Urban Air Toxics Concentrations In Grand Junction

May 2001 through April 2002

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Prepared by the

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

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Executive Summary

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This report discusses results for ambient air toxics monitoring conducted at two locations in Grand Junction during the period May 2001 through April 2002. As part of the Environmental Protection Agency's (EPA) Urban Air Toxics Pilot Project (UATPP), twenty-four hour long samples were collected on a once every six day basis for over a year. Sampling occurred at two locations in Grand Junction. The Mesa County Health Department (MCHD) site was at 515 Patterson Road. The Traffic engineering department (Traffic) site was at 925 Fourth Avenue. Samples were taken with equipment provided by Eastern Research Group (ERG), a consulting firm contracted by EPA to provide support to the national network. The ERG samplers collected two different types of samples. A dinitrophenyl-hydrazine (DNPH) cartridge collected carbonyl samples by EPA Method TO-11A. DNPH cartridges were analyzed for twelve different carbonyls. Air was also drawn into a stainless steel canister. The canisters were analyzed for 58 volatile organic compounds (VOCs) by EPA method TO-15. In addition, High Volume samplers collected Total Suspended Particulate matter samples that were analyzed for eleven different metals. Thus, the total number of chemical compounds assessed is 81. Of the 81 chemicals assessed, 22 were never measured above the method detection limit. Nine others were detected less than 10 % of the time.

Three carbonyls were present in all samples at both sites, with annual mean concentrations greater than one part per billion. These are formaldehyde, acetaldehyde, and acetone. The other carbonyls were present in smaller amounts, and showed strong correlation to these three main ones. Formaldehyde and acetaldehyde are present at levels higher than the "EPA benchmark" goal, which is to maintain the cancer risk level from each compound at less than one in a million excess cancer cases. Automobiles are believed to be the largest emission source for these aldehydes, either as direct emissions, or as compounds forming from photochemical reactions. The impacts from aldehydes are difficult to control, because they can form as hydrocarbons emitted from automobiles and industrial processes that react in the presence of sunlight. Analysis of results from the EPA national Urban Air Toxics Network indicates that formaldehyde, acetaldehyde, and acetone are problems on a nationwide scale. Thus, the situation in Grand Junction is typical of most American cities.

For the volatile organic compounds, acetylene, toluene, and m,p-xylenes were present at both sites, with annual means greater than one part per billion. These compounds were detected over 98 % of the time, at both monitoring locations. Compounds with annual means above their EPA "benchmark" concentrations, indicating greater than a one in a million risk of cancer, were 1-3 butadiene, benzene, and carbon tetrachloride. These compounds were present in more than 80 % of the samples taken. Results from EPA's national network indicate that these three are also a problem on a nationwide scale. 1-3 butadiene and benzene are believed to result from automobile emissions, while carbon tetrachloride is an industrially-emitted compound. Acetylene appears to be from a localized source, such as the hospital next to the MCHD site.

Some other VOCs were present on a more localized basis, appearing at one site, but less often at the other. These are likely emitted from local industrial operations. Acetonitrile was more common at MCHD than at the Traffic site. Conversely, acrylonitrile detections only occurred at the Traffic site. Ethyl acrylate and 1,1,2,2-tetrachloroethane were detected a single time at Traffic, but never at MCHD. Results of the single detections, with one-half the detection level substituted for the non-detects, seem to imply that ethyl acrylate and 1,1,2,2-tetrachloroethane are present at levels above their EPA "benchmark" concentrations, with a greater than one-in-a-million risk of cancer. However, the fact that only one detection occurred makes this calculation highly uncertain for these two compounds.

Tetrachloroethylene, or perchloroethylene, occurred at both sites, just under 40 % of the time. Concentrations suggest that this compound, used in dry cleaning, presents a greater than one-in-a-million risk of cancer. These results are consistent with EPA's national analyses, which indicate that levels of tetrachloroethylene are of concern in urban areas throughout the United States. p-Dichlorobenzene occurred less than 10 % of the time at the two sites, but annual averages calculated indicate this compound may be a concern. Unlike many of the others discussed, this one appears to be a local problem. However, the fact that concentrations are detected infrequently adds uncertainty to the risk calculation.

For the metals, almost every sample had very low, but measurable, levels. Mercury was an exception, as it was detected only once during the study. However, mercury is a volatile compound, and the study used a filter-

based sampling method. Thus, the lack of mercury detections is possibly due to limitations in sampling methodology, and the true levels are not known. Lead was the metal detected at the highest concentrations. However, lead levels were well below the standards of 1.5 micrograms per cubic meter, as a monthly (Colorado standard) or a quarterly (federal standard) average. Arsenic, a known carcinogen, was present at levels greater than the EPA "benchmark" for a one-in-a-million risk of cancer. However, the levels of arsenic detected were low, were typical of other cities in Colorado, and were similar to other national air toxics monitoring sites. Chromium results also exceeded the EPA benchmark for hexavalent chromium. However, the sampling method was unable to distinguish between hexavalent chromium, which is known to cause cancer, and trivalent chromium, which is not believed to cause cancer. Thus, the assumption that all the chromium measured was in the carcinogenic form probably overestimates the risk. The Environmental Protection Agency is considering a new analytical method for the network, which will allow more accurate measurements of hexavalent chromium. Manganese levels at the Traffic site were just below the EPA threshold for health effects not involving cancer. This is believed to be related to a localized source.

In conclusion, a number of compounds related to vehicular emissions are present in Grand Junction air, at levels which may present a concern. These are formaldehyde, acetaldehyde, benzene, and 1,3-butadiene. Carbon tetrachloride and tetrachloroethylene, which are from industrial sources, also may be a concern. These six compounds appear to be at problem levels throughout the urban areas of the United States. Arsenic, chromium, and manganese may also be of concern, but appear to be from localized sources. Acrylonitrile and acetonitrile occur sporadically and locally. Less certain are results for ethyl acrylate and 1,1,2,2-tetrachloroethane, which were detected only once during the study.

It should be noted that there are a number of limitations with the health risk conclusions in this study. The study represents only the central area of Grand Junction. The cancer risk values assume that an individual is exposed to these levels for an entire lifetime (70 years). The non-cancer health risk values are uncertain, because EPA has not calculated risk levels for short-term health effects. The 24 hour long averaging period used for sampling may not capture high levels of chemicals that occur on a very short-term basis. Finally, the cancer risk levels calculated represent an increase over the "background level" cancer risk in society. For people in the United States, the risk of contracting cancer is between one in two and one-in-three. The Environmental Protection Agency, as a policy decision, has set the goal that no one chemical present in air should contribute to this overall 0.33 – 0.50 cancer risk by more than one-in-a-million (.000001). Calculations in this report use EPA's most recent, best estimates of a one-in-a-million risk level for each chemical compound. However, EPA's risk estimates, as well as actual concentrations of chemicals in the air, change over time. Therefore, this study is best viewed as a "snapshot" in time, indicating which chemicals should be the focus of state or federal regulatory action. Results of the study indicate that the main chemicals of concern in Grand Junction air are the same as the ones upon which EPA is focusing nationally.

Section 1 - Introduction

Introduction

This report discusses results for ambient air toxics monitoring conducted at two locations in Grand Junction during the period May 2001 through April 2002. As part of the Environmental Protection Agency's (EPA) Urban Air Toxics Pilot Project (UATPP), twenty-four hour long samples were collected on a once every six day basis for over a year. Samples were taken with equipment provided by Eastern Research Group (ERG), a consulting firm contracted by EPA to provide support to the national network. The ERG samplers collected two different types of samples. A dinitrophenylhydrazine (DNPH) cartridge collected carbonyl samples by EPA Method TO-11A. DNPH cartridges were analyzed for twelve different carbonyls. Air was also drawn into a stainless steel canister. The canisters were analyzed for 58 volatile organic compounds (VOCs) by EPA method TO-15. In addition, High Volume samplers collected Total Suspended Particulate matter samples that were analyzed for eleven different metals. Thus, the total number of chemical compounds assessed is 81.

This report presents results according to the monitoring method employed. Thus, one chapter discusses the carbonyls, one presents VOC information, and the last one summarizes the metals analyzed by the ICP method. For consistency, each chapter follows the same format. The chapter begins with a presentation of summary statistics for all compounds analyzed by the method. It then discusses the percentage of samples in which each chemical was detected. Results are split out and analyzed for weekday versus weekend time periods. Some summary graphs of groups of compounds are presented. Correlation coefficients (a statistical measure of how well the presence of some compounds is associated with the presence of other compounds) are developed. The section then presents a brief discussion of quality assurance statistics, such as blank and precision results, that are available upon request to CDPHE. Finally, there is a section entitled "Compounds of Significance: Sources and Health Effects". This is one of the most important portions of the report, for it discusses each chemical which has an annual average concentration in Grand Junction air of one part per billion (ppb) or greater, or which has air concentrations above EPA levels of concern. This section gives a brief summary of each chemical's use, its air emission sources, its potential health effects, and concentrations in typical urban air. Where possible, levels are compared to EPA "benchmark" health criteria. (EPA has not developed recommended "benchmark" levels for all compounds). At the end of the chapter is a reference section listing sources of information regarding toxicity and health effects for the chemical compounds measured at annual average levels of 1 ppb or more.

The report ends with a concluding chapter that summarizes results of this study. Compounds present in Grand Junction air at levels above EPA "benchmark" levels are formaldehyde, acetaldehyde, 1-3 butadiene, benzene, carbon tetrachloride, tetrachloroethylene, p-dichlorobenzene, arsenic, cadmium, and chromium. It should be noted that EPA has not developed "benchmark" levels for a number of compounds, and that the effect of combined exposure to these compounds is not known. On the positive side, 22 of the 81 compounds were not detected in Grand Junction air. Nine others were present 10 % or less of the time.

Site Information

The Urban Air Toxics Pilot Project at Grand Junction, Colorado sampled at two separate locations. The first was the Mesa County Health Department (GJ – MCHD) at 515 Patterson Road. This site was chosen because it had existing monitoring for PM2.5 and PM10, thus providing contemporaneous size-selective particulate matter data. The site represents neighborhood scale pollutant exposures from small city traffic sources. The area is primarily residential, though a hospital was located next to the site. The second site was the Mesa County Traffic Engineering site (GJ – Traffic) at 925 Fourth Avenue. It was in a light industrial area. There are a few residences nearby. The site captured neighborhood scale pollutant exposure. Photographs of these two locations follow in Figures 1.1 and 1.2.

Meteorological data were available from the Stocker Stadium site at Twelfth Street and North Avenue. This station also had PM10 and CO monitoring. As this site was midway between the two air toxics sites, it should provide representative meteorological data for both locations. A city map showing all three stations follows (Figure 1.3).

