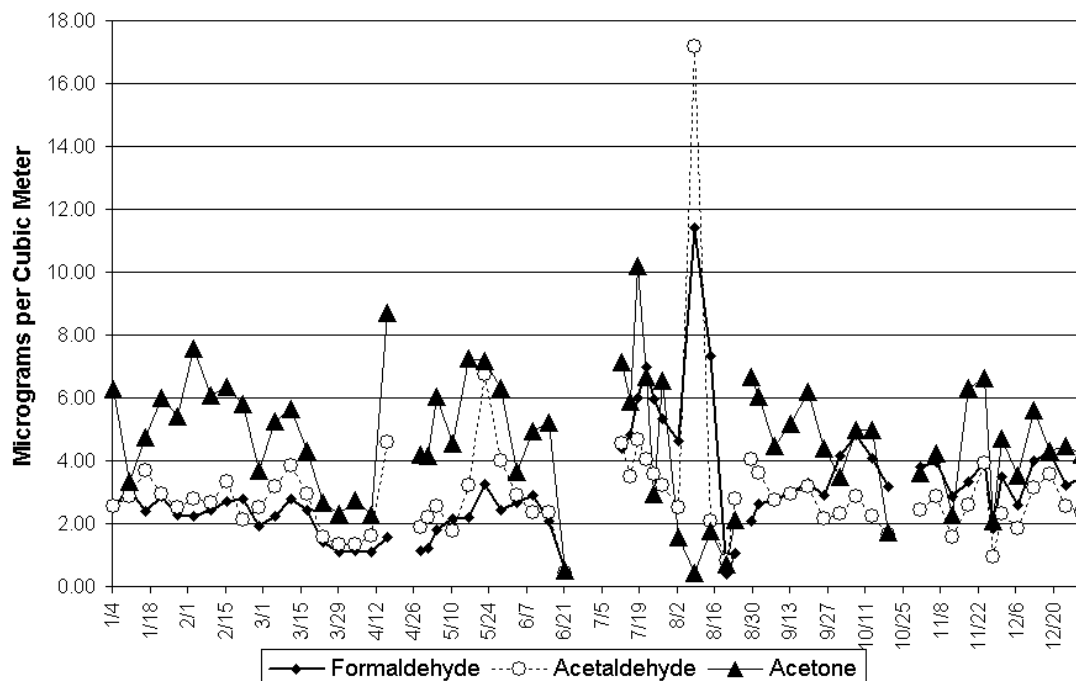


Figure 2.2 Sample Day Comparisons for 2005

Grand Junction - Carbonyl - Sample Day Comparisons



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 2005 are presented in this section. There were 59 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 some samples taken on a one-in-three frequency during the summer months, for a total of 68 samples attempted. Of these, six samples were voided, and 4 were missed in the field (not taken), for a percentage data recovery rate of 85 percent.

Table 3.2 summarizes the annual maximum and mean concentrations for each of the 59 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.

The early 2005 acetonitrile data were invalidated. The sampler was contaminated with this compound because of a common manifold for sampling carbonyls and VOCs. Acetonitrile used to prepare the carbonyl cartridges can diffuse back through the manifold, and enter the canister sampling line. This problem, discovered at a remote site in Custer, South Dakota, as well as in Grand Junction and Denver, Colorado, led national contractor ERG to redesign their manifold system.

In 2005 a new compound, acrolein, was added to the sampling list. This was the result of a study, which showed this compound could be effectively captured and analyzed with the canister method. The compound is of special interest, because EPA analyses for the National Air Toxics Assessment (NATA) have suggested that it may be an important compound in determining public health risk. In previous years, there was no accepted method to analyze for acrolein.

Table 3.1 VOC Sample Summary - 2005

Grand Junction - Powell Site	CAS Number*	58 Samples Taken	
		Number of Samples Detected	Percentage of Samples Detected
1,1,1-Trichloroethane	71-55-6	32	55.2
1,1,2,2-Tetrachloroethane	79-34-5	1	1.7
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	5	8.6
1,2,4-Trimethylbenzene	95-63-6	53	91.4
1,2-Dibromoethane	106-93-4	0	0.0
1,2-Dichloroethane	107-06-2	1	1.7
1,2-Dichloropropane	78-87-5	0	0.0
1,3,5-Trimethylbenzene	108-67-8	50	86.2
1,3-Butadiene	106-99-0	40	69.0
Acetonitrile ***	75-05-8	17	46.6
Acetylene	74-86-2	58	100.0
Acrolein	107-02-8	41	70.7
Acrylonitrile	107-13-1	2	3.4
Benzene	71-43-2	58	100.0
Bromochloromethane	74-97-5	0	0.0
Bromodichloromethane	75-27-4	0	0.0
Bromoform	75-25-2	0	0.0
Bromomethane	74-83-9	27	46.6
Carbon Tetrachloride	56-23-5	49	84.5
Chlorobenzene	108-90-7	0	0.0
Chloroethane	75-00-3	22	37.9
Chloroform	67-66-3	23	39.7
Chloromethane	74-87-3	57	98.3
Chloromethylbenzene	100-44-7	0	0.0
Chloroprene	126-99-8	0	0.0
cis-1,2-Dichloroethylene	156-59-4	1	1.7
cis-1,3-Dichloropropene	10061-01-5	0	0.0
Dibromochloromethane	124-48-1	0	0.0
Dichlorodifluoromethane	75-71-8	58	100.0
Dichloromethane	75-09-2	48	82.8
Dichlorotetrafluoroethane	76-14-2	32	55.2
Ethyl Acrylate	140-88-5	0	0.0
Ethyl tert-Butyl Ether	637-92-3	0	0.0
Ethylbenzene	100-41-4	58	100.0
Hexachloro-1,3-butadiene	87-68-3	10	17.2
m,p-Xylene	100-01-6	58	100.0
m-Dichlorobenzene	541-73-1	0	0.0
Methyl Ethyl Ketone	78-93-3	15	25.9
Methyl Isobutyl Ketone	108-10-1	10	17.2
Methyl Methacrylate	80-62-6	13	22.4
Methyl tert-Butyl Ether	1634-04-4	0	0.0
n-Octane	111-65-9	40	69.0
o-Dichlorobenzene	95-50-1	0	0.0
o-Xylene	95-47-6	58	100.0
p-Dichlorobenzene	106-46-7	23	39.7
Propylene	115-07-1	58	100.0
Styrene	100-42-5	56	96.6
tert-Amyl Methyl Ether	994-05-8	0	0.0
Tetrachloroethylene	127-18-4	30	51.7
Toluene	108-88-3	58	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	10	17.2
Trichlorofluoromethane	75-69-4	58	100.0
Trichlorotrifluoroethane	76-13-1	58	100.0
Vinyl chloride	75-01-4	1	1.7

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

*** Acetonitrile samples were voided through 4/10/2005 because of possible contamination in the sample line.

Table 3.2 VOC Data Summary Comparisons - 2004 – 2005

Grand Junction - Powell Site	CAS Number*	2005 Statistics (µg/m ³)			2004 Statistics (µg/m ³)		
		Maximum**	Mean**	Average MDL	Maximum**	Mean**	Average MDL
1,1,1-Trichloroethane	71-55-6	0.22	0.15	0.20	ND	ND	0.27
1,1,2,2-Tetrachloroethane	79-34-5	0.17	0.16	0.31	ND	ND	0.34
1,1,2-Trichloroethane	79-00-5	ND	ND	0.29	ND	ND	0.44
1,1-Dichloroethane	75-34-3	ND	ND	0.15	ND	ND	0.20
1,1-Dichloroethene	75-35-4	ND	ND	0.18	ND	ND	0.20
1,2,4-Trichlorobenzene	120-82-1	0.67	0.58	1.20	ND	ND	1.34
1,2,4-Trimethylbenzene	95-63-6	2.80	1.01	0.29	3.64	1.21	0.29
1,2-Dibromoethane	106-93-4	ND	ND	0.32	ND	ND	0.38
1,2-Dichloroethane	107-06-2	0.16	0.10	0.19	ND	ND	0.24
1,2-Dichloropropane	78-87-5	ND	ND	0.24	ND	ND	0.32
1,3,5-Trimethylbenzene	108-67-8	0.88	0.33	0.17	1.23	0.40	0.20
1,3-Butadiene	106-99-0	0.62	0.20	0.12	1.11	0.19	0.13
Acetonitrile ***	75-05-8	394.55	17.18	0.14	Void	Void	0.22
Acetylene	74-86-2	6.31	2.05	0.05	10.39	2.26	0.05
Acrolein	107-02-8	3.05	0.81	0.08	Not Sampled	Not Sampled	
Acrylonitrile	107-13-1	0.48	0.07	0.13	1.06	0.03	0.17
Benzene	71-43-2	3.55	1.95	0.12	8.50	2.25	0.16
Bromochloromethane	74-97-5	ND	ND	0.31	ND	ND	0.48
Bromodichloromethane	75-27-4	ND	ND	0.24	ND	ND	0.27
Bromoform	75-25-2	ND	ND	0.43	ND	ND	0.62
Bromomethane	74-83-9	0.23	0.08	0.19	0.50	0.01	0.19
Carbon Tetrachloride	56-23-5	0.94	0.49	0.32	0.88	0.48	0.38
Chlorobenzene	108-90-7	ND	ND	0.14	ND	ND	0.18
Chloroethane	75-00-3	0.13	0.09	0.20	0.37	0.01	0.26
Chloroform	67-66-3	0.39	0.11	0.17	1.55	0.01	0.20
Chloromethane	74-87-3	1.96	1.32	0.11	ND	ND	0.10
Chloromethylbenzene	100-44-7	ND	ND	0.21	ND	ND	0.26
Chloroprene	126-99-8	ND	ND	0.15	ND	ND	0.18
cis-1,2-Dichloroethylene	156-59-4	0.52	0.09	0.17	ND	ND	0.24
cis-1,3-Dichloropropene	10061-01-5	ND	ND	0.17	ND	ND	0.23
Dibromochloromethane	124-48-1	ND	ND	0.41	ND	ND	0.60
Dichlorodifluoromethane	75-71-8	4.15	3.18	0.10	4.40	3.07	0.15
Dichloromethane	75-09-2	2.88	0.43	0.22	4.90	0.44	0.28
Dichlorotetrafluoroethane	76-14-2	0.21	0.12	0.15	0.28	0.01	0.21
Ethyl Acrylate	140-88-5	ND	ND	0.23	ND	ND	0.25
Ethyl tert-Butyl Ether	637-92-3	ND	ND	0.19	ND	ND	.021
Ethylbenzene	100-41-4	5.30	1.36	0.13	3.4	1.20	0.17
Hexachloro-1,3-butadiene	87-68-3	1.76	0.99	2.52	ND	ND	1.71
m,p-Xylene	100-01-6	20.24	4.62	0.18	9.51	3.73	0.22
m-Dichlorobenzene	541-73-1	ND	ND	0.34	ND	ND	0.42
Methyl Ethyl Ketone	78-93-3	3.33	0.43	0.28	40.41	2.56	0.44
Methyl Isobutyl Ketone	108-10-1	1.15	0.18	0.27	2.46	0.13	0.33
Methyl Methacrylate	80-62-6	14.05	0.79	0.32	11.59	1.18	0.45
Methyl tert-Butyl Ether	1634-04-4	ND	ND	0.24	0.54	0.01	0.25
n-Octane	111-65-9	0.84	0.34	0.22	1.35	0.27	0.28
o-Dichlorobenzene	95-50-1	ND	ND	0.29	ND	ND	0.24
o-Xylene	95-47-6	9.21	1.97	0.15	3.78	1.55	0.17
p-Dichlorobenzene	106-46-7	0.30	0.14	0.36	ND	ND	0.36
Propylene	115-07-1	3.29	1.32	0.10	5.52	1.41	0.12
Styrene	100-42-5	12.78	1.05	0.15	19.98	2.18	0.17
tert-Amyl Methyl Ether	994-05-8	ND	ND	0.26	ND	ND	0.29
Tetrachloroethylene	127-18-4	0.75	0.27	0.25	1.09	0.21	0.34
Toluene	108-88-3	13.00	5.53	0.14	14.81	5.58	0.19
trans-1,2-Dichloroethylene	156-60-5	ND	ND	0.18	ND	ND	0.20
trans-1,3-Dichloropropene	10061-02-6	ND	ND	0.21	0.45	0.01	0.23
Trichloroethylene	79-01-6	0.27	0.12	0.24	ND	ND	0.27
Trichlorofluoromethane	75-69-4	2.30	1.63	0.17	10.34	2.17	0.22
Trichlorotrifluoroethane	76-13-1	1.30	0.81	0.27	4.06	0.77	0.31
Vinyl chloride	75-01-4	0.05	0.05	0.10	ND	ND	0.10

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

** ND – Non-Detect sample recorded a concentration less than the detection limit for this compound.

*** Acetonitrile samples were voided through 4/10/2005 because of possible contamination in the sample line.

Percentage of Samples For Which Compound Was Detected

Table 3.1 shows the percentage of the samples in which each VOC was detected. Thirteen of the compounds were detected in over 90 percent of the samples. These compounds are listed in Table 3.3. All of these compounds were detected over 90 percent of the time in 2004 as well. Two compounds that were present over 90 percent of the time in 2004 dropped somewhat in 2005. 1,3,5-trimethylebenzene was at measurable levels in 86.2 percent of the 2005 samples. Methyl ethyl ketone, present over 90 percent of the time in 2004, was only seen 25.9 percent of the time in 2005.

Twenty-one VOCs were not detected at all during the study. Compounds not detected are listed in Table 3.4. All of these compounds, except for methyl tert-butyl ether, were not detected in 2004 either. 1,1,1-Trichloroethane was detected 55.2 percent of the time in 2005, but it was not detected at all in 2004. This may be due to an improved detection limit. In 2004, the detection limit was $0.27 \mu\text{g}/\text{m}^3$ while in 2005 the detection limit was reduced to $0.20 \mu\text{g}/\text{m}^3$. 1,1,2,2-Tetrachloroethane, 1,2-dichloroethane, cis - 1,2-dichloroethylene and vinyl chloride, were not detected at all in 2004, however they each had a single detection during the year 2005. In contrast, methyl tert-butyl ether, detected once in 2004, had no detections in 2005. 1,2,4-Trichlorobenzene was seen 8.6 percent of the time in 2005 but not at all in 2004. This may also be due to the improved detection limit. In 2004 it was $1.34 \mu\text{g}/\text{m}^3$ and in 2005 it was $1.20 \mu\text{g}/\text{m}^3$. These improvements caused more samples to be at a measurable level. Hexachloro-1,3-butadiene, not detected in 2004, was detected 17.2 percent of the time in 2005. This was in spite of the fact that the detection level for 2005, $2.52 \mu\text{g}/\text{m}^3$, was higher than the 2004 detection level of $1.71 \mu\text{g}/\text{m}^3$.

Vinyl chloride was only detected once during the two years. Methyl tert-butyl ether (MTBE), a fuel additive, was detected in a single 2004 sample. The fuel additives ethyl tert-butyl ether (ETBE) and tert-amyl methyl ether (TAME), were not detected in 2005. The list of compounds in Table 3.3 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

1,2,4 - Trimethylbenzene Acetylene Benzene Chloromethane Dichlorodifluoromethane Ethylbenzene m,p - xylene	o - xylene Propylene Styrene Toluene Trichlorofluoromethane Trichlorotrifluoroethane
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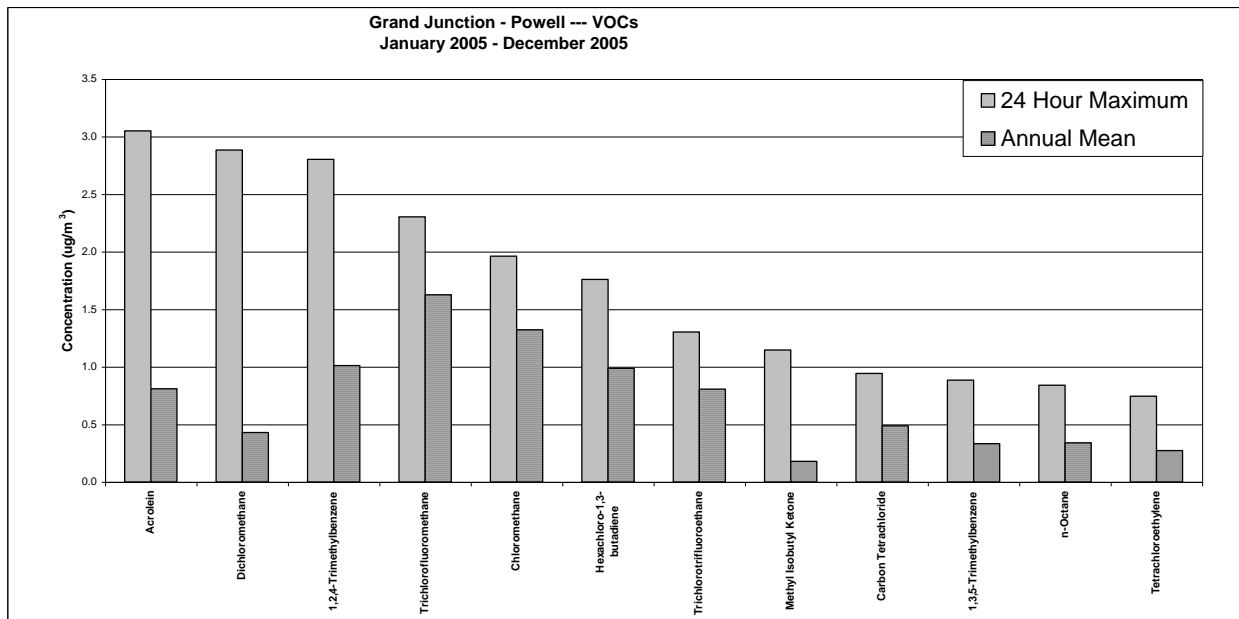
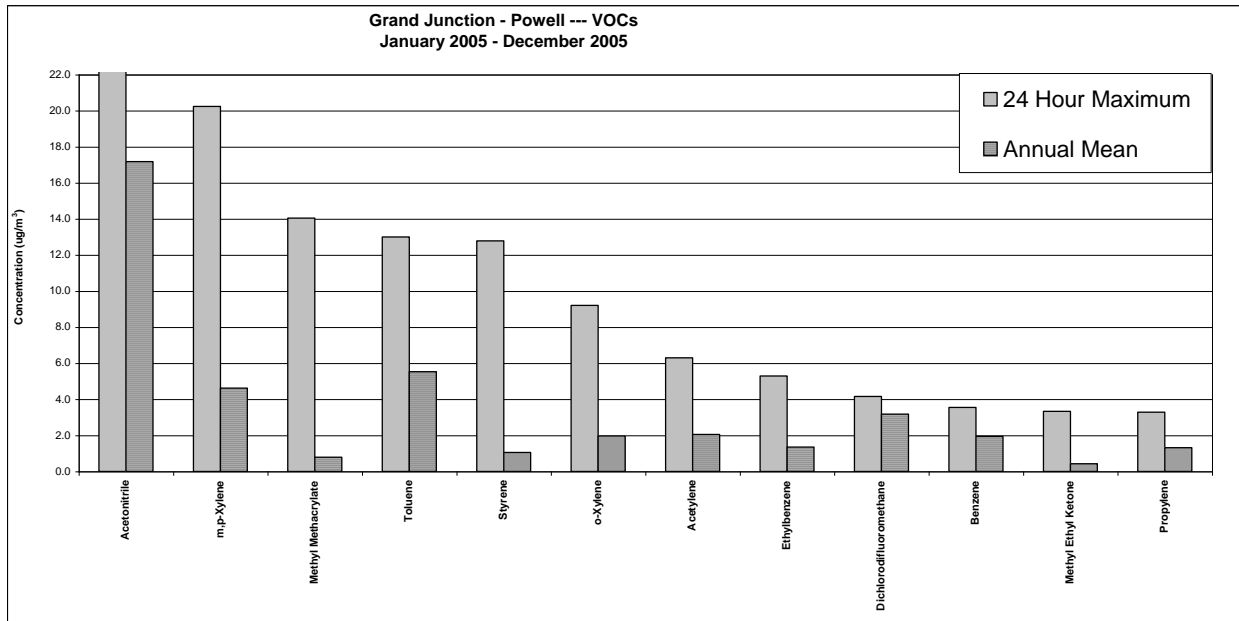
Table 3.4 Volatile Organic Compounds Not Detected in the VOC Air Samples

1,1,2-Trichloroethane 1,1-Dichloroethane 1,1-Dichloroethene 1,2-Dibromoethane 1,2-Dichloropropane Bromochloromethane Bromodichloromethane	Bromoform Chlorobenzene Chloromethylbenzene Chloroprene cis - 1,3-Dichloropropene Dibromochloromethane Ethyl Acrylate	Ethyl tert-Butyl Ether m-Dichlorobenzene Methyl tert-butyl Ether o-Dichlorobenzene tert-Amyl Methyl Ether trans - 1,2-Dichloroethylene trans - 1,3-Dichloropropene
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Graphs – Volatile Organic Compounds

Figure 3.1 has three graphs showing the 24-hour maximum and annual mean concentrations for each of the 38 compounds that were detected. These graphs are ordered from highest to lowest 24-hour maximum. Note that the first graph has a Y-axis that goes from 0 to 22.0 micrograms per cubic meter while the Y-axis on the second and third graphs only goes from 0 to 3.5 micrograms per cubic meter. The maximum for acetonitrile ($394.6 \mu\text{g}/\text{m}^3$) is not shown in order to display the values of the other compounds. The three peaks of acetonitrile are shown in the daily sample graph of Figure 3.5. The reason for these outlier values is not known but remains under investigation. Some of the VOC compounds monitored showed seasonality. Acetylene, propylene and 1,3-butadiene appear to be lower in the summer. Other VOC compounds monitored did not show any clear seasonality. This is shown in the graphs in Figures 3.2 through 3.7.