Figure 1.1 – Grand Junction – Mesa County Health Department Site Photos
515 Patterson Road

Site Photo: Looking Southwest

Site Photo: Particulate samplers, to west

Site Photo: VOC inlet, to west

Looking **NORTH**

Looking **NORTHEAST**

Looking **EAST**

Looking **SOUTHEAST**

Looking **SOUTH**

Looking **SOUTHWEST**

Looking **WEST**

Looking **NORTHWEST**

Figure 1.2 – Grand Junction – Mesa County Traffic Engineering Site Photos
925 Fourth Avenue

Site Photo: Looking North

Site Photo: TSP samplers, to north

Site Photo: VOC inlet, to southeast

Looking **NORTH**

Looking **NORTHEAST**

Looking **EAST**

Looking **SOUTHEAST**

Looking **SOUTH**

Looking **SOUTHWEST**

Looking **WEST**

Looking **NORTHWEST**

Figure 1.3 – Grand Junction Sites Map

Section 2 - Carbonyls at Grand Junction Stations

May 2001 to April 2002

Summary Statistics - Carbonyls

Minimum, Maximum, Mean – All Samples

Carbonyl data collected at the Grand Junction stations from May 2001 through April 2002 are presented in this section of the Air Toxics Monitoring Report. For the year-long period, carbonyls were sampled on a one-in-six day basis, for a total of 60 samples attempted. Both sites obtained excellent data recovery. (See Table 2.1).

Tables 2.2 and 2.3 summarize the annual minimum, maximum, and mean concentrations for each carbonyl compound measured during the study. Results show that the most prevalent carbonyls in Grand Junction air are formaldehyde, acetone, and acetaldehyde, in that order. The other nine carbonyl compounds measured occur at concentration levels significantly below those of these top three compounds.

Table 2.1 - Percentage Data Recovery For Carbonyl Samples

Station	Sample Days Scheduled	Samples Recovered	Percentage Recovered
Grand Junction – MCHD	**60**	**56**	**93.3 %**
Grand Junction - Traffic	**60**	**60**	**100.0 %**

It should be noted that the annual means reported in Tables 2.2 and 2.3 were calculated by averaging all samples with values above the method detection limit. That is, samples with chemical concentrations below the instrumentation's ability to measure, which were reported as "non-detects", are not included in the annual averages. This means that the annual averages for substances that are detected infrequently are overestimated. For example isovaleraldehyde had 71% of the samples at a non-detect level. The annual mean reported is calculated from the 29% of samples that were above the detection limit. The annual mean calculation only includes the highest-concentration samples, not accounting for periods when the compound was not at measurable levels.

This data calculation problem can sometimes be ameliorated by substituting one-half of the detection level for the "non-detect" days, allowing a mean calculation that better accounts for low-concentration time periods. In this case, it was not possible to conduct this analysis. The amount of each carbonyl that the instrument can measure must be divided by the individual air volume for each day's sample. The laboratory did this calculation internally, and did not list the volume for each sample. Thus, detection limits for the "non-detect" samples can not be readily determined.

This problem should not significantly affect the annual means for substances that were at measurable levels most of the time. All of the carbonyls, except for isovaleraldehyde and 2,5-dimethylbenzaldehyde, were present at least 90% of the time. However, the true annual means of isovaleraldehyde and 2,5-dimethylbenzaldehyde may be well below the numbers reported here.

Percentage of Samples For Which Compound Was Detected

Tables 2.2 and 2.3 show that most of these compounds were present in air over 90% of the time the air was sampled. However, isovaleraldehyde and 2,5-dimethylbenzaldehyde were seen less frequently, with detections in only one-quarter to one-third of the air samples taken. This frequency of occurrence is similar to that noted in the 2000 – 2001 study of similar compounds in downtown Denver.

Table 2.2 – Carbonyl Compounds Data Summary – 24 Hour Samples at MCHD Site

	Summary Statistics (PPB)			Count of Non-Detects		Percentage of Samples In Which Compound Was Detected
	Maximum	Minimum	Mean	Number	Percentage	
MCHD Site						
Formaldehyde	13.12	0.92	4.91	0	0	100
Acetaldehyde	3.49	0.40	1.35	0	0	100
Acetone	10.10	1.36	4.33	0	0	100
Propionaldehyde	0.96	0.03	0.14	0	0	100
Crotonaldehyde	0.27	0.01	0.05	6	10	90
Butyr/Isobutyraldehyde	0.47	0.06	0.22	0	0	100
Benzaldehyde	0.40	0.02	0.14	1	2	98
Isovaleraldehyde	0.39	0.01	0.09	41	71	29
Valeraldehyde	0.30	0.01	0.09	5	9	91
Tolualdehydes	0.22	0.02	0.09	0	0	100
Hexaldehyde	1.42	0.01	0.33	1	2	98
2,5-Dimethylbenzaldehyde	0.16	0.00	0.05	38	66	34

Table 2.3 – Carbonyl Compounds Data Summary – 24 Hour Samples at Traffic Site

	Summary Statistics (PPB)			Count of Non-Detects		Percentage of Samples In Which Compound Was Detected
	Maximum	Minimum	Mean	Number	Percentage	
Traffic Site						
Formaldehyde	14.00	2.14	5.78	0	0	100
Acetaldehyde	2.55	0.47	1.38	0	0	100
Acetone	18.65	1.44	3.44	0	0	100
Propionaldehyde	0.48	0.04	0.14	1	2	98
Crotonaldehyde	0.28	0.01	0.04	5	8	92
Butyr/Isobutyraldehyde	0.54	0.04	0.22	0	0	100
Benzaldehyde	0.26	0.03	0.09	0	0	100
Isovaleraldehyde	0.28	0.00	0.04	50	83	17
Valeraldehyde	0.30	0.01	0.07	0	0	100
Tolualdehydes	0.33	0.02	0.09	3	5	95
Hexaldehyde	1.38	0.05	0.29	1	2	98
2,5-Dimethylbenzaldehyde	0.05	0.00	0.03	43	72	28

Weekend Vs. Weekday Results

For the year of carbonyl data, an analysis of weekday versus weekend levels was conducted. All 24-hour samples taken on Mondays, Tuesdays, Wednesdays, Thursdays, or Fridays were placed in one pool. All 24-hour samples taken on Saturdays or Sundays were placed in the other pool. Days when a numerical value, above or below the laboratory detection limit, was reported were averaged to obtain a weekday pool average versus a weekend pool average. For the purposes of this calculation, non-detect ("ND") values were not used. Tables 2.4 and 2.5 give summary statistics for minimum, maximum and mean of the weekend samples versus the same statistics for the weekday samples. Figures 2.1 and 2.2 are graphs of these results. For almost all carbonyls, the weekday mean is close to the weekend one. Formaldehyde is an exception, being in larger concentrations on the weekend. This pattern is the reverse of that found in the 2000 – 2001 downtown Denver study, where the weekday mean was greater than the weekend one.

Graphs - Carbonyls

Individual Compounds

The most prevalent three carbonyl compounds measured during the study are graphed in Figures 2.3 and 2.4. Formaldehyde showed the highest levels, with most graphed concentrations falling between one and fourteen parts per billion. Acetaldehyde was consistently present at levels of one to four parts per billion. Acetone levels generally hovered between two and ten parts per billion. The other nine carbonyl compounds were present at levels well below two parts per billion. The spring/summer period (May through October) showed higher concentrations than the rest of the year at MCHD. At the Traffic site, the values did not show much seasonal variation.

Compounds As Groups

Figures 2.3 amd 2.4 show the annual trends for the largest concentration carbonyl compounds: formaldehyde, acetone and acetaldehyde. Generally, concentrations of these compounds rise and fall together, suggesting a common emissions source.

Table 2.4 – Weekend Vs. Weekday Statistics for 24-Hour Carbonyl Samples – MCHD Site

MCHD site (GJCO) 515 Patterson Rd., Grand Jct.	Summary Statistics WEEKEND (PPBV)			Summary Statistics WEEKDAY (PPBV)		
	Maximum	Minimum	Mean	Maximum	Minimum	Mean
Formaldehyde	13.12	1.03	5.44	13.07	0.92	4.73
Acetaldehyde	2.52	0.59	1.40	3.49	0.40	1.33
Acetone	9.83	1.82	4.69	10.10	1.36	4.21
Propionaldehyde	0.27	0.05	0.13	0.96	0.03	0.15
Crotonaldehyde	0.27	0.01	0.08	0.16	0.01	0.04
Butyr/Isobutyraldehyde	0.40	0.09	0.22	0.47	0.06	0.22
Benzaldehyde	0.40	0.02	0.15	0.36	0.03	0.14
Isovaleraldehyde	0.06	0.02	0.04	0.39	0.01	0.11
Valeraldehyde	0.30	0.01	0.10	0.25	0.01	0.09
Tolualdehydes	0.21	0.03	0.09	0.22	0.02	0.09
Hexaldehyde	1.42	0.02	0.42	1.24	0.01	0.30
2,5-Dimethylbenzaldehyde	0.11	0.01	0.06	0.16	0.00	0.05

Table 2.5 – Weekend Vs. Weekday Statistics for 24-Hour Carbonyl Samples – Traffic Site

Traffic Services site (G2CO) 925 4th Ave., Grand Jct.	Summary Statistics WEEKEND (PPBV)			Summary Statistics WEEKDAY (PPBV)		
	Maximum	Minimum	Mean	Maximum	Minimum	Mean
Formaldehyde	14.00	2.28	6.09	14.00	2.14	5.64
Acetaldehyde	2.41	0.66	1.41	2.55	0.47	1.37
Acetone	6.49	1.44	3.27	18.65	1.45	3.52
Propionaldehyde	0.48	0.05	0.15	0.30	0.04	0.14
Crotonaldehyde	0.22	0.01	0.05	0.28	0.01	0.04
Butyr/Isobutyraldehyde	0.36	0.09	0.22	0.54	0.04	0.23
Benzaldehyde	0.26	0.03	0.10	0.26	0.03	0.09
Isovaleraldehyde	0.04	0.01	0.02	0.28	0.00	0.05
Valeraldehyde	0.15	0.02	0.06	0.30	0.01	0.07
Tolualdehydes	0.20	0.03	0.09	0.33	0.02	0.09
Hexaldehyde	1.14	0.06	0.36	1.38	0.05	0.27
2,5-Dimethylbenzaldehyde	0.05	0.01	0.03	0.05	0.01	0.03