Figure 3.1 Annual Mean and 24 Hour Maximum VOCs



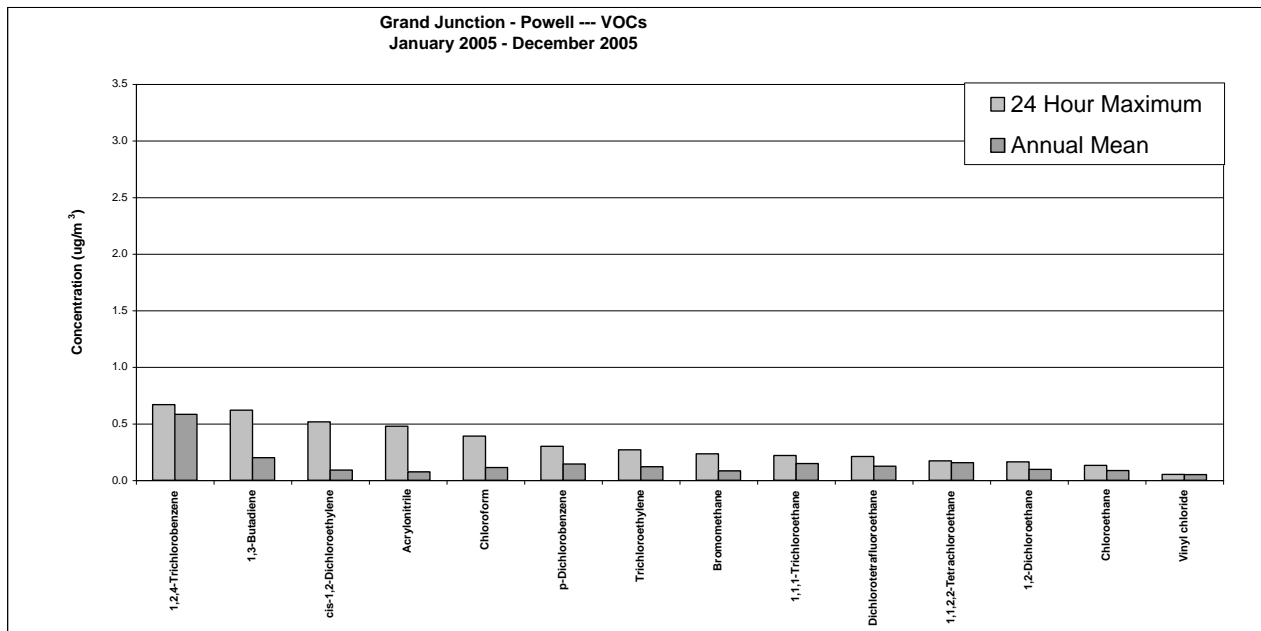


Figure 3.2 Toluene, Benzene and Ethylbenzene

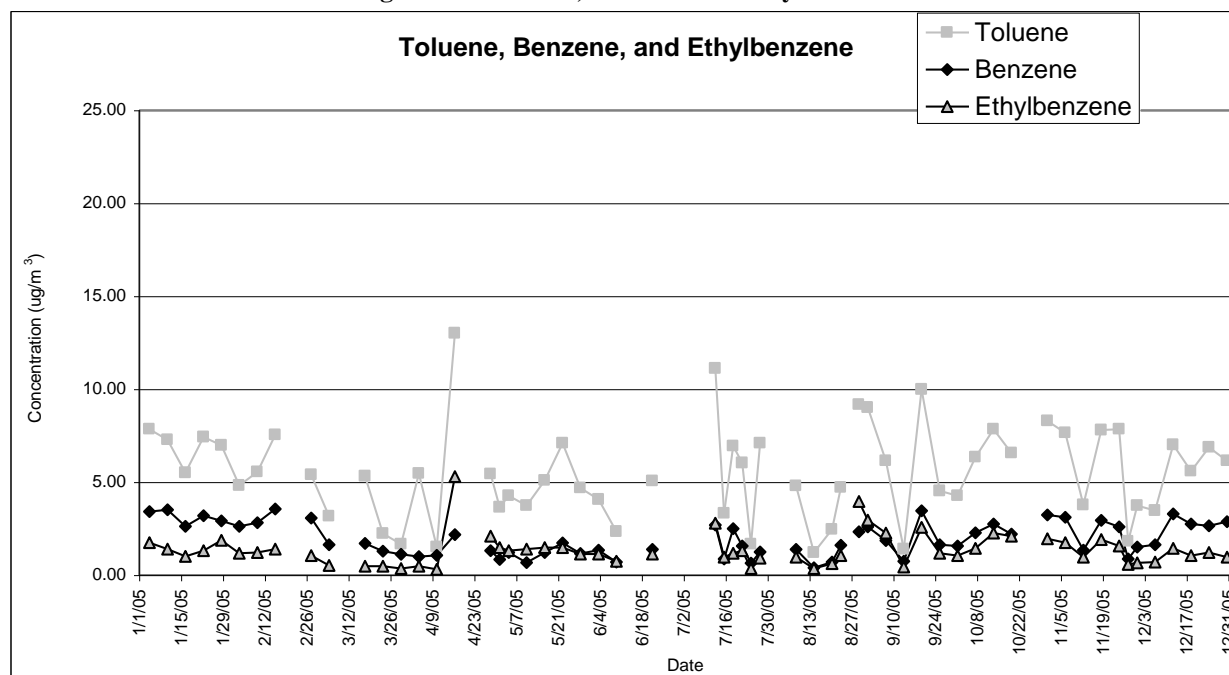


Figure 3.3 Styrene, Xylenes and 1,2,4-Trimethylbenzene

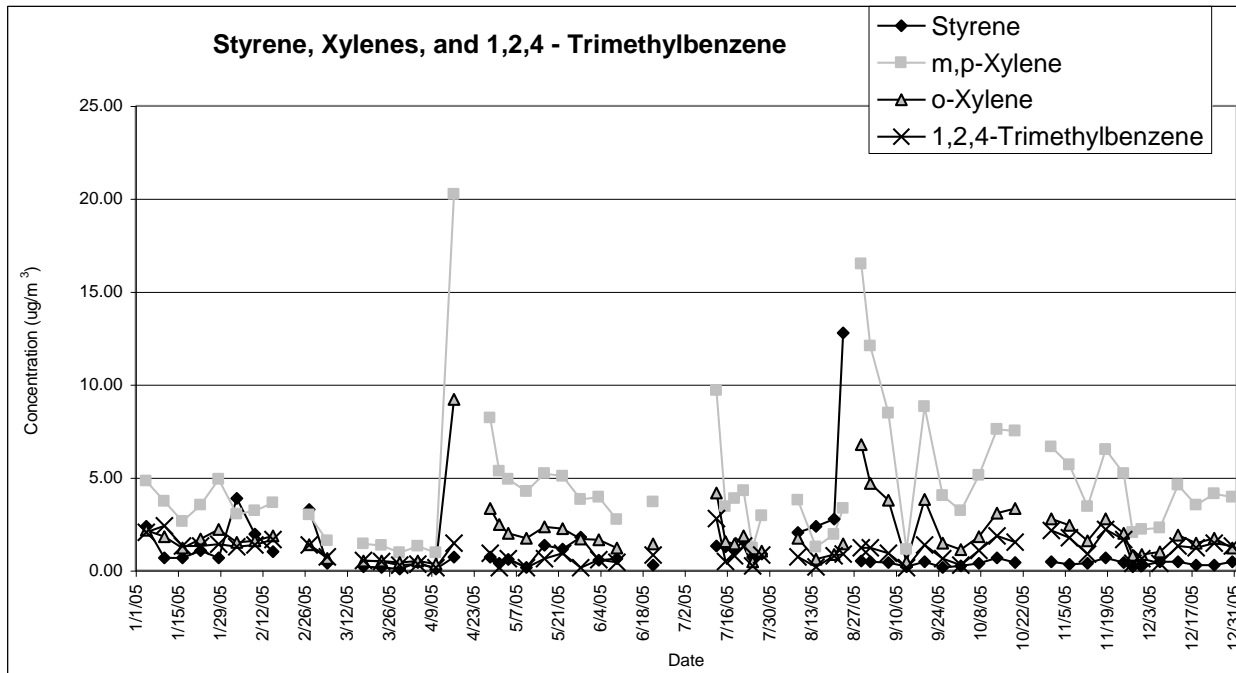


Figure 3.4 Trichlorofluoromethane, Chloromethane, and Dichloromethane

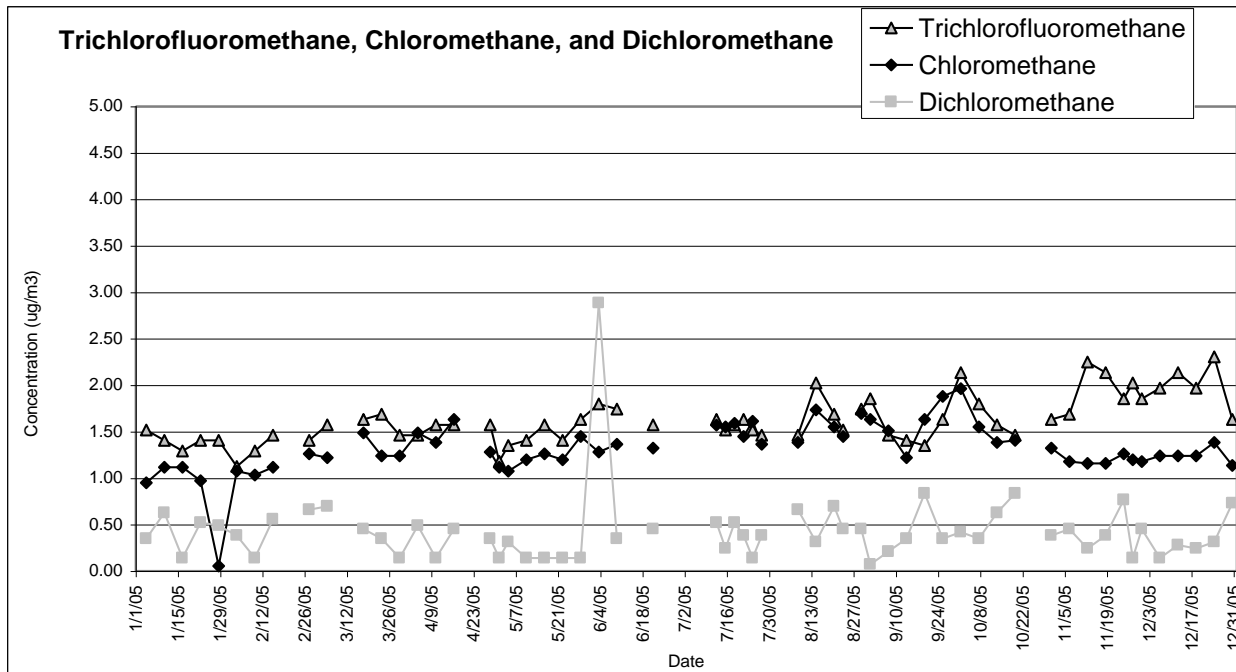


Figure 3.5 Acetonitrile

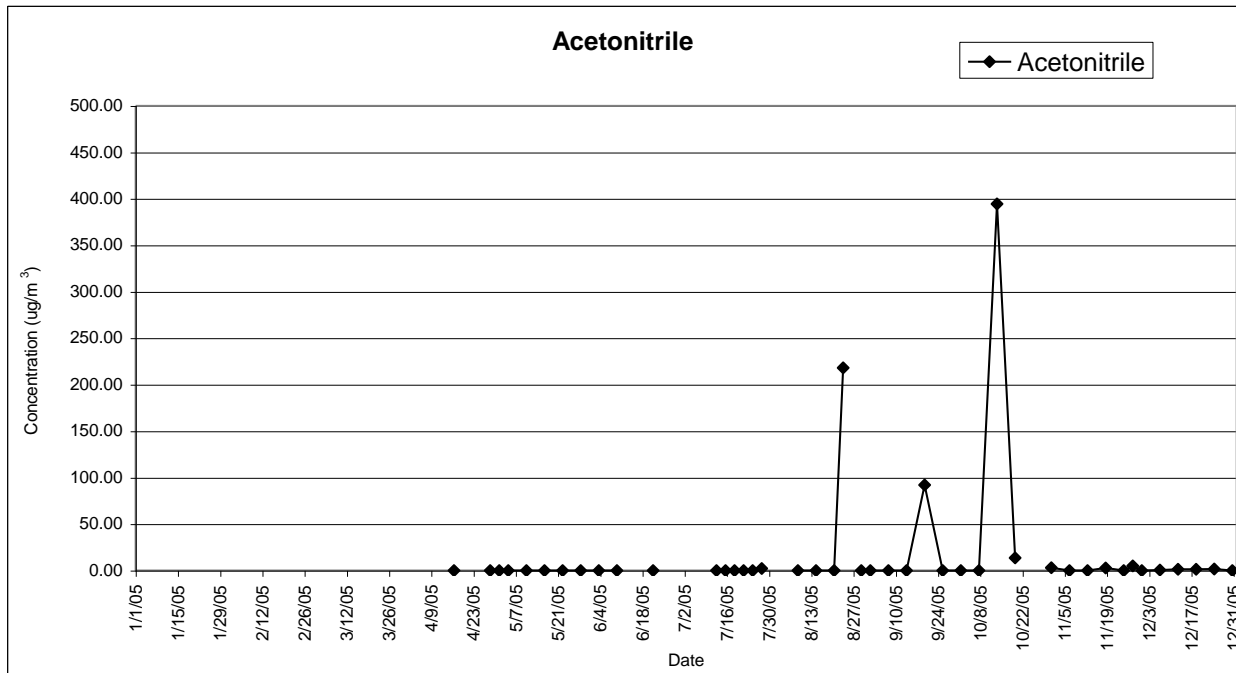


Figure 3.6 Acetylene and Propylene

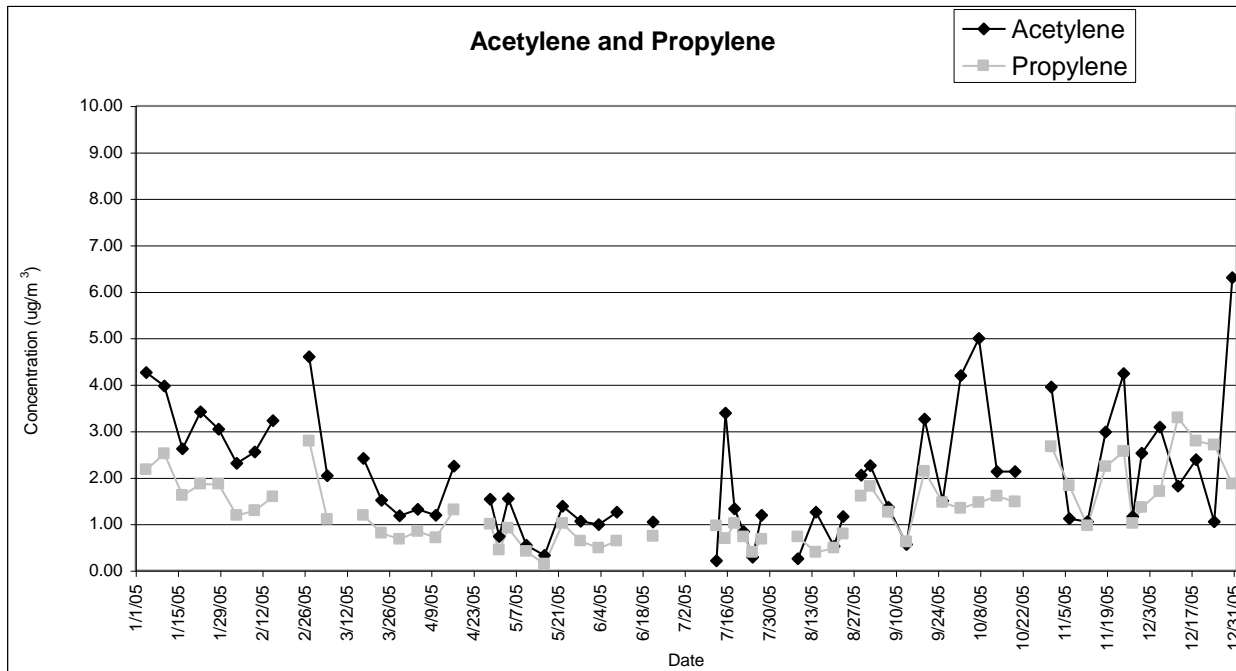
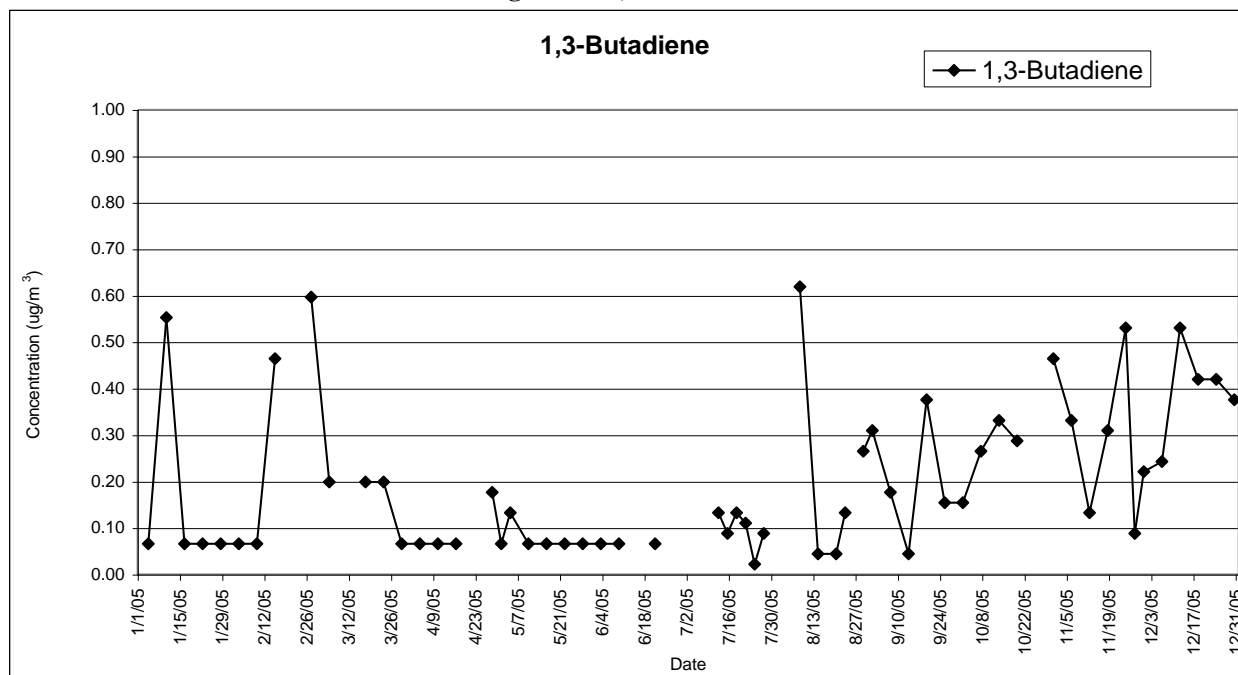


Figure 3.7 1,3-Butadiene



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 have similar trends. Figure 3.5 shows the acetonitrile peaks, which are still under investigation. In Figure 3.6, acetylene and propylene trend together. Figure 3.7 shows 1,3-butadiene. Although present in very small amounts, this compound is believed to be a significant component of the total cancer risk from airborne toxic compounds.

Precision of Sample Results – Volatile Organic Compounds

Every other month, 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. On the duplicate sampling dates, the laboratory also conducted a test of the precision on the duplicate samples by injecting two samples of each canister's air into the gas chromatograph/mass spectrometer. These samples are known as the laboratory replicates. This project collected these two types of precision data in order to assess both sampling and analysis procedures. 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. Occasional extra samples were taken on an every-third-day frequency, for a total of 66 samples attempted. Of these, 59 were recovered, for a percentage data recovery of 89.

During 2005, two metals samplers were used. For the first four samples of the year, a PM₁₀ high volume sampler took the samples. This was the same instrument used to collect the 2004 samples. In late January, a PM₁₀ low volume sampler was installed. The rest of the 2005 samples were taken with the low-volume model. This change was instituted as the high volume sampler filters had been showing contamination with chromium and nickel. The contamination was believed to have come from knives used to cut the filters at the factory. Therefore, the air toxics steering group recommended to switch to Teflon filters as a means of avoiding the metals contamination in the blank filters. This meant that a low volume sampler was required.

Table 4.1 Metals Sample Summary - 2005

Grand Junction – Powell Site	CAS Number	59 Samples Taken	
		Number of Samples Above Detection Limit	Percentage of Samples Above Detection Limit
Antimony	7440-36-0	38	64.4
Arsenic	7440-38-2	2	3.4
Beryllium	7440-41-7	18	30.5
Cadmium	7440-43-9	11	18.8
Chromium (total)	7440-47-3	59	100.0
Lead	7439-92-1	59	100.0
Manganese	7439-96-5	59	100.0
Nickel	7440-02-0	15	25.4

Table 4.1 shows the percentage of the samples in which each metal was detected. Chromium (total), lead and manganese were detected in all samples. Arsenic was rarely detected. Nickel, cadmium and beryllium were seen less than one-third of the time.

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 low concentrations.

Table 4.2 Metals Data Summary Comparisons 2004 - 2005

Grand Junction – Powell Site	CAS Number	2005 Statistics (µg/m ³)			2004 Statistics (µg/m ³)		
		Maximum	Mean	Average MDL	Maximum	Mean	Average MDL
Antimony	7440-36-0	0.00324	0.00134	.00074	0.0074	0.0004	0.0009
Arsenic	7440-38-2	0.00289	0.00213	.00422	0.0019	0.0003	0.00014
Beryllium	7440-41-7	0.00126	0.00091	.00146	ND**	ND	0.00016
Cadmium	7440-43-9	0.00353	0.00035	.00050	0.0010	0.0001	0.0007
Chromium (total)	7440-47-3	0.17206	0.03167	.00385	0.0137	0.0019	0.00036
Lead	7439-92-1	0.01179	0.00401	.00052	0.0112	0.0049	0.00012
Manganese	7439-96-5	0.03106	0.01199	.00072	0.0275	0.0130	0.00019
Nickel	7440-02-0	0.00298	0.00091	.00108	0.0069	0.0006	0.00017

The mean and MDL are bolded in cases where the annual mean was below the MDL.

** - Not Detected

There are a couple of points about Table 4.2 that can cause confusion. The first is that the “Average MDL’s” for 2005 are higher than the “Average MDL’s” for 2004. This was caused by the change in sampling method from the High Volume PM₁₀ sampler, to Low Volume PM₁₀ samplers. These sampling methods use different filter media and different air flow rates. The high volume samplers use a quartz filter medium that is 8 inches wide and 10 inches long (about the size of this piece of paper). The low volume samplers use a Teflon filter that is 47 mm in diameter (about the size of the lid on a jar of olives). The second major difference is in the amount of air that flows through the filter. The high volume sampler has an air flow through the filter of approximately 1000 liters per minute. The low volume sampler has an air flow of approximately 16.7 liters per minute. At first glance this does not seem like an improvement. However, it does offer a significant advantage: the Teflon filters are less subject to contamination of metals during the production and processing.

Another point to be aware of in this table is 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 detected only twice out of 59 samples. Beryllium was detected only 16 times out of 59 samples. Cadmium was detected only 11 times and nickel was detected only 15 times out of 59 samples.

Graphs – Metals

The metal compounds measured during the study are graphed in Figure 4.1. This figure shows that total chromium, lead, and manganese were the metals at highest concentration. Total chromium was higher in 2005 than in 2004. Perhaps this was due to the chromium contamination problem. However, these results suggest that blank variability is making it difficult to assess true concentrations of total chromium. In the 2004 blank data, total chromium was the only metal at detectable levels in the blanks, with one sample at 3.123 µg/filter. Chromium was not detectable for the other two 2004 blanks taken. In spite of a new sampling method in 2005, high blanks for total chromium still occurred.

Figure 4.2 shows that lead, manganese, and chromium were at low levels for most of the year. During the months of April, May, and June, total chromium peaked several times. The reason for these peaks are still under investigation. The April and May peaks coincided with high hexavalent chromium levels as well (Figure 5.2). This indicates that the levels are most likely real and not an artifact of sampling or analysis, since these two species of chromium are sampled and analyzed by separate methods.

Figure 4.1 Maximum and Annual Mean Metals - 2005

Grand Junction - Powell --- PM10 Metals
January 2005 - December 2005

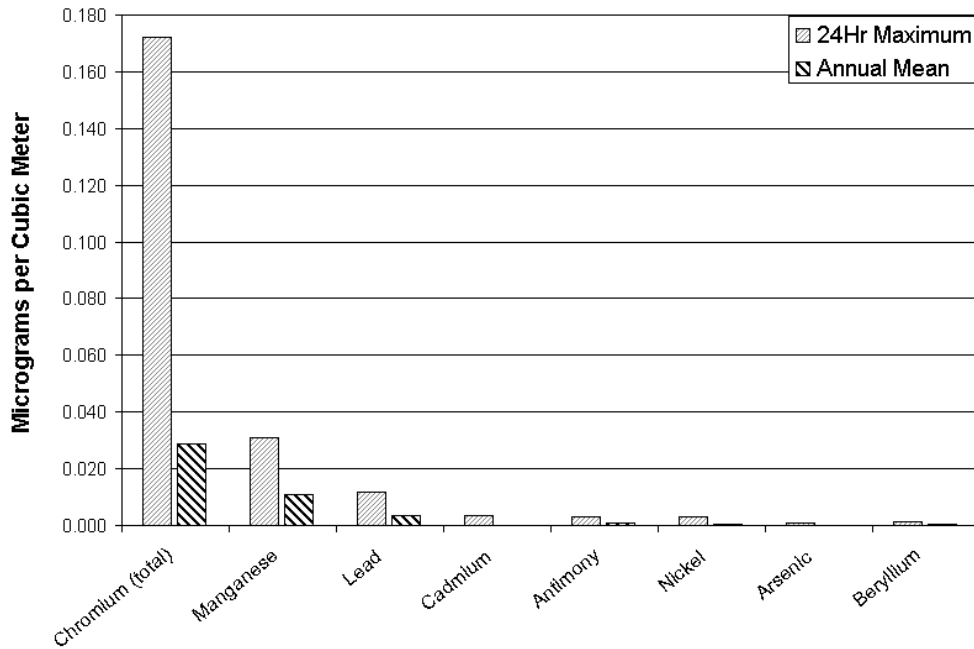
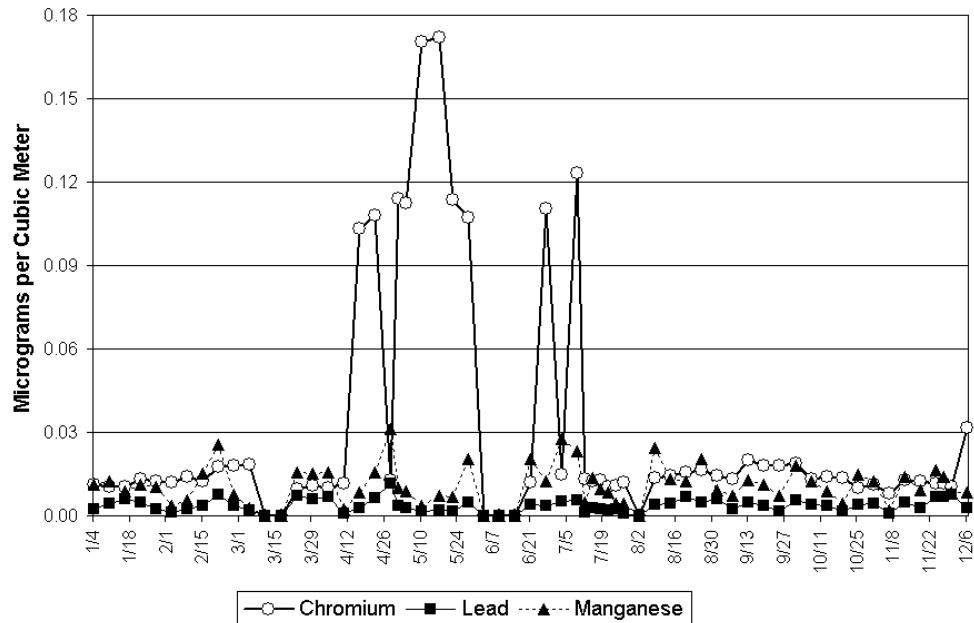


Figure 4.2 Total Chromium, Lead, and Manganese – 2005

Grand Junction Trends 2005 --- PM10 Metals



Precision of Sample Results – Metals Compounds

From January through September 10, 2005 a second PM₁₀ sampler was run simultaneously with the main one. These duplicates were taken on an every-twelfth-day schedule, or every other sample. From September 10, 2005 through the end of the year duplicate samples were taken on every sampling day. These duplicates, were collected in order to assess the precision (repeatability) of the metals sampling method. In general, duplicates for all compounds showed good agreement. The exceptions were 3 total chromium samples from March and June. These differences may be related to blank contamination.

Field Blanks – Metals Compounds

Twice a month the laboratory would analyze a “blank”, or unused, filter for metals. The purpose of this extra analysis was to determine if there was any contamination of the filter during manufacturing or during laboratory processing. In 2004, total chromium contamination was a problem for National Air Toxics Network samples. 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 2005 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 3.6 µg/filter.

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 2005 through December 2005 are presented in this section.

In early January 2005, a new hexavalent chromium sampler was added to the Grand Junction site. The technical steering committee made this decision for the National Air Toxics 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.

During the year-long period, hexavalent chromium was sampled on an every-sixth-day basis, with occasional extra samples on a every-third-day frequency, for a total of 66 samples attempted. Of these, 59 were recovered, for a percentage data recovery of 89.

Table 5.1 summarizes the annual maximum and mean concentrations for hexavalent chromium during the study. 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

Grand Junction – Powell Site	CAS Number	Maximum ng/m ³	Mean ng/m ³	59 Samples Taken		Minimum Detection Level ng/m ³
				Number Above Detection	Percentage Above Detection	
Hexavalent Chromium	1854-02-99	0.0952	0.0230	40	67.8	0.0173
Total Chromium	7440-43-3	172.1	31.7	59	100.0	0.0038

ng/m³ - nanograms per cubic meter

Percentage of Samples For Which Compound Was Detected

Hexavalent chromium was at detectable levels about two-thirds of the time. Total chromium (measured from the PM₁₀ filters) was always present.

Graphs – Hexavalent Chromium

Table 5.1 shows annual maximum and mean hexavalent chromium concentrations for 2005. The maximum of 0.095 ng/m³ was less than one-thousandth of the total chromium annual maximum of 0.172 µg/m³ shown in Section 4. The annual mean of 0.023 ng/m³ was a fraction of the total chromium annual mean of 0.032 µg/m³ shown in Section 4. This indicates that most chromium in Grand Junction air is not in the hexavalent form.