Figure 2.1 - Weekday Vs. Weekend Mean for Carbonyls At Grand Junction MCHD Site

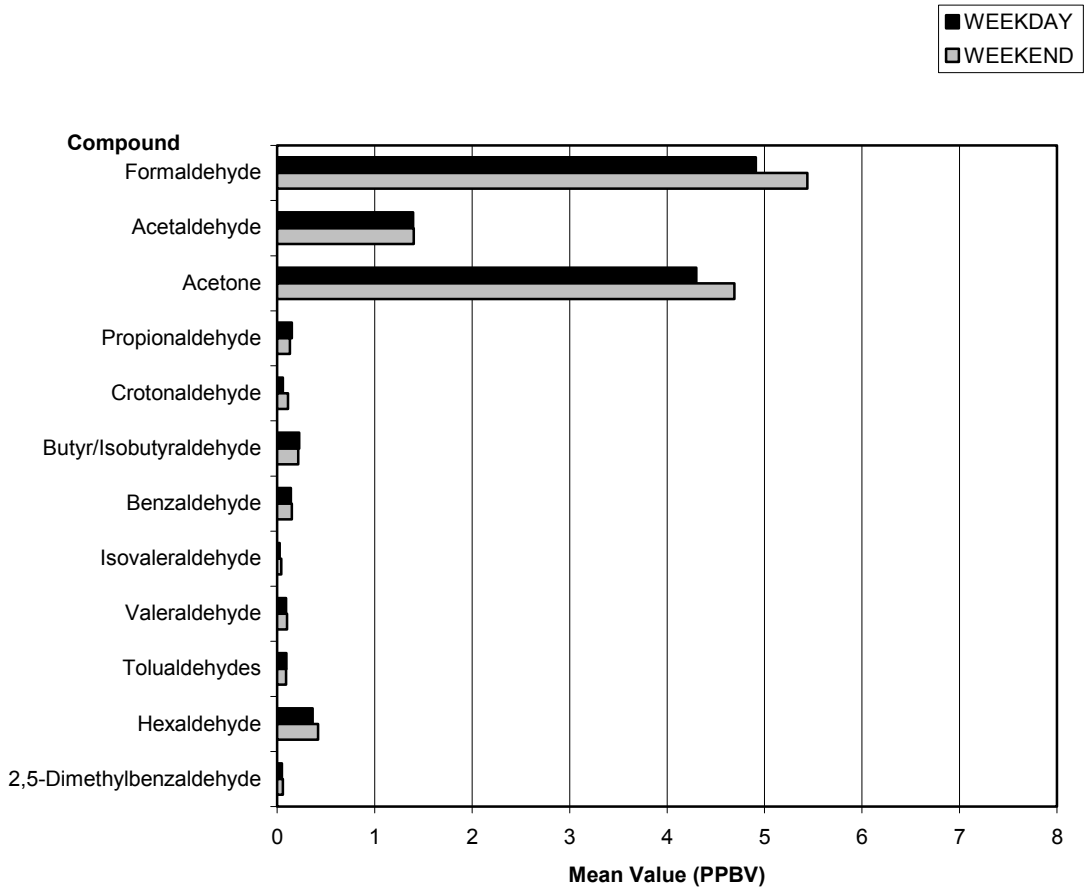


Figure 2.2 - Weekday Vs. Weekend Mean for Carbonyls At Grand Junction Traffic Services Site

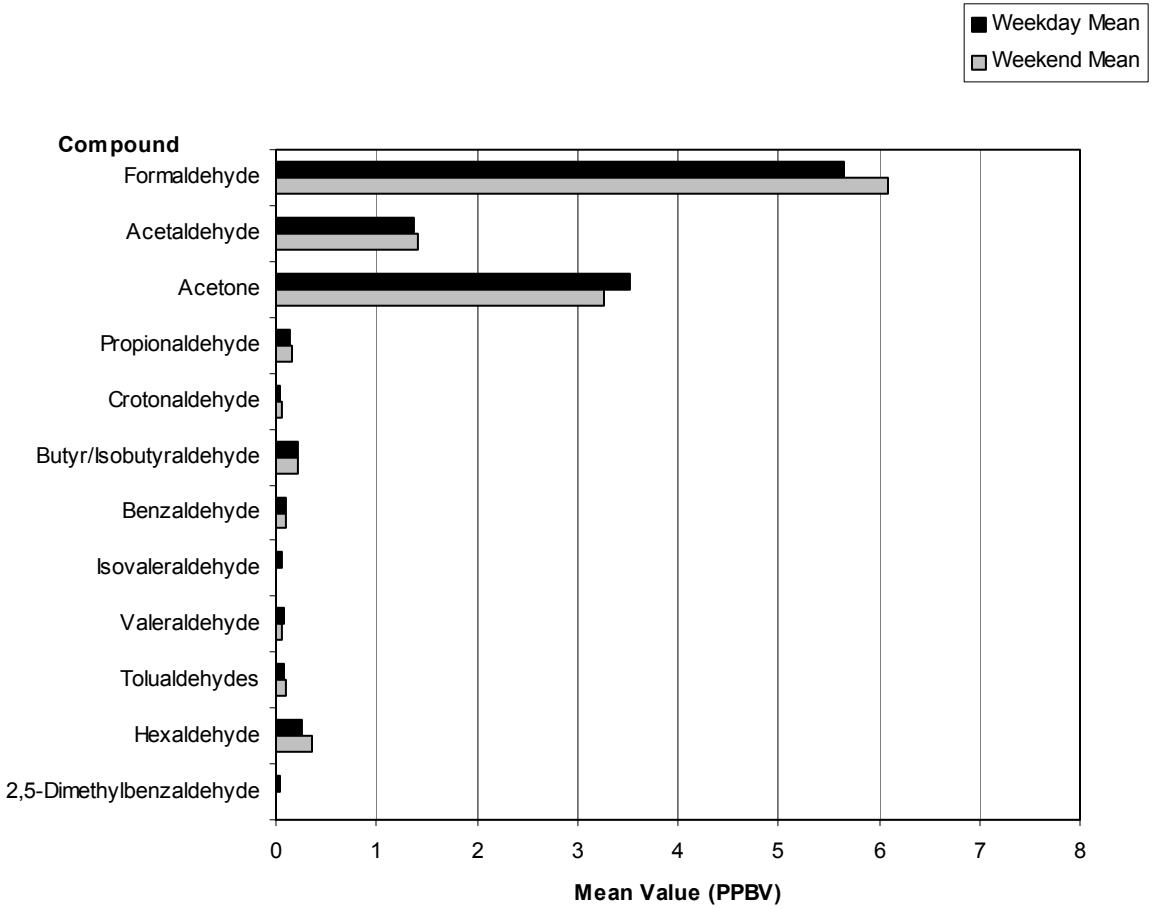


Figure 2.3 - Largest Concentration Carbonyls At Grand Junction - MCHD

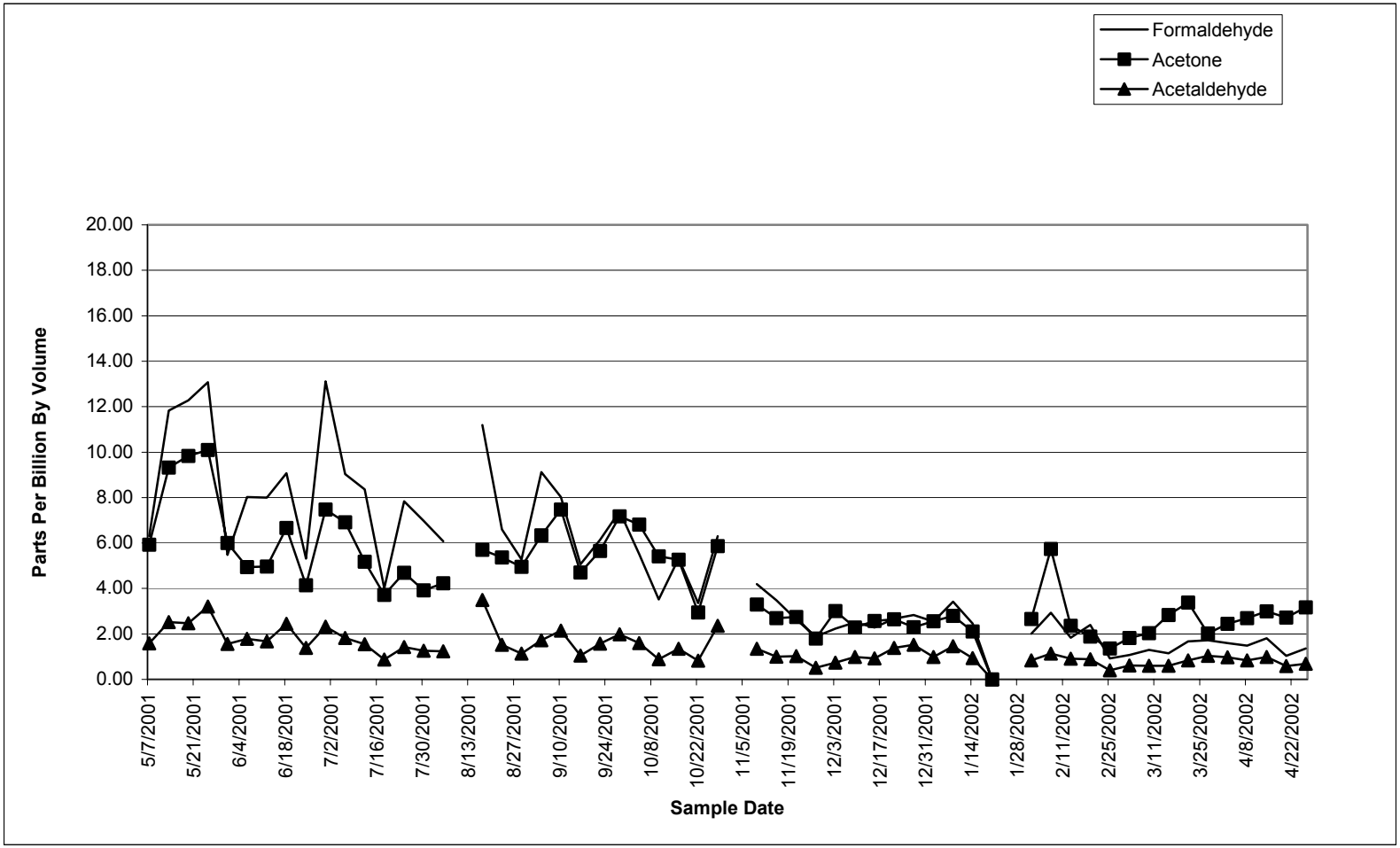
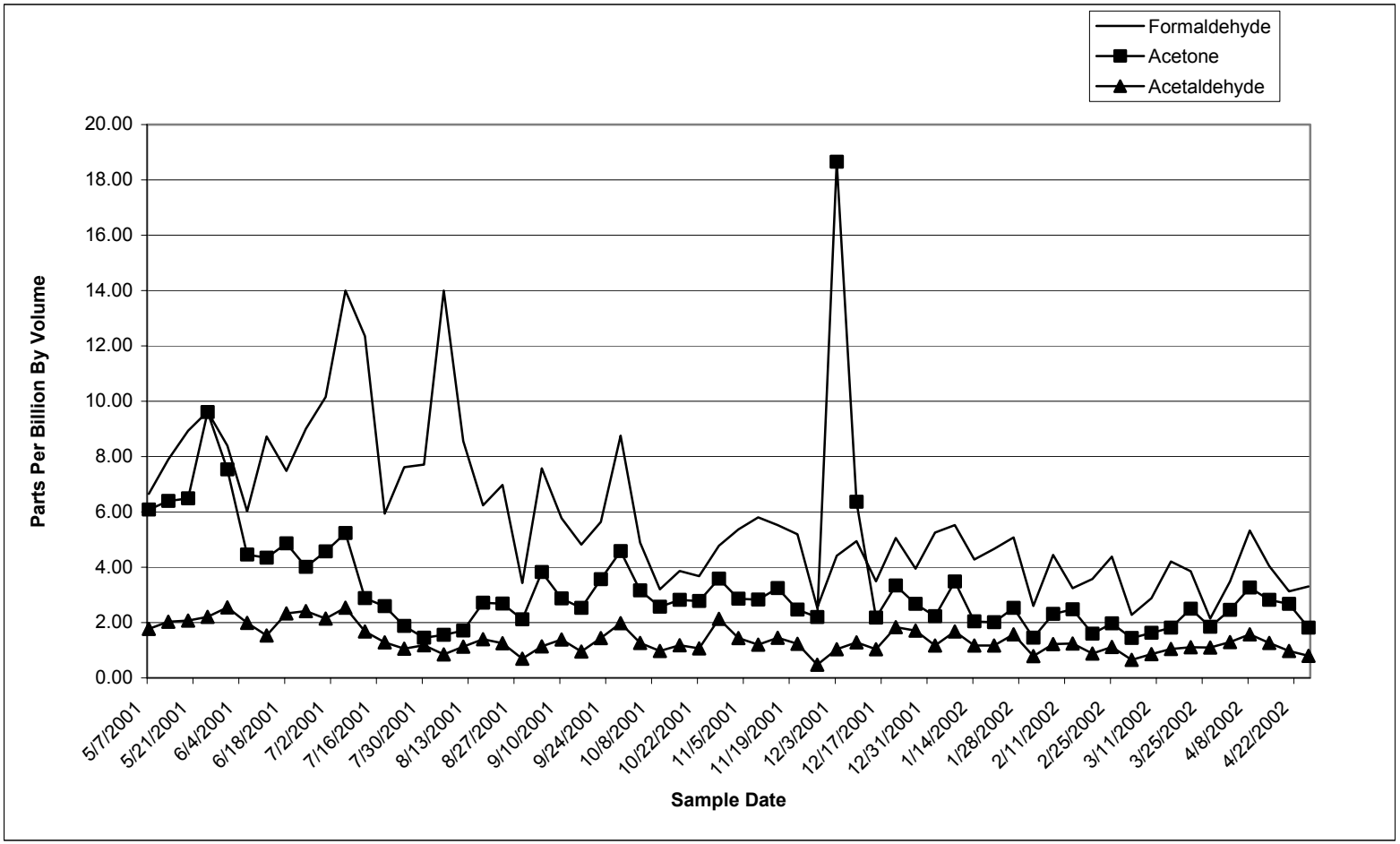