Figure 5.1 Average and Maximum Hexavalent Chromium– 2005

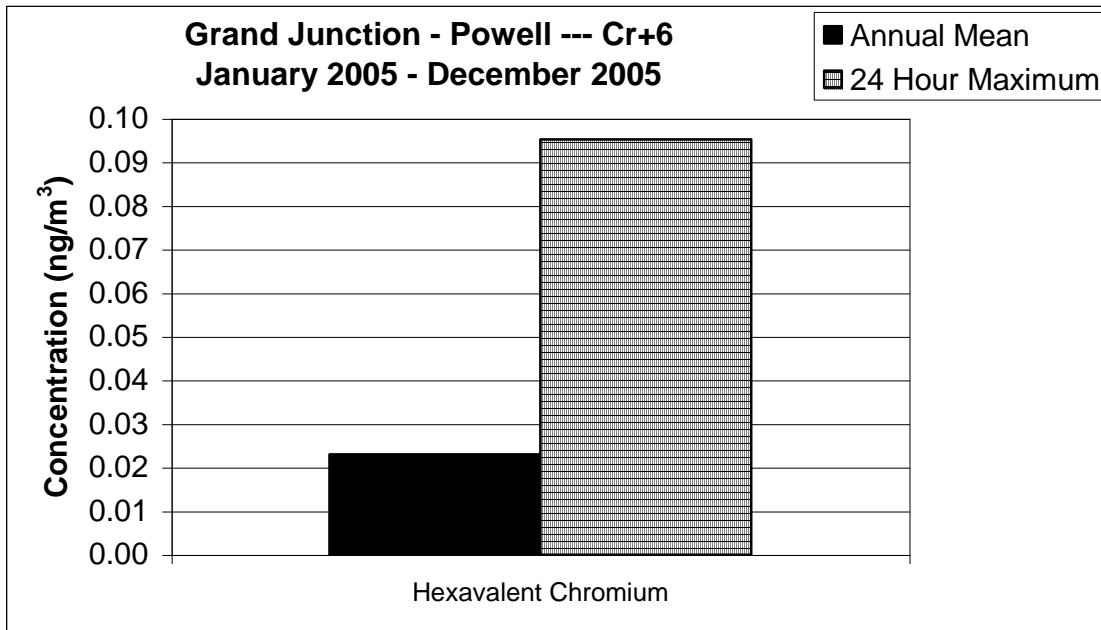
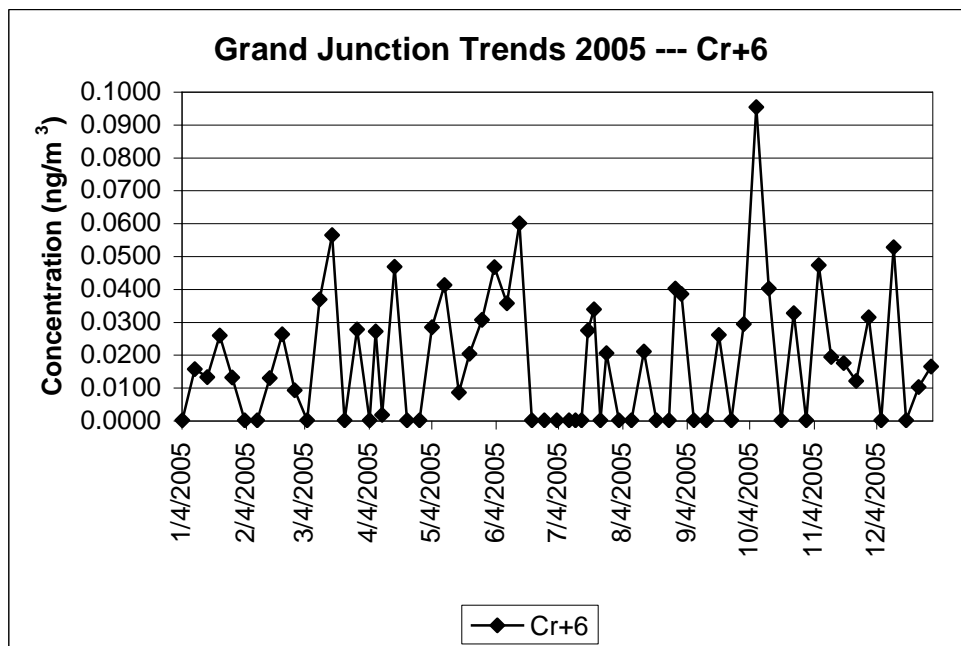


Figure 5.2 Daily Hexavalent Chromium – 2005



Precision of Sample Results – Hexavalent Chromium

Every other month a second hexavalent chromium sampler was run simultaneously with the main one. These additional samples were collected in order to assess the precision (repeatability) of the sampling method. In general, duplicates for four of the six duplicate dates showed good agreement.

Field Blanks – Hexavalent Chromium

Twice a month a filter was transported to the field, placed on a 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 23 field blanks taken, only one showed a detectable level 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

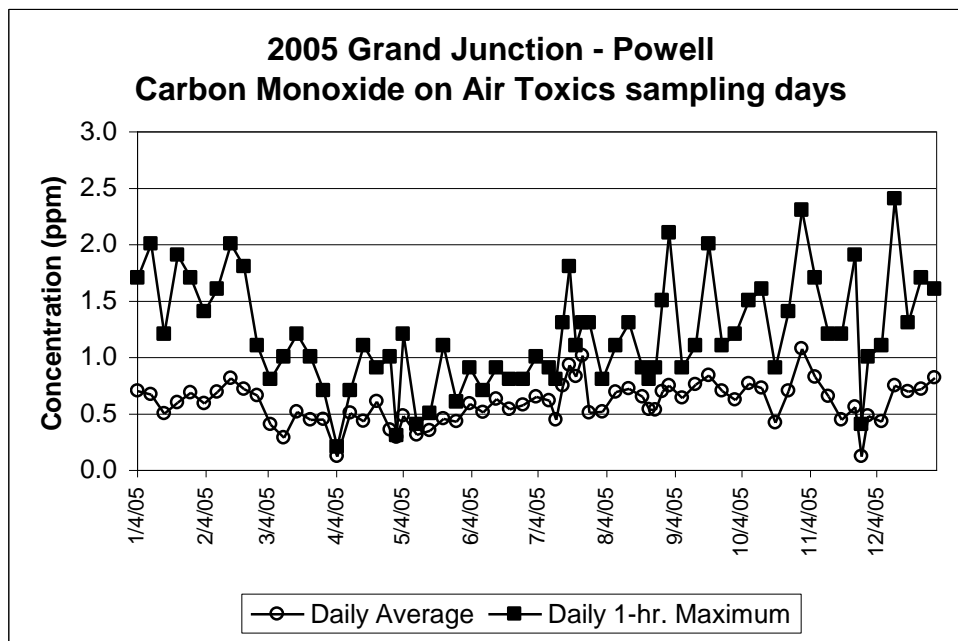
The Colorado Department of Public Health and Environment operates a carbon monoxide monitor at the Grand Junction – Powell station. This monitor was installed on January 29, 2004 as a part of the Colorado Department of Public Health & Environment's statewide air quality measurement network. Results of the statewide carbon monoxide monitoring network are discussed in "Colorado: 2005 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 - 2005

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	35	2.8	2.7	9	2.0	2.0

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). Compared to Table 6.1, this graph indicates that the air toxics sampling dates did not capture the dates with the worst carbon monoxide values. The daily averages of the air toxics sampling dates have values generally centering around 0.75 ppm, a bit lower than the mean for the complete record. 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 - 2005



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 station. These samplers serve to indicate the status of Grand Junction regarding the NAAQS for PM₁₀ and PM_{2.5}. Results of the statewide particulate matter monitoring network are discussed in “Colorado: 2005 Air Quality Data Report”, by the Air Pollution Control Division. Table 7.1 shows the percentage PM₁₀ data recovery for the year. This table combines four January samples from the high-volume PM₁₀ sampler with the rest of the year’s data from the low-volume PM₁₀ sampler. Table 7.2 shows the most recent annual PM₁₀ NAAQS statistics for this area. Figures 7.3 and 7.4 give the same information for PM_{2.5}. Grand Junction is well below the national air standards for particulate matter.

Table 7.1 Percentage Data Recovery for PM₁₀ Samples - 2005

Station	Samples Recovered	Sample Days Scheduled	Percentage Recovered
Grand Junction - Powell Site	110	124	88.7

Table 7.2 Data Summary for PM₁₀ Samples - 2005

Grand Junction – Powell Site	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	50	25.6	150	197.8 *	61.5

* This value occurred on April 19, 2005, as a result of a dust storm blowing from Arizona and Utah.

Note: This Table is based on all samples taken at the site, on an every-third-day schedule.

Table 7.3 Percentage Data Recovery for PM_{2.5} Samples - 2005

Station	Samples Recovered	Sample Days Scheduled	Percentage Recovered
Grand Junction - Powell Site	121	122	99.2

Table 7.4 Data Summary for PM_{2.5} Samples - 2005

Grand Junction – Powell Site	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}	15	8.36	65	18.2

Note: This Table is based on all samples taken at the site, on an every-third-day schedule.

Figure 7.1 PM₁₀ Data - 2005

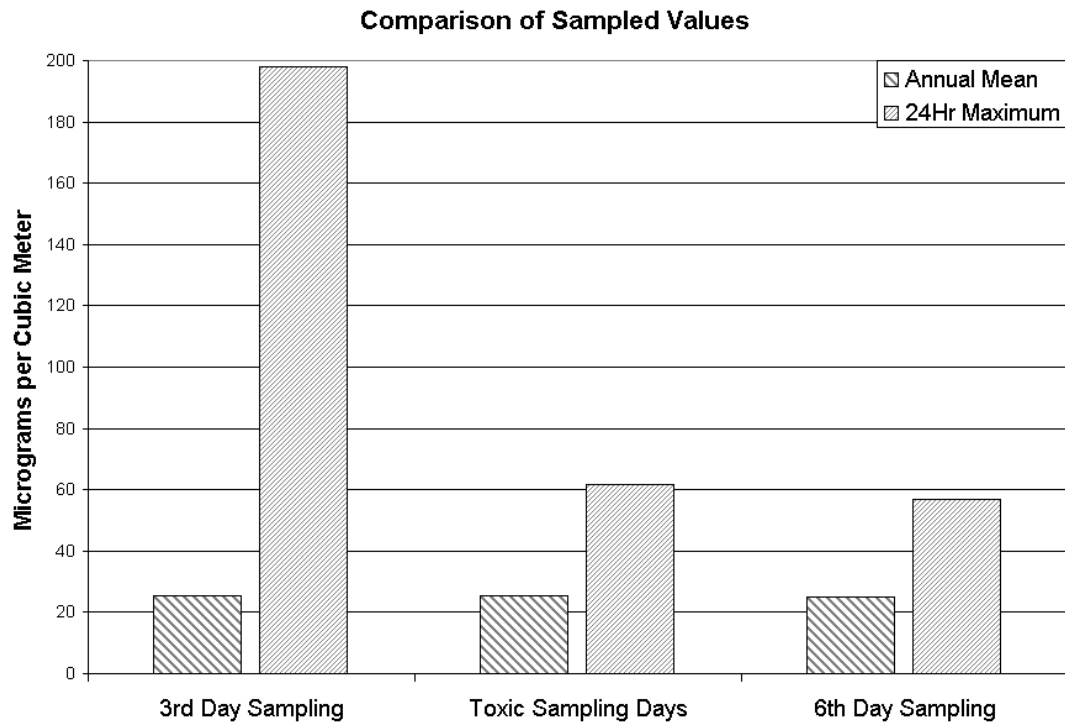


Figure 7.1 shows PM₁₀ statistics for all samples (every 3rd day schedule), samples taken on the EPA minimum-recommended schedule (every 6th day sampling), and for the samples taken on the EPA toxic sampling days schedule. The means calculated show little variation. The 24-hour maximum is more variable.

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.