Figure 2.4 - Largest Concentration Carbonyls At Grand Junction - Traffic



Correlation Coefficients Between Compounds – Carbonyls

A correlation coefficient analysis conducted for the twelve carbonyl compounds, across the entire year of data, shows that almost all compounds are strongly correlated to formaldehyde and acetaldehyde (Tables 2.5 and 2.6). As these are the carbonyls with the largest concentrations in air, it is not that surprising that the lower concentration carbonyls are correlated to them. Acetone shows correlation to the other carbonyls, but the relationship is not as strong as that for formaldehyde and acetaldehyde.

Precision of Sample Results – Carbonyls

Periodically throughout the year, a second carbonyl cartridge was sampled simultaneously with the main sample. These additional samples, known as duplicates, were collected in order to assess the precision (repeatability) of the carbonyl sampling method. On the duplicate sampling dates, 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. These samples are known as the laboratory replicates. Thus, this project collected two types of precision data – duplicate data, which assesses both sampling and analysis procedures, and replicate data, which assesses laboratory analytical method repeatability. Detailed information regarding precision and laboratory replicate results is available upon request.

Field Blanks – Carbonyls

For quality assurance purposes, field blanks were periodically taken by attaching a blank DNPH 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, or contamination that might occur in sample installation or shipping. Most cartridges had small amounts of formaldehyde, acetaldehyde, and acetone. The other nine compounds occasionally had detectable amounts on the blanks. Detailed information regarding field blank results is available upon request.

Table 2.6 - Correlation Coefficients for Carbonyls – Grand Junction – MCHD Site

	Formaldehyde	Acetaldehyde	Acetone	Propionalde.	Crotonalde.	Butyr/Isobutyr.
Formaldehyde	**1.00**					
Acetaldehyde	**0.90**	**1.00**				
Acetone	**0.89**	**0.82**	**1.00**			
Propionaldehyde	0.41	0.43	0.33	**1.00**		
Crotonaldehyde	**0.77**	**0.58**	**0.65**	0.25	**1.00**	
Butyr/Isobutyraldehyde	**0.66**	**0.78**	**0.69**	0.34	0.37	**1.00**
Benzaldehyde	**0.97**	**0.88**	**0.89**	0.41	**0.71**	**0.65**
Isovaleraldehyde	**0.66**	0.22	0.13	**0.65**	0.45	-0.18
Valeraldehyde	**0.89**	**0.88**	**0.78**	0.40	**0.60**	**0.76**
Tolualdehydes	**0.76**	**0.72**	**0.68**	0.32	**0.66**	**0.51**
Hexaldehyde	**0.86**	**0.70**	**0.77**	0.27	**0.91**	0.39
2,5-Dimethylbenzaldehyde	**0.65**	**0.64**	**0.72**	**0.68**	**0.69**	**0.57**

	Benzaldehyde	Isovaleralde.	Valeraldehyde	Tolualdehydes	Hexaldehyde	2,5-Dimethylben.
Formaldehyde						
Acetaldehyde						
Acetone						
Propionaldehyde						
Crotonaldehyde						
Butyr/Isobutyraldehyde						
Benzaldehyde	**1.00**					
Isovaleraldehyde	**0.66**	**1.00**				
Valeraldehyde	**0.87**	0.25	**1.00**			
Tolualdehydes	**0.84**	0.38	**0.81**	**1.00**		
Hexaldehyde	**0.82**	0.43	**0.73**	**0.71**	**1.00**	
2,5-Dimethylbenzaldehyde	**0.70**	No Correlation	**0.67**	**0.63**	**0.65**	**1.00**

Bold = Correlation greater than 0.50
No Correlation = These compounds were never detected at the same time.

Table 2.7 - Correlation Coefficients for Carbonyls – Grand Junction – Traffic Site

	Formaldehyde	Acetaldehyde	Acetone	Propionalde.	Crotonalde.	Butyr/Isobutyr.
Formaldehyde	**1.00**					
Acetaldehyde	**0.60**	**1.00**				
Acetone	0.25	0.41	**1.00**			
Propionaldehyde	0.34	**0.77**	**0.68**	**1.00**		
Crotonaldehyde	**0.60**	**0.51**	0.25	0.45	**1.00**	
Butyr/Isobutyraldehyde	0.01	0.36	0.03	0.32	-0.08	**1.00**
Benzaldehyde	**0.79**	**0.67**	0.23	0.43	0.45	0.02
Isovaleraldehyde	**0.54**	-0.14	-0.32	0.06	-0.06	-0.44
Valeraldehyde	**0.59**	**0.69**	0.33	0.43	**0.55**	0.37
Tolualdehydes	**0.64**	**0.66**	0.33	**0.53**	**0.76**	-0.07
Hexaldehyde	**0.84**	**0.68**	0.29	0.43	**0.77**	0.01
2,5-Dimethylbenzaldehyde	**0.91**	0.43	**0.54**	0.15	**0.68**	-0.21

	Benzaldehyde	Isovaleralde.	Valeraldehyde	Tolualdehydes	Hexaldehyde	2,5-Dimethylben.
Formaldehyde						
Acetaldehyde						
Acetone						
Propionaldehyde						
Crotonaldehyde						
Butyr/Isobutyraldehyde						
Benzaldehyde	**1.00**					
Isovaleraldehyde	0.17	**1.00**				
Valeraldehyde	**0.54**	-0.34	**1.00**			
Tolualdehydes	**0.59**	0.00	0.40	**1.00**		
Hexaldehyde	**0.78**	0.02	**0.60**	**0.74**	**1.00**	
2,5-Dimethylbenzaldehyde	**0.86**	-0.06	0.41	**0.85**	**0.91**	**1.00**

Bold = Correlation greater than 0.50

Compounds of Significance: Sources and Health Effects

Of the twelve carbonyl compounds sampled, three showed annual mean concentrations greater than 1 part per billion (ppb) in Grand Junction air. These are: formaldehyde, acetaldehyde, and acetone. Information regarding the nature, sources, and potential health effects of each of these compounds is given below. Levels observed in Grand Junction are also compared to national EPA "benchmark" concentrations, which are used to evaluate whether areas are meeting national EPA goals for reducing concentrations of hazardous air pollutants. However, unlike national ambient air quality standards governing pollutants such as carbon monoxide or ozone, these EPA "benchmark" values do not have the force of law or regulation. They are simply levels at which EPA believes these pollutants may begin to cause health effects in sensitive members of the population.

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 resins, particleboard, plywood, and glues. It is also employed in chemical manufacturing of pharmaceuticals, herbicides, and sealants. Textile finishes, such as used for "permanent press" clothes, contain formaldehyde (Kirk-Othmer, Vol 11, pages 245 - 246).

Although it is used in industry, the largest source of formaldehyde in outdoor air is combustion. 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 that may cause burning in the eyes, nose, and lungs. At 0.4 – 3 ppm, it may cause the eyes to tear. 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). Thus, the main concerns with this compound are its irritant properties and its potential ability to cause cancer of the nose and throat.

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 levels observed in Grand Junction during this study, 4.9 ppb (MCHD) and 5.8 ppb (Traffic) are within the "suburban" range. The significance of the Grand Junction levels can be assessed by comparing them to national EPA "benchmark" values for formaldehyde.

As part of its national air toxics analysis effort, EPA has developed recommended benchmark concentrations for various hazardous air pollutants. For each hazardous air pollutant the EPA has tried to develop an "acute" benchmark, as well as "chronic" and "cancer risk" benchmarks. The acute benchmark value represents a value that an individual may be exposed to for a short period of time, without risk of health effects. The period of time may vary for each pollutant, but for the purposes of the analysis here, one compares the highest twenty-four hour daily value observed over the year with the "acute" benchmark. The "chronic" and "cancer risk" benchmarks represent concentrations to which an individual may be exposed over a lifetime without a large risk of incurring health effects. For the purposes of the analysis here, one compares the annual mean to the "chronic" and "cancer risk" benchmarks.

The benchmarks for the hazardous air pollutants may be found on the following EPA web page:

http://www.epa.gov/ttn/atw/toxsource/summary.html

Tables 2.8 and 2.9 summarize the EPA benchmarks available for formaldehyde. As seen from the table, formaldehyde has benchmarks for long-exposure period health effects (cancer and chronic), but "acute" benchmarks for a 24-hour period have yet to be developed.

Table 2.8 compares the annual mean value of formaldehyde to the EPA "unit risk factor" for developing cancer. Columns two and three of Table 2.8 give the annual mean, as measured in parts per billion volume and then converted to micrograms per cubic meter (ug/m3). Column four of Table 2.8 gives the concentration (unit risk factor) associated with a one-in-one million risk of contracting cancer. Column five, Cancer Risk in Ambient Air, relates the annual concentration of formaldehyde observed at the Grand Junction stations to the risk of contracting cancer. EPA's goal is for the risk in column five to be 1 X 10-6 or less. Thus, the values for formaldehyde in Grand Junction air are about 78 - 92 times higher than the EPA goal. Since these stations are part of a nationwide EPA study, results such as this suggest that reducing concentrations of formaldehyde in outdoor air should be a priority for EPA.

Table 2.9 compares the annual mean values of this compound to the EPA "Hazard Quotient" value for the risk of chronic (non-cancer) health effects. Column four, Non-cancer Chronic, of Table 2.9 gives the value below which EPA believes chronic health effects to the population will not occur. Column five is a ratio of the annual mean (column 3) to the Non-cancer chronic value in column four. EPA's goal is that this "Hazard Quotient" be less than 1.0. (That is, the annual concentration should be less than the Non-cancer chronic value for the pollutant). For formaldehyde, the values are below the EPA goal.

Therefore, inhalation of formaldehyde in Grand Junction air is one of the greatest potential contributors to cancers related to ambient airborne chemicals. As concentrations measured in Grand Junction are typical of suburban areas of the United States, this is a nationwide concern, rather than an issue unique to this area.

Table 2.8 - Formaldehyde Annual Mean Versus Cancer Risk

Annual Mean Versus Cancer Risk				
Compound	**Annual Mean ppbv**	**Annual Mean ug/m3**	**Cancer Risk Factor Per ug/m3 ((1/(ug/m3))**	**Cancer Risk In Ambient Air**
Formaldehyde - MCHD	**4.91**	**6.03**	**0.000013**	**7.84E-05**
Formaldehyde - Traffic	**5.78**	**7.10**	**0.000013**	**9.23E-05**

Table 2.9 - Formaldehyde Annual Mean Versus Non-Cancer Chronic Risk

Annual Mean Versus Non-Cancer Chronic Risk				
Compound	**Annual Mean ppbv**	**Annual Mean ug/m3**	**Noncancer Chronic Factor, ug/m3**	**Noncancer Chronic Hazard Quotient**
Formaldehyde - MCHD	**4.91**	**6.03**	**9.8**	**0.62**
Formaldehyde - Traffic	**5.78**	**7.10**	**9.8**	**0.72**

Acetaldehyde

Acetaldehyde is a hydrocarbon with the formula CH_3CHO. It is thus closely related to formaldehyde, HCHO. Like formaldehyde, it exists in the atmosphere as a gas with a pungent odor. It is used in the manufacture of acetic acid, acetic anhydride, chloral, glyoxal, and other chemicals. 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).

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 photochemical reaction pathways, forming formaldehyde. Wood burning and emissions from petroleum refineries are also sources.

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).

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 means observed in this Grand Junction study, 1.35 ppb (MCHD) and 1.38 ppb (Traffic) are almost identical to the California data. The significance of the Grand Junction levels can be assessed by comparing them to national EPA "benchmark" values for acetaldehyde.

Tables 2.10 and 2.11 summarize the EPA benchmarks available for acetaldehyde. This compound has benchmarks for long-exposure period health effects (cancer and chronic), but "acute" benchmarks for a 24-hour period have yet to be developed.

Table 2.10 compares the annual mean value of acetaldehyde to the EPA "unit risk factor" for developing cancer. Columns two and three of Table 2.10 give the annual mean of acetaldehyde, as measured in parts per billion volume and then converted to micrograms per cubic meter (ug/m3). Column four of Table 2.10 gives the concen-tration (unit risk factor) associated with a one-in-one million risk of contracting cancer. EPA's goal is for the risk in column five to be 1 X 10-6 or less. Thus, the values for acetaldehyde in Grand Junction air are about five times higher than the EPA goal. Since these stations are part of a nationwide EPA study, results such as this suggest that reducing concentrations of acetaldehyde in outdoor air should be a priority for EPA.

Table 2.11 compares the annual mean values of acetaldehyde to the EPA "Hazard Quotient" value for the risk of chronic (non-cancer) health effects. Column four, Non-cancer Chronic, of Table 2.11 gives the value below which EPA believes chronic health effects to the population will not occur. Column five is a ratio of the annual mean (column 3) to the Non-cancer chronic value in column four. EPA's goal is that this "Hazard Quotient" be less than 1.0. (That is, the annual concentration should be less than the Non-cancer chronic value for the pollutant). For acetaldehyde, the hazard quotient is well below the EPA goal of 1.0.

Therefore, inhalation of acetaldehyde in Grand Junction air is believed to be one of the significant potential contributors to cancers related to ambient airborne chemicals. Acetaldehyde in Grand Junction air does not appear to be at high enough levels to cause irritant effects to the population. 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.

Table 2.10 - Acetaldehyde Annual Mean Versus Cancer Risk

Annual Mean Versus Cancer Risk				
Compound	**Annual Mean ppbv**	**Annual Mean ug/m3**	**Cancer Risk Factor Per ug/m3 ((1/(ug/m3))**	**Cancer Risk In Ambient Air**
Acetaldehyde - MCHD	**1.35**	**2.43**	**0.0000022**	**5.35E-06**
Acetaldehyde - Traffic	**1.38**	**2.49**	**0.0000022**	**5.47E-06**

Table 2.11 - Acetaldehyde Annual Mean Versus Non-Cancer Chronic Risk

Annual Mean Versus Non-Cancer Chronic Risk				
Compound	**Annual Mean ppbv**	**Annual Mean ug/m3**	**Noncancer Chronic Factor, ug/m3**	**Noncancer Chronic Hazard Quotient**
Acetaldehyde - MCHD	**1.35**	**2.43**	**9.0**	**0.27**
Acetaldehyde - Traffic	**1.38**	**2.49**	**9.0**	**0.28**

Acetone

Acetone is a hydrocarbon compound with the formula CH_3COCH_3. It is also known as dimethyl ketone or 2-propanone. Like formaldehyde and acetaldehyde, it exists in the atmosphere as a colorless gas with a pungent odor. Its primary industrial use is as a solvent in production of paints, adhesives, cleaners, and inks (Kirk-Othmer, Vol 1, page 189).

Sources of acetone in the ambient air are similar to those of formaldehyde and acetaldehyde. Automobile exhaust, wood burning, and petroleum refining are important sources. For acetone, solvent usage is also a large source of emissions. Unlike the other two carbonyl compounds discussed here, acetone does not readily react in air and can be transported for long distances (ATSDR Toxicological Profile for Acetone).

The Agency for Toxic Substances and Disease Registry lists a number of possible health effects that may occur from inhalation of acetone. Acetone is an irritant that may cause burning in eyes, nose and lungs. At very high levels, it can cause headaches, lightheadedness, dizziness, and confusion (ATSDR Toxicological Profile for Acetone). It should be noted that most of the health effects information on acetone is based on research on workers, who had job-related exposures at much higher levels than those seen in outdoor air. Currently, there is not enough information to determine whether acetone is carcinogenic (cancer-causing). Research indicates that acetone may cause problems for developing animal fetuses. It is not known whether acetone causes birth defects in humans.

ATSDR cites research suggesting that urban areas of the United States may have mean concentrations of 6.9 ppb (ATSDR Toxicological Profile for Acetone). This is higher than the 4.33 ppb (MCHD) and 3.44 ppb (Traffic) annual means this study observed in Grand Junction. Unfortunately, the Environmental Protection Agency has not developed "benchmark" values for acetone. Thus, the health significance of these Grand Junction levels is difficult to determine. However, acetone's close association with formaldehyde and acetaldehyde, which are known to be above EPA cancer risk "benchmark" levels, suggests that emission control strategies directed against the other carbonyls would also reduce acetone concentrations**.**

References for Carbonyls Section

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Section 3 - Volatile Organic Compounds at Grand Junction Stations

May 2001 to April 2002

Summary Statistics – Volatile Organic Compounds

Minimum, Maximum, Mean – All Samples

Volatile organic compound (VOC) data collected at the Grand Junction stations from May 2001 through April 2002 are presented in this section of the Air Toxics Monitoring Report. For the year-long period, volatile organic compounds were sampled on a one-in-six day basis, for a total of 60 samples attempted. Of these, the laboratory successfully processed 57 and 58, for percentage data recovery rates exceeding 90 %. (See Table 3.1).

Tables 3.2 and 3.3 summarize the annual minimum, maximum, and mean concentrations for each of the 58 volatile organic compounds measured during the study. Results show that acetylene, acetonitrile, toluene, and m,p-xylenes were the compounds with the highest concentrations in ambient air. These compounds all had sample mean levels greater than one ppb, and with the exception of acetonitrile, were detected in over 98% of the canister samples taken.

It should be noted that the annual means were calculated by a method that attempts to account for days when sample concentrations were below the measurable sample detection limit. For compounds detected 100 % of the time, the annual mean is simply an average of all the samples. For samples never detected above the measurable sample detection limit, the results are reported as "ND", not detected. For the other samples, the values reported by the laboratory are averaged with the "ND" values. The "ND" is replaced by an estimate, calculated as one-half of the sample detection limit. This is an accepted technique for calculating annual values when some of the samples were less than the laboratory's ability to measure. It should be noted that the EPA national advisory board overseeing this project has expressed some concern that this method of always using one-half of the detection limit for the "ND" values might artificially skew the annual means, in a way that is difficult to determine. The board therefore requested that laboratories report readings below the detection limit as valid numbers. (The detection limit is generally defined as plus three standard deviations of the lowest signal distinguishable, so it is possible to get "readings" below the detection limit). The board felt that reporting of these somewhat uncertain quantities would be better than using one-half the detection limit as a default. The individual sample reports from the laboratory show that, in some cases, the laboratory did report a sample concentration less than the detection limit. In other cases, this was not possible, and they used "ND". In situations where a number below detection limit was reported, it was included in the annual mean. For samples reported as "ND", this report uses one-half of the detection limit to calculate the annual mean.