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

Metal/Compound	Maximum (ug/m3)	Mean (ug/m3)
Antimony	0.05360	0.00593
Arsenic	0.00261	0.00039
Aluminum	0.16200	0.04426
Barium	0.04790	0.00940
Bromine	0.00572	0.00193
Cadmium	0.01750	0.00231
Calcium	0.21400	0.07572
Chromium (Total)	0.00723	0.00140
Cobalt	0.00164	0.00016
Copper	0.01070	0.00246
Cerium	0.11600	0.01245
Cesium	0.07250	0.00279
Europium	0.01190	0.00151
Gallium	0.00712	0.00070
Iron	0.24300	0.10279
Hafnium	0.01330	0.00128
Lead	0.01510	0.00296
Indium	0.01790	0.00166
Manganese	0.00703	0.00212
Iridium	0.00631	0.00064
Molybdenum	0.00642	0.00035
Nickel	0.00350	0.00058
Magnesium	0.08970	0.00660
Mercury *	0.00991	0.00155
Gold	0.00876	0.00055
Lanthanum	0.04180	0.00806
Niobium	0.00419	0.00027
Phosphorus	0.01670	0.00130
Selenium	0.00339	0.00096
Tin	0.02470	0.00400
Titanium	0.03050	0.00896
Samarium	0.01280	0.00164
Scandium	0.00163	0.00015
Vanadium	0.00700	0.00131
Silicon	0.58200	0.18672
Silver	0.01720	0.00209
Zinc	0.08110	0.01287
Strontium	0.00365	0.00121
Sulfur	0.56500	0.25857
Tantalum	0.00956	0.00091
Terbium	0.02230	0.00429
Rubidium	0.00234	0.00036
Potassium	0.18500	0.06829
Yttrium	0.00326	0.00046
Sodium	0.27200	0.01491
Zirconium	0.00616	0.00113
Tungsten	0.00991	0.00128
Organic Carbon	9.80000	4.38741
Elemental Carbon	2.32000	0.78429
Nitrate	4.18000	0.77679
Ammonium	1.31000	0.42124
Sodium Ion	0.15000	0.02997
Potassium Ion	0.14700	0.03035

Metal/Compound	Maximum (ug/m3)	Mean (ug/m3)
Sulfate	1.88	0.77502

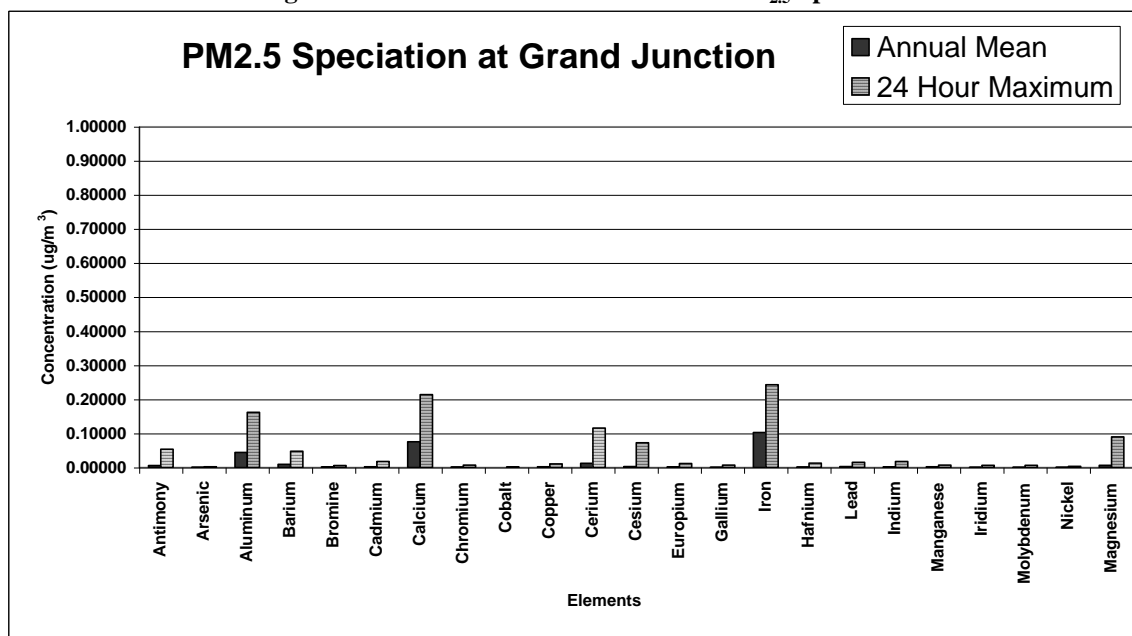
* Mercury is highly volatile. Therefore, the use of filter sampling methods likely underestimates ambient concentrations.

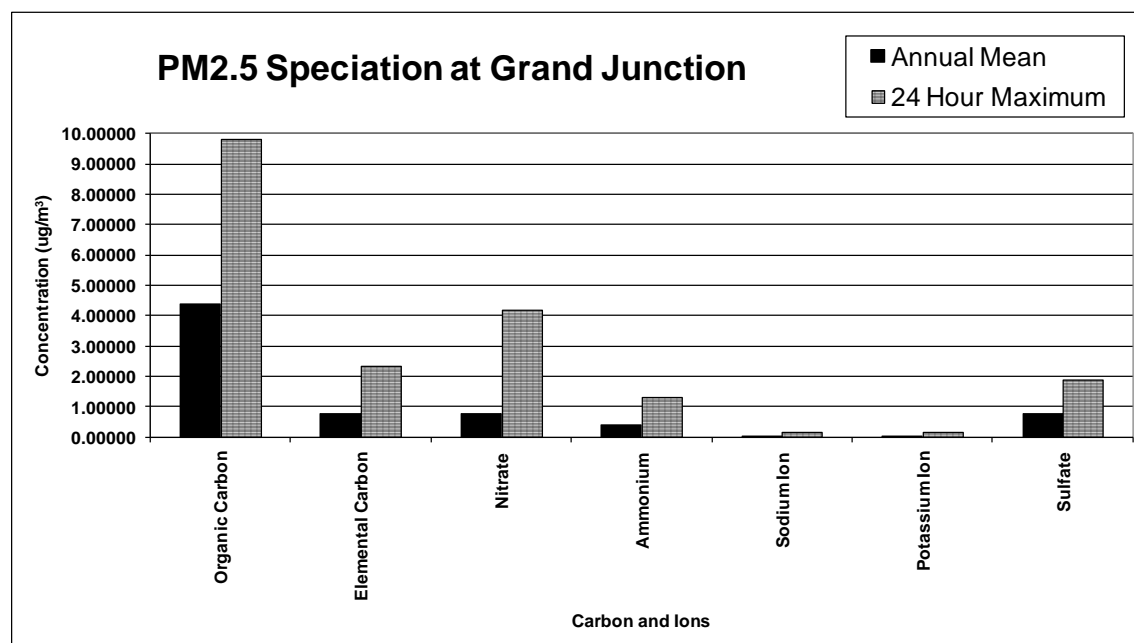
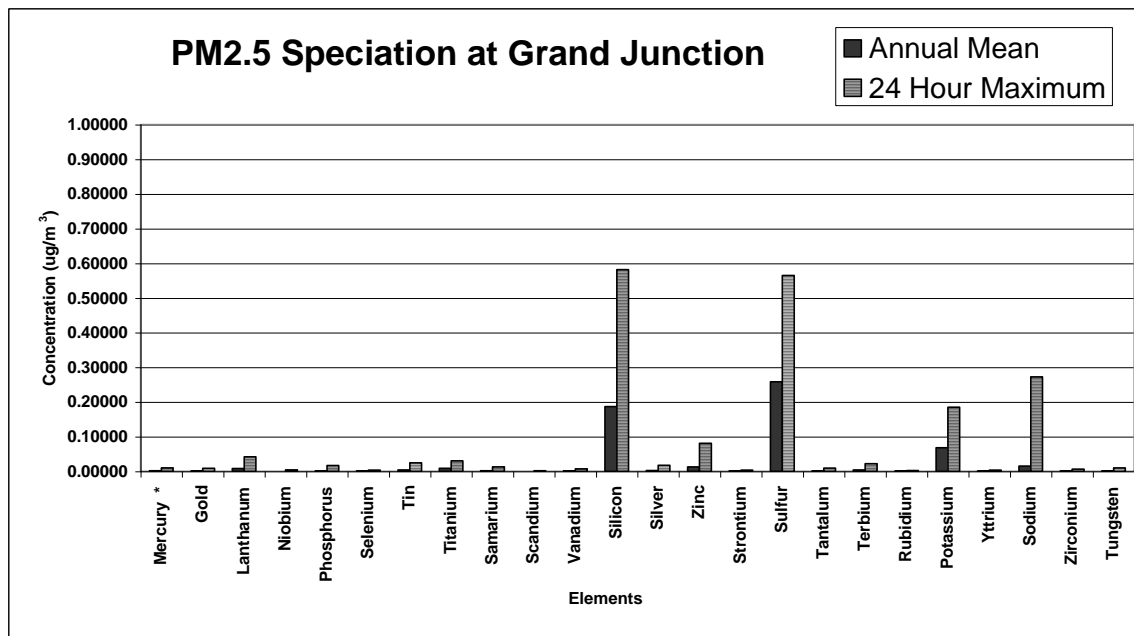
Graphs – PM_{2.5} Speciation Data

Graphs of mean and maximum concentration for various elemental species indicate that those with the highest concentrations were aluminum, calcium, iron, silicon, sulfur, cesium, and sodium. These elements are all present in the earth's crust, which suggests that wind blown dust is an important component of PM_{2.5} at this location. The reason for higher maxima for cesium is not known. This element has both naturally-occurring, non-radioactive forms (in minerals), and man-made, radioactive forms (from nuclear power plants and atmospheric fallout from nuclear weapons testing).

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).

Figure 8.1 Maximum and Annual Mean PM_{2.5} Speciation - 2005





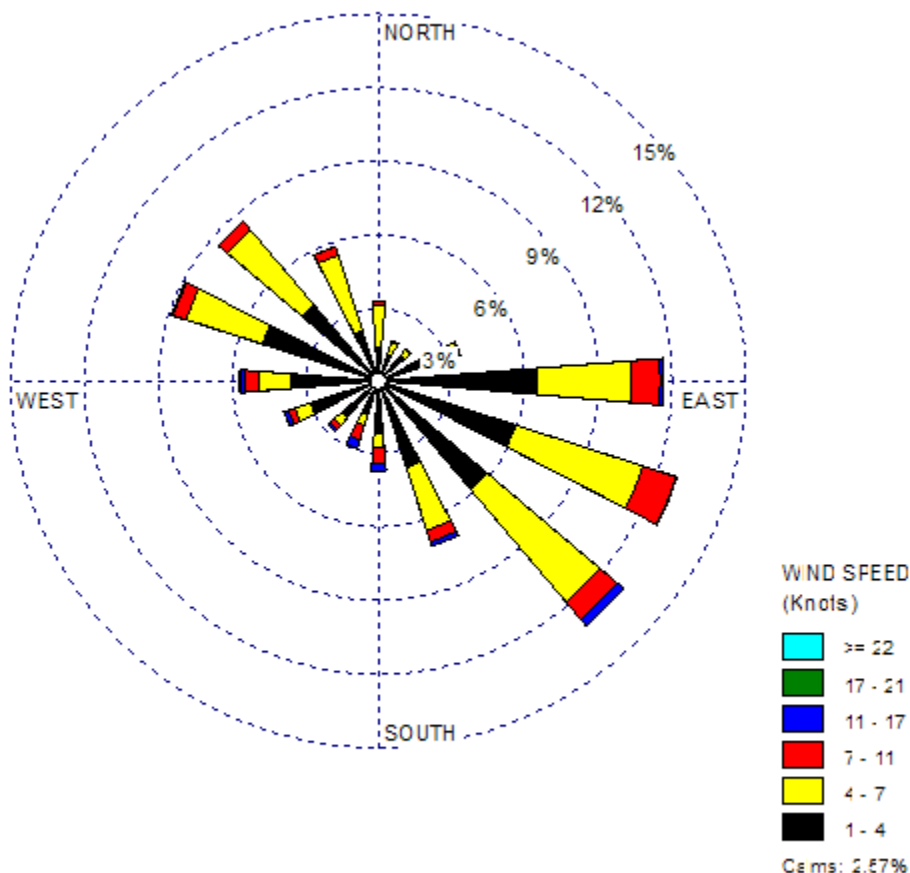
Section 9: Meteorology

Meteorological Parameters Monitored

A meteorological tower at the Pitkin shelter site measures wind speed, wind direction, relative humidity and temperature. The year 2005 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 9% of the winds are from the west-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 the “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.



Section 10: Summary and Conclusions

The National Air Toxic Trends Study in Grand Junction for 2005 demonstrated that the improved, lower detection limits for carbonyls and VOCs did not result in a greater number of compounds detected. However, it did confirm the reduction of these compounds that has taken place since the 2001-2002 Pilot Study.

Levels of acetaldehyde and acetone did decrease from the 2004 study by more than 80 percent for the daily maximums and more than 40 percent for the annual means. Formaldehyde maximums declined 70 percent and the annual mean declined 10 percent for the same period. The highest daily concentration for any air pollutant can vary dramatically from year to year, due to changes in weather patterns. Therefore, annual 24 hour maximums do not have a great deal of significance in the determination of long-term trends. However, changes in annual average concentrations are significant. These declines in annual average acetaldehyde and formaldehyde concentrations may be related to improvements in automobile emission controls. Better emission controls lead to steady air quality improvement, as older cars leave the road and are replaced by cleaner models.

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. The comparison of the annual means and 24 hour maximums suggest that the hexavalent form of chromium is less than one-thousandth of the total chromium concentration. This relationship will need additional study to confirm.

A look at the highest concentration days for each pollutant indicated that the “high” days for each compound were not the “high” days for the other compounds. An exception was July 21, 2005, which was high for PM_{10} , $\text{PM}_{2.5}$, and carbonyls. The reason for this is not known.

This study is expected to continue for a number of additional years. Results from subsequent years will be available in separate reports.

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 Website, 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, Vol 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 2005 mean observed in this Grand Junction study, 1.7 ppb, is a bit above the California data, but acetaldehyde in Grand Junction occurs at levels typical of large urban areas. Acetaldehyde levels are therefore 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 2005 was 0.08 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 those used for "permanent press" clothes, contain formaldehyde (Kirk-Othmer, Vol 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 EPA IRIS 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 2005, 2.5 ppb, is within the "suburban" range.

Volatile Organic Compounds

Volatile organic compounds that are potential risk drivers include acetonitrile, acrolein, 1,3 – butadiene, benzene, carbon tetrachloride, 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 annual mean of 10.2 ppb at Grand Junction is a bit above the normal range.