Table 3.1 - Percentage Data Recovery For VOC Samples – Grand Junction Sites

Station	Sample Days Scheduled	Samples Recovered	Percentage Recovered
Grand Junction - MCHD	**57**	**60**	**95.0 %**
Grand Junction - Traffic	**58**	**60**	**96.7 %**

Table 3.2 - VOC Data Summary – GJ MCHD

MCHD site (GJCO)	Summary Statistics (PPBV)			Count of Non-Detects		Percentage of Samples In Which Compound Was Detected
	Minimum	Maximum	Mean	Number	Percentage	
ACETYLENE	0.86	82.59	14.50	0	0	100
PROPYLENE	0.23	2.65	0.78	0	0	100
DICHLORODIFLUOROMETHANE	0.45	0.75	0.59	0	0	100
CHLOROMETHANE	0.41	1.58	0.61	1	2	98
DICHLOROTETRAFLUOROETHANE	0.01	0.03	0.02	48	84	16
VINYL CHLORIDE	ND	ND	ND	57	100	0
1,3-BUTADIENE	0.02	0.41	0.10	10	18	82
BROMOMETHANE	ND	ND	ND	57	100	0
CHLOROETHANE	ND	ND	ND	57	100	0
ACETONITRILE	0.59	83.81	8.37	39	68	32
TRICHLOROFLUOROMETHANE	0.18	1.42	0.34	0	0	100
ACRYLONITRILE	ND	ND	ND	57	100	0
1,1-DICHLOROETHENE	ND	ND	ND	57	100	0
METHYLENE CHLORIDE	0.02	1.11	0.14	13	23	77
TRICHLOROTRIFLUOROETHANE	0.08	0.17	0.11	0	0	100
trans - 1,2 - DICHLOROETHYLENE	ND	ND	ND	57	100	0
1,1 - DICHLOROETHANE	ND	ND	ND	57	100	0
METHYL tert-BUTYL ETHER	0.08	2.13	0.50	24	42	58
METHYL ETHYL KETONE	0.24	4.96	0.79	17	30	70
CHLOROPRENE	ND	ND	ND	57	100	0
cis-1,2-DICHLOROETHYLENE	ND	ND	ND	57	100	0
BROMOCHLOROMETHANE	ND	ND	ND	57	100	0
CHLOROFORM	0.01	0.06	0.03	46	81	19
ETHYL tert-BUTYL ETHER	ND	ND	ND	57	100	0
1,2 - DICHLOROETHANE	ND	ND	ND	57	100	0

MCHD site (GJCO)	Summary Statistics (PPBV)			Count of Non-Detects		Percentage of Samples In Which Compound Was Detected
	Minimum	Maximum	Mean	Number	Percentage	
1,1,1 - TRICHLOROETHANE	0.01	0.93	0.05	21	37	63
BENZENE	0.22	2.72	0.90	0	0	100
CARBON TETRACHLORIDE	0.03	0.12	0.08	3	5	95
tert-AMYL METHYL ETHER	ND	ND	ND	57	100	0
1,2 - DICHLOROPROPANE	ND	ND	ND	57	100	0
ETHYL ACRYLATE	ND	ND	ND	57	100	0
BROMODICHLOROMETHANE	ND	ND	ND	57	100	0
TRICHLOROETHYLENE	0.34	0.34	0.05	56	98	2
METHYL METHACRYLATE	0.10	0.53	0.14	52	91	9
cis -1,3 - DICHLOROPROPENE	ND	ND	ND	57	100	0
METHYL ISOBUTYL KETONE	ND	ND	ND	57	100	0
trans - 1,3 - DICHLOROPROPENE	ND	ND	ND	57	100	0
1,1,2 - TRICHLOROETHANE	ND	ND	ND	57	100	0
TOLUENE	0.40	33.26	3.70	0	0	100
DIBROMOCHLOROMETHANE	ND	ND	ND	57	100	0
1,2-DIBROMOETHANE	ND	ND	ND	57	100	0
N-OCTANE	0.03	1.02	0.11	12	21	79
TETRACHLOROETHYLENE	0.02	0.23	0.04	35	61	39
CHLOROBENZENE	ND	ND	ND	57	100	0
ETHYLBENZENE	0.09	10.68	0.84	0	0	100
m,p - XYLENE	0.20	33.98	2.78	0	0	100
BROMOFORM	ND	ND	ND	57	100	0
STYRENE	0.03	0.17	0.07	20	35	65
1,1,2,2 - TETRACHLOROETHANE	ND	ND	ND	57	100	0
o - XYLENE	0.06	9.69	0.85	0	0	100
1,3,5-TRIMETHYLBENZENE	0.02	0.28	0.08	6	11	89

MCHD site (GJCO)	Summary Statistics (PPBV)			Count of Non-Detects		Percentage of Samples In Which Compound Was Detected
	Minimum	Maximum	Mean	Number	Percentage	
1,2,4-TRIMETHYLBENZENE	0.07	0.84	0.24	2	4	96
m - DICHLOROBENZENE	0.02	0.10	0.05	53	93	7
CHLOROMETHYLBENZENE	ND	ND	ND	57	100	0
p - DICHLOROBENZENE	0.02	0.08	0.06	54	95	5
o - DICHLOROBENZENE	ND	ND	ND	57	100	0
1,2,4-TRICHLOROBENZENE	ND	ND	ND	57	100	0
HEXACHLORO-1,3-BUTADIENE	ND	ND	ND	57	100	0

Table 3.2, completed.

Table 3.3 - VOC Data Summary – GJ Traffic

Traffic Services site (G2CO)	Summary Statistics (PPBV)			Count of Non-Detects		Percentage of Samples In Which Compound Was Detected
	Minimum	Maximum	Mean	Number	Percentage	
ACETYLENE	0.90	13.52	3.22	1	2	98
PROPYLENE	0.22	2.21	0.74	0	0	100
DICHLORODIFLUOROMETHANE	0.44	0.85	0.59	0	0	100
CHLOROMETHANE	0.44	0.81	0.59	0	0	100
DICHLOROTETRAFLUOROETHANE	0.01	0.03	0.03	50	86	14
VINYL CHLORIDE	ND	ND	ND	58	100	0
1,3-BUTADIENE	0.02	0.33	0.09	10	17	83
BROMOMETHANE	ND	ND	ND	58	100	0
CHLOROETHANE	0.07	0.07	0.05	57	98	2
ACETONITRILE	0.97	27.69	0.99	50	86	14
TRICHLOROFLUOROMETHANE	0.17	1.36	0.32	0	0	100
ACRYLONITRILE	0.08	1.03	0.18	53	91	9
1,1-DICHLOROETHENE	ND	ND	ND	58	100	0
METHYLENE CHLORIDE	0.02	1.29	0.16	5	9	91
TRICHLOROTRIFLUOROETHANE	0.08	0.16	0.11	0	0	100
trans - 1,2 - DICHLOROETHYLENE	ND	ND	ND	58	100	0
1,1 - DICHLOROETHANE	ND	ND	ND	58	100	0
METHYL tert-BUTYL ETHER	0.04	1.08	0.13	47	81	19
METHYL ETHYL KETONE	0.08	3.13	0.96	11	19	81
CHLOROPRENE	ND	ND	ND	58	100	0
cis-1,2-DICHLOROETHYLENE	0.04	0.06	0.05	57	98	2
BROMOCHLOROMETHANE	ND	ND	ND	58	100	0
CHLOROFORM	0.01	0.07	0.03	51	88	12
ETHYL tert-BUTYL ETHER	ND	ND	ND	58	100	0

Traffic Services site (G2CO)	Summary Statistics (PPBV)			Count of Non-Detects		Percentage of Samples In Which Compound Was Detected
	Minimum	Maximum	Mean	Number	Percentage	
1,2 - DICHLOROETHANE	ND	ND	ND	58	100	0
1,1,1 - TRICHLOROETHANE	0.02	0.11	0.04	16	28	72
BENZENE	0.22	2.12	0.66	0	0	100
CARBON TETRACHLORIDE	0.03	0.12	0.08	2	3	97
tert-AMYL METHYL ETHER	ND	ND	ND	58	100	0
1,2 - DICHLOROPROPANE	ND	ND	ND	58	100	0
ETHYL ACRYLATE	0.03	0.17	0.11	57	98	2
BROMODICHLOROMETHANE	ND	ND	ND	58	100	0
TRICHLOROETHYLENE	0.05	0.08	0.04	54	93	7
METHYL METHACRYLATE	0.14	0.45	0.14	53	91	9
cis -1,3 - DICHLOROPROPENE	ND	ND	ND	58	100	0
METHYL ISOBUTYL KETONE	0.10	0.58	0.14	45	78	22
trans - 1,3 - DICHLOROPROPENE	ND	ND	ND	58	100	0
1,1,2 - TRICHLOROETHANE	ND	ND	ND	58	100	0
TOLUENE	0.58	9.39	2.66	0	0	100
DIBROMOCHLOROMETHANE	ND	ND	ND	58	100	0
1,2-DIBROMOETHANE	ND	ND	ND	58	100	0
N-OCTANE	0.02	0.89	0.11	9	16	84
TETRACHLOROETHYLENE	0.02	0.30	0.05	36	62	38
CHLOROBENZENE	ND	ND	ND	58	100	0
ETHYLBENZENE	0.10	4.16	0.64	1	2	98
m,p - XYLENE	0.26	14.32	2.34	0	0	100
BROMOFORM	ND	ND	ND	58	100	0
STYRENE	0.01	0.31	0.08	13	22	78
1,1,2,2 - TETRACHLOROETHANE	0.06	0.10	0.06	57	98	2
o - XYLENE	0.11	4.14	0.95	0	0	100
1,3,5-TRIMETHYLBENZENE	0.03	0.54	0.11	3	5	95

Traffic Services site (G2CO)	Summary Statistics (PPBV)			Count of Non-Detects		Percentage of Samples In Which Compound Was Detected
	Minimum	Maximum	Mean	Number	Percentage	
1,2,4-TRIMETHYLBENZENE	0.05	1.73	0.33	0	0	100
m - DICHLOROBENZENE	ND	ND	ND	58	100	0
CHLOROMETHYLBENZENE	ND	ND	ND	58	100	0
p - DICHLOROBENZENE	0.01	0.08	0.05	52	90	10
o - DICHLOROBENZENE	ND	ND	ND	58	100	0
1,2,4-TRICHLOROBENZENE	ND	ND	ND	58	100	0
HEXACHLORO-1,3-BUTADIENE	ND	ND	ND	58	100	0

Table 3.3, completed

Percentage of Samples For Which Compound Was Detected

Tables 3.2 and 3.3 show the percentage of the samples in which each VOC was detected. Thirteen of the compounds were detected in over 90% of the samples. These compounds are listed in Table 3.4. In contrast, at MCHD, 28 VOCs were never detected at all during the study. At the Traffic site, 24 VOCs were never detected. This is about one-half of the compounds that were sampled. Compounds never detected are listed in Table 3.5. It is interesting to note that vinyl chloride, which is considered to be very toxic, was not detected. Ethyl tert-butyl ether (ETBE) and tert-amyl methyl ether (TAME), which are added to automotive fuels to increase oxygen, were not detected. However, methyl tert-butyl ether (MTBE), which is another fuel additive, was detected at both locations.

Comparing the two lists of compounds in Table 3.5 suggests that compounds which were not detected at one site, but were at the other, are from local sources. The more industrialized Traffic site detected six compounds that were not seen at MCHD. These are: chloroethane, acrylonitrile, cis-1,2-dichloroethylene, ethyl acrylate, methyl isobutyl ketone, and 1,1,2,2-tetrachloroethane. However, four of these six were only seen once at Traffic, raising questions about how significance this difference may be. It is likely that the other two compounds, acrylonitrile and methyl isobutyl ketone really do have local sources at Traffic, that are not present at MCHD. The MCHD had two local compounds that were not seen at the Traffic location. These are m-dichlorobenzene and 1,2,4-trichloro-benzene.

Table 3.4 - Compounds Detected in Over 90% of the VOC Air Samples Taken at Grand Junction Stations

ACETYLENE
PROPYLENE
DICHLORODIFLUOROMETHANE
CHLOROMETHANE
TRICHLOROFLUOROMETHANE
TRICHLOROTRIFLUOROETHANE
BENZENE
CARBON TETRACHLORIDE
TOLUENE
ETHYLBENZENE
m,p - XYLENE
o - XYLENE
1,2,4-TRIMETHYLBENZENE

Note: Methylene Chloride was detected only 77 % of the time at Traffic, but 91 % of the time at MCHD.

Table 3.5 - Compounds Never Detected in the VOC Air Samples Taken at Grand Junction Stations

Compounds Never Detected in the VOC Samples Taken at Grand Junction - MCHD	Compounds Never Detected in the VOC Samples Taken at Grand Junction - Traffic
Vinyl Chloride	Vinyl Chloride
Bromomethane	Bromomethane
Chloroethane	*
Acrylonitrile	
1,1 - Dichloroethene	1,1-Dichloroethene
trans - 1,2-Dichloroethylene	trans - 1,2-Dichloroethylene
1,1 - Dichloroethane	1,1 - Dichloroethane
Chloroprene	Chloroprene
cis - 1,2 - Dichloroethylene	*
Bromochloromethane	Bromochloromethane
Ethyl tert-butyl Ether	Ethyl tert-butyl Ether
1,2 - Dichloroethane	1,2 - Dichloroethane
Tert-Amyl Methyl Ether	Tert-Amyl Methyl Ether
1,2 - Dichloropropane	1,2 - Dichloropropane
Ethyl Acrylate	*
Bromodichloromethane	Bromodichloromethane
cis - 1,3 - Dichloropropene	cis - 1,3 - Dichloropropene
Methyl Isobutyl Ketone	
trans - 1,3 - Dichloropropene	trans - 1,3 - Dichloropropene
1,1,2 - Trichloroethane	1,1,2 - Trichloroethane
Dibromochloromethane	Dibromochloromethane
1,2 - Dibromoethane	1,2 - Dibromoethane
Chlorobenzene	Chlorobenzene
Bromoform	Bromoform
1,1,2,2 - Tetrachloroethane	*
	m - Dichlorobenzene
Chloromethylbenzene	Chloromethylbenzene
o - Dichlorobenzene	o - Dichlorobenzene
1,2,4 - Trichlorobenzene	1,2,4 - Trichlorobenzene
Hexachloro - 1,3 - Butadiene	Hexachloro - 1,3 - Butadiene

* Compounds that were never detected at MCHD, but had a single detection at the Traffic site, were: chloroethane, cis-1,2-dichloroethylene, ethyl acrylate, and 1,1,2,2-tetrachloroethane.

Weekend Vs. Weekday Results

For the year of VOC data, an analysis of weekday versus weekend levels was conducted. All 24-hour samples taken on Mondays, Tuesdays, Wednesdays, Thursdays, or Fridays were placed in one pool. All 24-hour samples taken on Saturdays or Sundays were placed in the other pool. Days when a numerical value, above or below the laboratory detection limit, was reported were averaged to obtain a weekday pool average versus a weekend pool average. For samples never detected above the measurable sample detection limit, the results are reported as "ND", not detected. For the other samples, the values reported by the laboratory are averaged with the "ND" values. The "ND" is replaced by an estimate, calculated as one-half of the sample detection limit. Tables 3.6 and 3.7 give summary statistics for minimum, maximum and mean of the weekday sample pool versus the same statistics for the weekend sample pool. Figures 3.1 and 3.2 are graphs of these results. There is not a consistent pattern regarding weekday versus weekend results. Acetonitrile is greater on the weekdays at MCHD, and greater on the weekends at Traffic. However, the Traffic result is skewed by one large reading on a weekend day.

Graphs – Volatile Organic Compounds

Graphs of all sample days reporting a numeric concentration (above or below the detection limit), were prepared. (Dates when the compound was reported as "ND", not detected, are not included on the graphs.) Two of the compounds detected at the highest concentrations were graphed with 16 ppbv as the maximum value on the y-axis. These compounds are acetylene and toluene (Figures 3.3 and 3.4). The MCHD site showed significantly greater acetylene, perhaps because of localized sources. A hospital is located next to the site. Propylene, methyl ethyl ketone, and benzene were the next-highest concentration compounds (Figures 3.5 and 3.6). Here, the two sites did not differ significantly. Dichloro-difluoromethane and chloromethane were consistently detected, at both sites, at concentrations around 0.6 ppb (Figures 3.7 and 3.8).

Trichlorofluoromethane, methylene chloride, and trichlorotrifluoroethane showed consistent relationships at both sites, but peak concentration dates varied a bit (Figures 3.9 and 3.10). Carbon tetrachloride and 1,1,1-trichloroethane concentrations were at or below 0.10 ppb at both sites (Figures 3.11 and 3.12). Acetonitrile (Figures 3.13 and 3.14) appeared sporadically, with detection much more frequent at MCHD than at the Traffic site. Evidently, sources of this compound are very localized.

1,3-butadiene was frequently detected at both locations (Figures 3.15 and 3.16). Although concentrations never exceeded 0.5 ppb, the presence of this compound is a concern, due to its toxicity. BTEX (Benzene, toluene, ethylbenzene and xylenes) compounds were generally at levels of 5 ppb or less, except for the first few samples taken (Figures 3.17 and 3.18). Highest concentrations for the first few samples only suggests that the sampling system had some sort of initial contamination, which disappeared over time.

The 1,2,4-trimethylbenzene isomer was always present at higher concentrations than the 1,3,5-trimethylbenzene isomer (Figures 3.19 and 3.20).

Finally, methyl tert-butyl ether (MTBE) (Figure 3.21), a gasoline additive used to add oxygen to motor fuels in the winter, showed a distinct seasonal pattern. Results indicate declining concentrations in late spring and summer, as winter fuel supplies were used up. Starting in November, concentrations are again detected at MCHD for the winter season. The pattern at the Traffic site is similar, but less pronounced.

Table 3.6 - Summary statistics for the weekday samples versus the same statistics for the weekend samples – GJ MCHD

MCHD site (GJCO)	Summary Statistics WEEKDAY (PPBV)			Summary Statistics WEEKEND (PPBV)		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
ACETYLENE	1.29	82.59	14.18	0.86	72.77	15.40
PROPYLENE	0.32	2.65	0.87	0.23	1.55	0.52
DICHLORODIFLUOROMETHANE	0.48	0.75	0.58	0.45	0.74	0.59
CHLOROMETHANE	0.41	1.58	0.63	0.03	0.81	0.57
DICHLOROTETRAFLUOROETHANE	0.01	0.01	0.03	0.01	0.03	0.02
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND
1,3-BUTADIENE	0.04	0.41	0.12	0.02	0.25	0.07
BROMOMETHANE	ND	ND	ND	ND	ND	ND
CHLOROETHANE	ND	ND	ND	ND	ND	ND
ACETONITRILE	0.13	83.81	9.88	0.13	31.06	4.14
TRICHLOROFLUOROMETHANE	0.20	1.42	0.34	0.18	0.48	0.32
ACRYLONITRILE	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHENE	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	0.02	0.64	0.11	0.02	1.11	0.23
TRICHLOROTRIFLUOROETHANE	0.08	0.17	0.11	0.08	0.15	0.11
trans - 1,2 - DICHLOROETHYLENE	ND	ND	ND	ND	ND	ND
1,1 - DICHLOROETHANE	ND	ND	ND	ND	ND	ND
METHYL tert-BUTYL ETHER	0.09	2.13	0.51	0.08	1.63	0.38
METHYL ETHYL KETONE	0.08	4.96	0.74	0.08	4.96	0.93
CHLOROPRENE	ND	ND	ND	ND	ND	ND
cis-1,2-DICHLOROETHYLENE	ND	ND	ND	ND	ND	ND
BROMOCHLOROMETHANE	ND	ND	ND	ND	ND	ND
CHLOROFORM	0.01	0.06	0.03	0.02	0.02	0.03
ETHYL tert-BUTYL ETHER	ND	ND	ND	ND	ND	ND
1,2 - DICHLOROETHANE	ND	ND	ND	ND	ND	ND