Acrolein

Acrolein is a hydrocarbon compound with the formula $\text{CH}_2=\text{CH}-\text{CHO}$. 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 this study, 0.4 ppb, is a bit higher than the urban number.

Benzene

Benzene is a hydrocarbon compound with the formula C_6H_6 . 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^\cdot) 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 2005 mean of 0.6 ppb observed in this study is somewhat lower.

1,3-Butadiene

1,3-Butadiene is a hydrocarbon compound with the formula C_4H_6 . 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 2005 at Grand Junction - Powell is 0.09 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 2005 observed at Grand Junction – Powell is at the same level.

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 2005 annual mean at Grand Junction - Powell was 0.04 ppb. These levels are greater than the network-wide mean value for California. However, this compound was detected less than half the time.

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. It damages 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. It also irritates 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 mean value of 0.21 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 2005 was 0.07 ppb.

Metals

Arsenic, chromium, and manganese are discussed below. Levels of lead observed in Grand Junction were below the Colorado state standard of $1.5 \mu\text{g}/\text{m}^3$ for a monthly 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 an 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). The 2005 mean level of 0.002 $\mu\text{g}/\text{m}^3$ at Grand Junction – Powell site falls within the cited rural range. 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, woodburning, 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 total chromium annual means measured at two Grand Junction sites in 2000 – 2001 are close to the California results. For 2005, the Grand Junction site had a mean of 0.032 $\mu\text{g}/\text{m}^3$ total chromium, and 0.023 ng/m^3 hexavalent chromium. This means that hexavalent chromium levels are considerably lower than the 3-8% fraction California estimated.

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 µg/m³ total manganese (CARB Fact Sheet on Manganese). The 0.012 annual mean for 2005 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

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

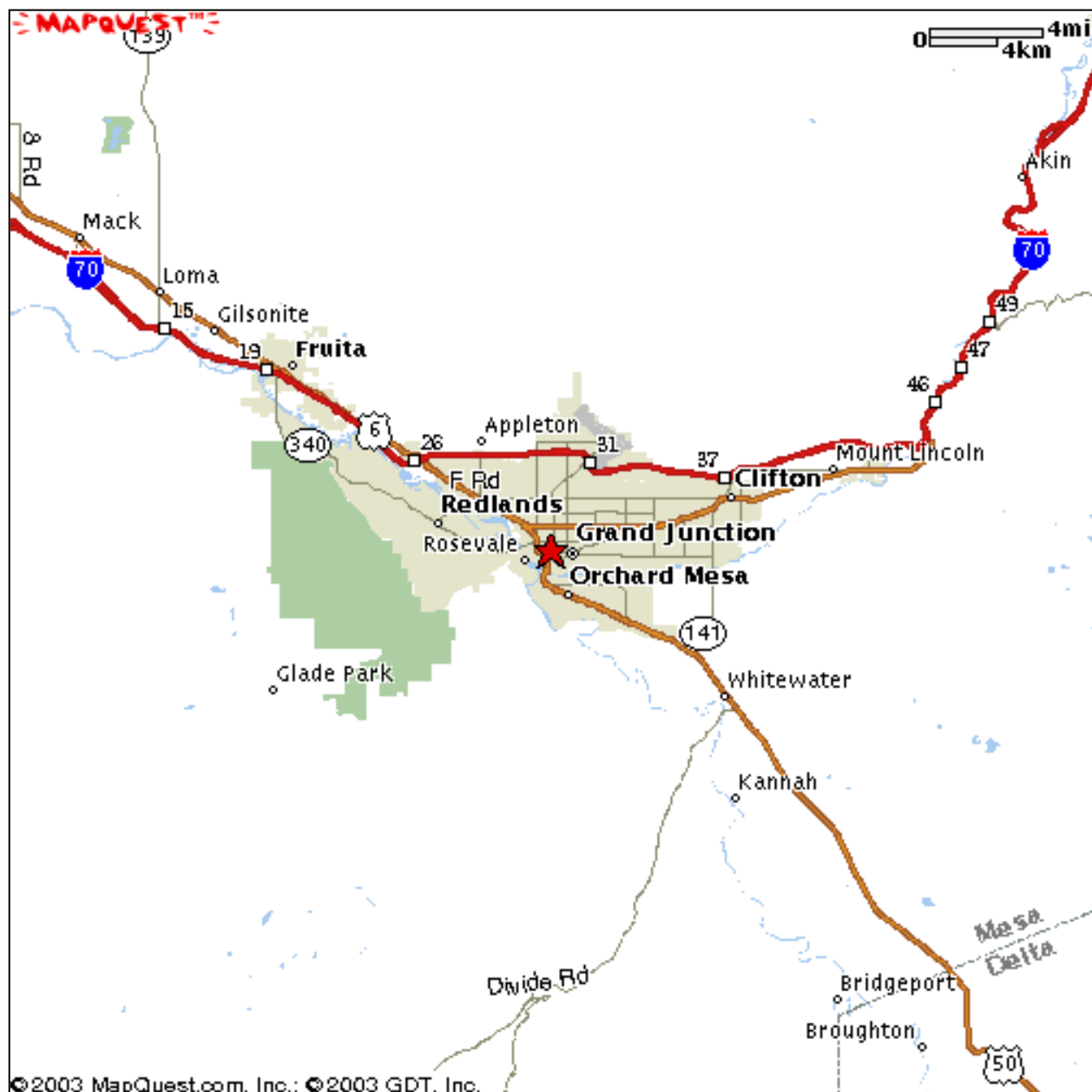
AQS ID: **08-077-0018** Site Name: **Grand Junction – Powell/ Pitkin (shelter)**

645 ¼ Pitkin Avenue, Grand Junction, CO 81501

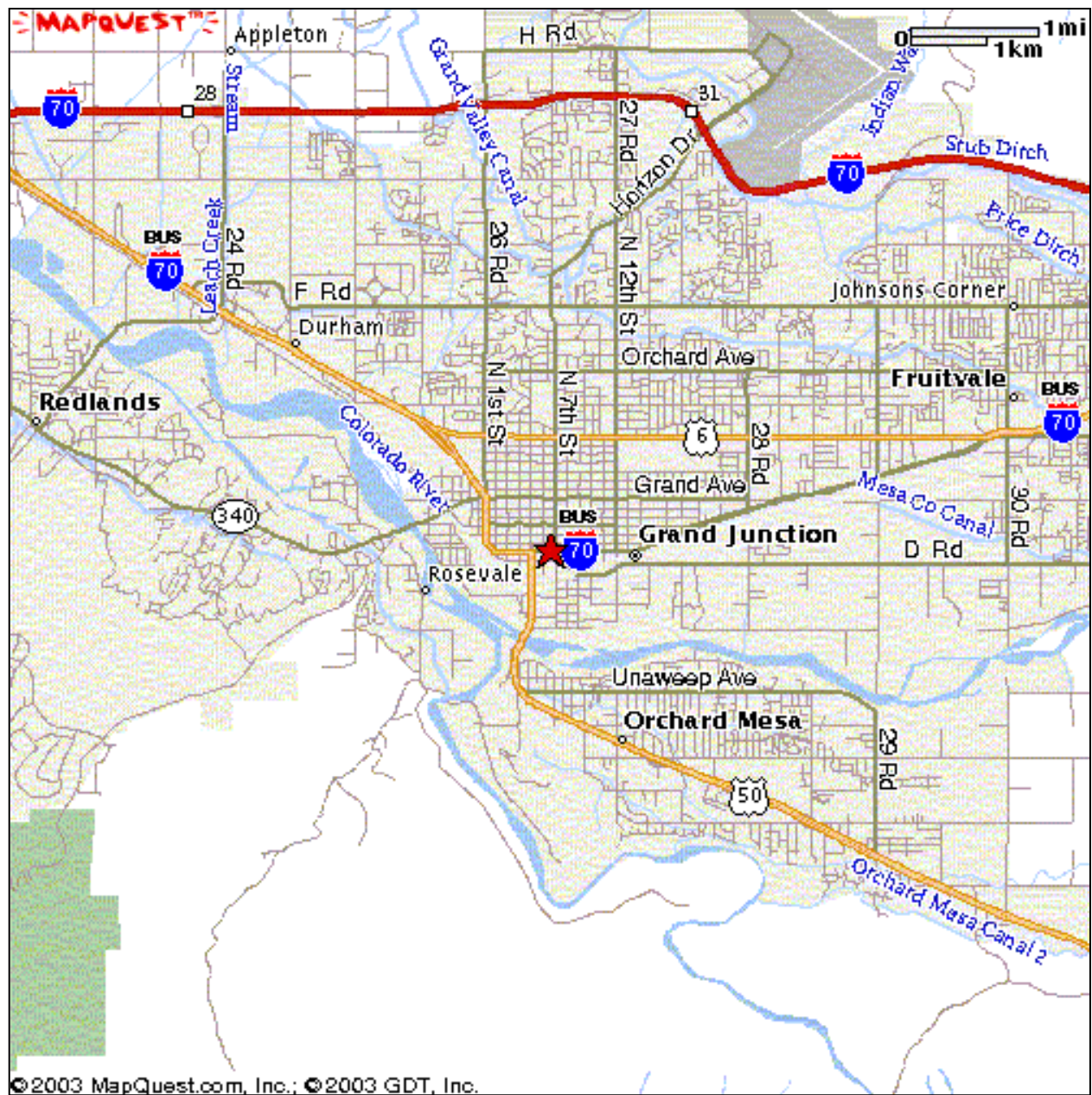
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39° 03' 51" N, 108° 33' 42" W

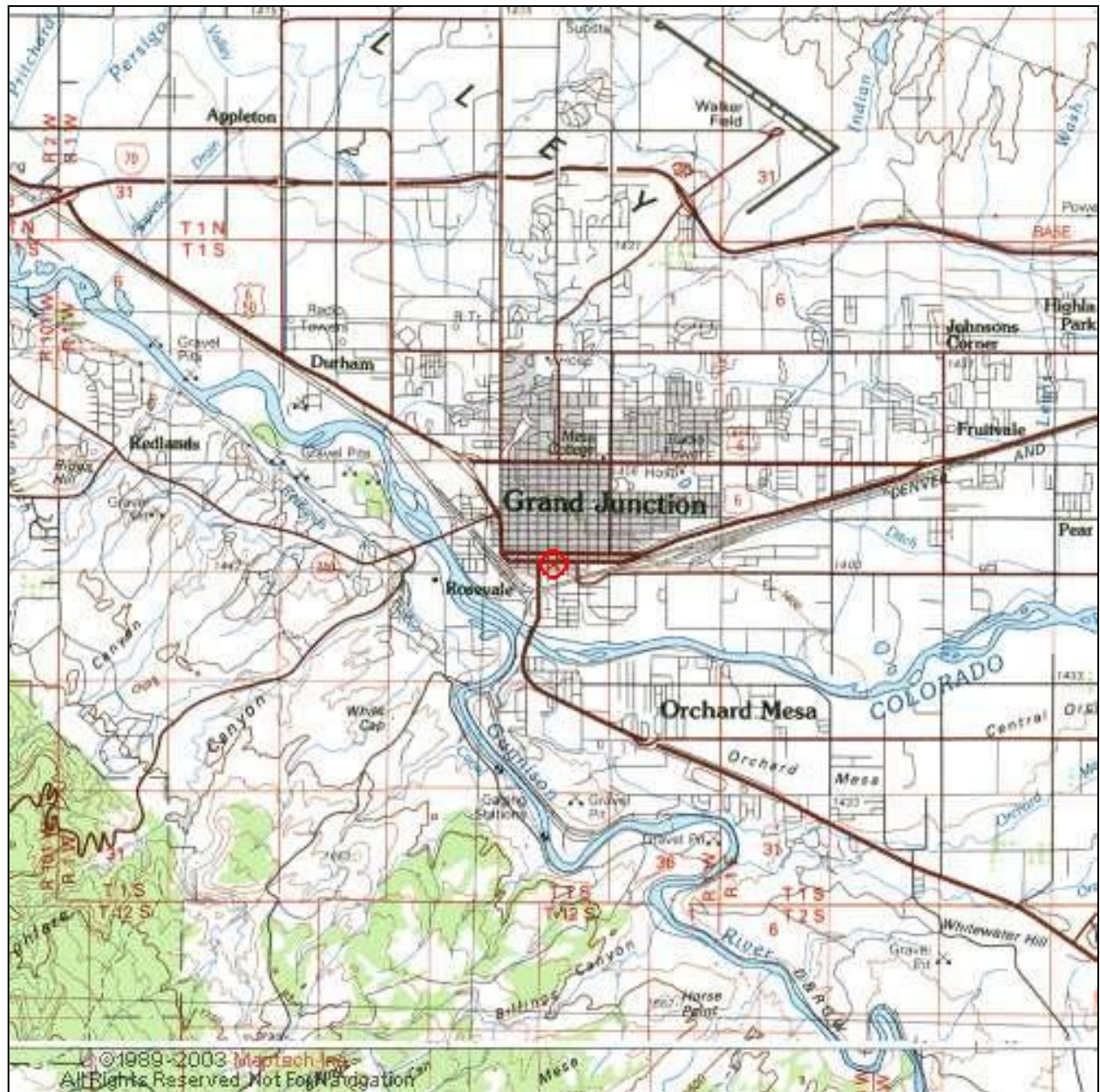
REGIONAL MAP (5 - 30 miles)



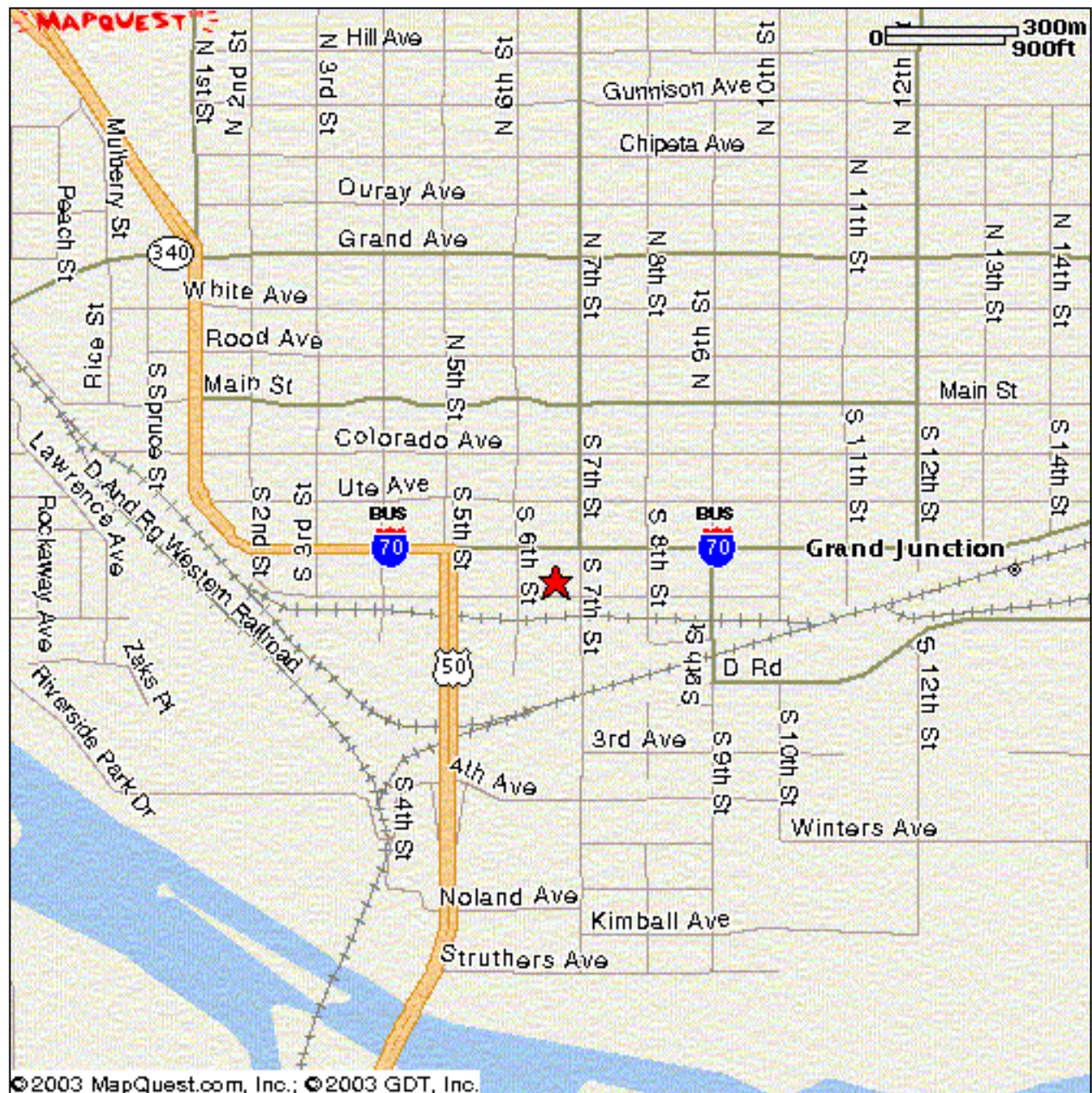
REGIONAL MAP (5 - 30 miles)



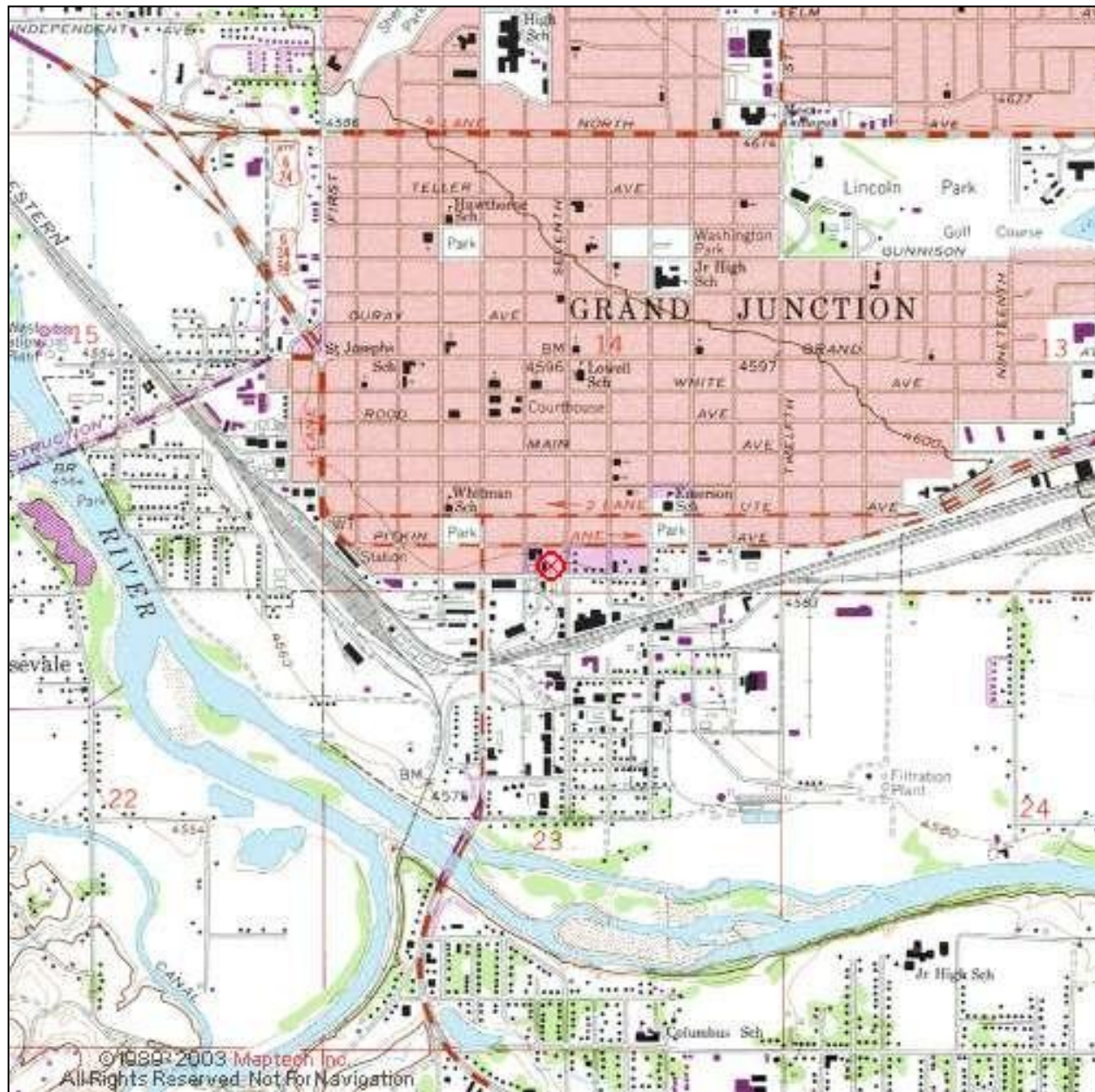
REGIONAL MAP (5 - 30 miles)



SITE MAP (1/4 - 1 mile)



SITE MAP (1/4 - 1 mile)



AQS ID: 08-077-0017

Site Name: Grand Junction – Powell Building



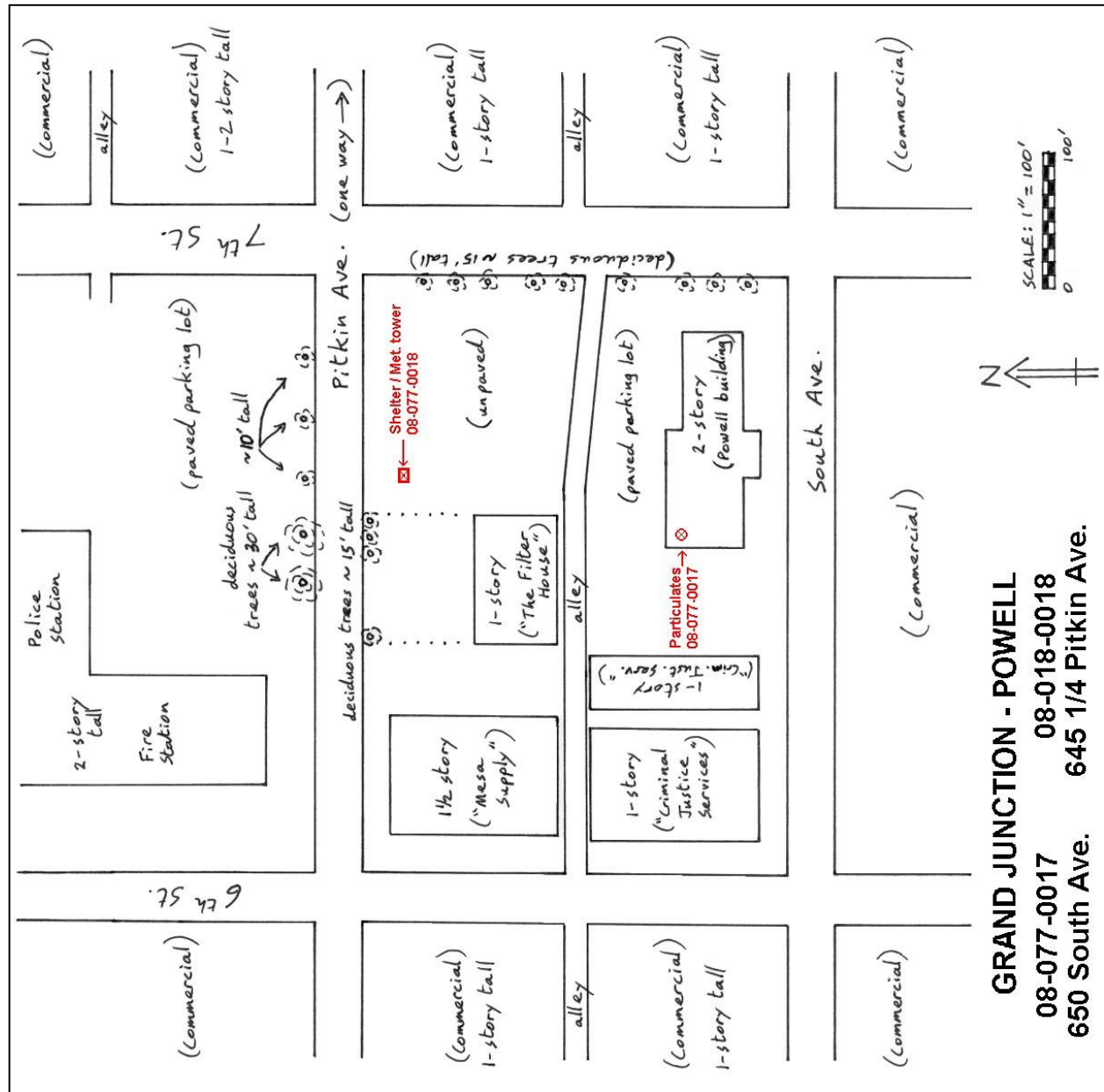


AQS ID: 08-077-0018

Site Name: Grand Junction – Powell (shelter)



SITE MAP (1/4 - 1 mile)



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



AQS ID: 08-077-0017

Site Name: Grand Junction – Powell Building

Photo Date: 01/21/2004

Looking NORTH



Looking NORTHEAST



AQS ID: **08-077-0017**

Site Name: **Grand Junction – Powell Building**

Photo Date: 01/21/2004

Looking EAST



Looking SOUTHEAST



AQS ID: **08-077-0017**

Site Name: **Grand Junction – Powell Building**

Photo Date: 01/21/2004

Looking SOUTH



Looking SOUTHWEST



AQS ID: **08-077-0017**

Site Name: **Grand Junction – Powell Building**

Photo Date: 01/21/2004

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



AQS ID: **08-077-0018**

Site Name: **Grand Junction – Powell (shelter)**

Photo Date: 01/21/2004

Looking NORTH



Looking NORTHEAST



AQS ID: **08-077-0018**

Site Name: **Grand Junction – Powell (shelter)**

Photo Date: 01/21/2004

Looking EAST



Looking SOUTHEAST



AQS ID: **08-077-0018**

Site Name: **Grand Junction – Powell (shelter)**

Photo Date: 01/21/2004

Looking SOUTH



Looking SOUTHWEST



AQS ID: **08-077-0018**

Site Name: **Grand Junction – Powell (shelter)**

Photo Date: 01/21/2004

Looking WEST



Looking **NORTHWEST**





**Colorado Department
of Public Health
and Environment**