MCHD site (GJCO)	Summary Statistics WEEKDAY (PPBV)			Summary Statistics WEEKEND (PPBV)		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
1,1,1 - TRICHLOROETHANE	0.02	0.93	0.05	0.01	0.06	0.03
BENZENE	0.44	2.72	1.01	0.22	1.19	0.59
CARBON TETRACHLORIDE	0.03	0.12	0.08	0.03	0.12	0.09
tert-AMYL METHYL ETHER	ND	ND	ND	ND	ND	ND
1,2 - DICHLOROPROPANE	ND	ND	ND	ND	ND	ND
ETHYL ACRYLATE	ND	ND	ND	ND	ND	ND
BROMODICHLOROMETHANE	ND	ND	ND	ND	ND	ND
TRICHLOROETHYLENE	0.04	0.34	0.05	ND	ND	ND
METHYL METHACRYLATE	0.09	0.53	0.14	ND	ND	ND
cis -1,3 - DICHLOROPROPENE	ND	ND	ND	ND	ND	ND
METHYL ISOBUTYL KETONE	ND	ND	ND	ND	ND	ND
trans - 1,3 - DICHLOROPROPENE	ND	ND	ND	ND	ND	ND
1,1,2 - TRICHLOROETHANE	ND	ND	ND	ND	ND	ND
TOLUENE	0.55	33.26	3.82	0.40	16.91	3.37
DIBROMOCHLOROMETHANE	ND	ND	ND	ND	ND	ND
1,2-DIBROMOETHANE	ND	ND	ND	ND	ND	ND
N-OCTANE	0.03	0.29	0.09	0.03	1.02	0.15
TETRACHLOROETHYLENE	0.03	0.23	0.05	0.02	0.03	0.03
CHLOROBENZENE	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	0.10	10.68	0.82	0.09	5.23	0.90
m,p - XYLENE	0.20	33.98	2.70	0.28	16.79	3.02
BROMOFORM	ND	ND	ND	ND	ND	ND
STYRENE	0.03	0.17	0.07	0.03	0.09	0.05
1,1,2,2 - TETRACHLOROETHANE	ND	ND	ND	ND	ND	ND
o - XYLENE	0.06	9.69	0.83	0.13	4.66	0.89
1,3,5-TRIMETHYLBENZENE	0.04	0.28	0.10	0.02	0.14	0.06
1,2,4-TRIMETHYLBENZENE	0.04	0.84	0.27	0.06	0.42	0.16
m - DICHLOROBENZENE	0.02	0.10	0.05	ND	ND	ND
CHLOROMETHYLBENZENE	ND	ND	ND	ND	ND	ND

MCHD site (GJCO)	Summary Statistics WEEKDAY (PPBV)			Summary Statistics WEEKEND (PPBV)		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
p - DICHLOROBENZENE	0.02	0.08	0.05	ND	ND	ND
o - DICHLOROBENZENE	ND	ND	ND	ND	ND	ND
1,2,4-TRICHLOROBENZENE	ND	ND	ND	ND	ND	ND
HEXACHLORO-1,3-BUTADIENE	ND	ND	ND	ND	ND	ND

Table 3.6, completed.

Table 3.7 - Summary statistics for the weekday samples versus the same statistics for the weekend samples – GJ Traffic

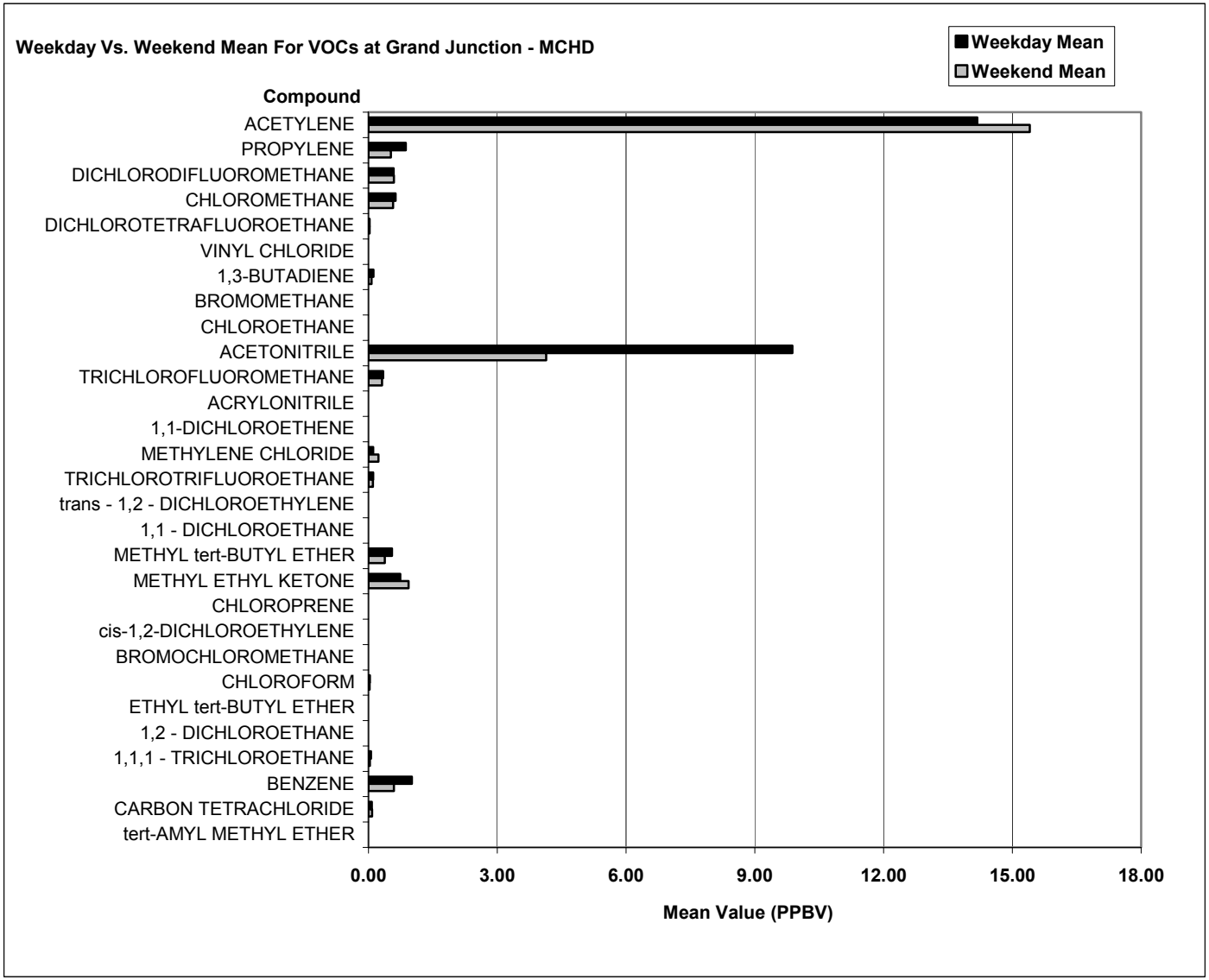
Traffic Services site (G2CO)	Summary Statistics WEEKDAY (PPBV)			Summary Statistics WEEKEND (PPBV)		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
ACETYLENE	0.07	9.50	2.98	0.90	13.52	3.76
PROPYLENE	0.30	2.21	0.77	0.22	1.80	0.69
DICHLORODIFLUOROMETHANE	0.47	0.85	0.59	0.44	0.70	0.57
CHLOROMETHANE	0.44	0.81	0.58	0.50	0.74	0.61
DICHLOROTETRAFLUOROETHANE	0.01	0.03	0.03	0.01	0.03	0.03
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND
1,3-BUTADIENE	0.02	0.33	0.09	0.02	0.19	0.08
BROMOMETHANE	ND	ND	ND	ND	ND	ND
CHLOROETHANE	ND	ND	ND	0.04	0.07	0.05
ACETONITRILE	0.13	2.65	0.36	0.13	27.69	2.13
TRICHLOROFLUOROMETHANE	0.21	0.61	0.30	0.17	1.36	0.38
ACRYLONITRILE	0.08	0.26	0.16	0.11	1.03	0.23
1,1-DICHLOROETHENE	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	0.02	1.29	0.16	0.03	0.61	0.17
TRICHLOROTRIFLUOROETHANE	0.08	0.16	0.11	0.08	0.16	0.11
trans - 1,2 - DICHLOROETHYLENE	ND	ND	ND	ND	ND	ND
1,1 - DICHLOROETHANE	ND	ND	ND	ND	ND	ND
METHYL tert-BUTYL ETHER	0.04	1.08	0.12	0.04	1.01	0.15
METHYL ETHYL KETONE	0.08	3.13	0.96	0.08	2.66	0.97
CHLOROPRENE	ND	ND	ND	ND	ND	ND

Traffic Services site (G2CO)	Summary Statistics WEEKDAY (PPBV)			Summary Statistics WEEKEND (PPBV)		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
cis-1,2-DICHLOROETHYLENE	ND	ND	ND	0.04	0.06	0.05
BROMOCHLOROMETHANE	ND	ND	ND	ND	ND	ND
CHLOROFORM	0.01	0.05	0.03	0.02	0.07	0.03
ETHYL tert-BUTYL ETHER	ND	ND	ND	ND	ND	ND
1,2 - DICHLOROETHANE	ND	ND	ND	ND	ND	ND
1,1,1 - TRICHLOROETHANE	0.02	0.11	0.04	0.03	0.09	0.04
BENZENE	0.24	2.12	0.69	0.22	1.59	0.60
CARBON TETRACHLORIDE	0.03	0.12	0.08	0.03	0.11	0.08
tert-AMYL METHYL ETHER	ND	ND	ND	ND	ND	ND
1,2 - DICHLOROPROPANE	ND	ND	ND	ND	ND	ND
ETHYL ACRYLATE	ND	ND	ND	0.03	0.17	0.11
BROMODICHLOROMETHANE	ND	ND	ND	ND	ND	ND
TRICHLOROETHYLENE	0.04	0.05	0.04	0.04	0.08	0.05
METHYL METHACRYLATE	0.09	0.45	0.15	0.09	0.21	0.16
cis -1,3 - DICHLOROPROPENE	ND	ND	ND	ND	ND	ND
METHYL ISOBUTYL KETONE	0.08	0.58	0.13	0.08	0.54	0.16
trans - 1,3 - DICHLOROPROPENE	ND	ND	ND	ND	ND	ND
1,1,2 - TRICHLOROETHANE	ND	ND	ND	ND	ND	ND
TOLUENE	0.65	8.83	2.60	0.58	9.39	2.81
DIBROMOCHLOROMETHANE	ND	ND	ND	ND	ND	ND
1,2-DIBROMOETHANE	ND	ND	ND	ND	ND	ND
N-OCTANE	0.02	0.89	0.11	0.03	0.61	0.11
TETRACHLOROETHYLENE	0.02	0.30	0.05	0.03	0.14	0.04
CHLOROBENZENE	ND	ND	ND	ND	ND	ND

Traffic Services site (G2CO)	Summary Statistics WEEKDAY (PPBV)			Summary Statistics WEEKEND (PPBV)		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
ETHYLBENZENE	0.11	4.16	0.64	0.06	2.83	0.65
m,p - XYLENE	0.39	14.32	2.32	0.26	9.61	2.39
BROMOFORM	ND	ND	ND	ND	ND	ND
STYRENE	0.01	0.30	0.08	0.03	0.31	0.08
1,1,2,2 - TETRACHLOROETHANE	ND	ND	ND	0.03	0.10	0.06
o - XYLENE	0.20	4.14	0.92	0.11	3.81	1.02
1,3,5-TRIMETHYLBENZENE	0.04	0.47	0.11	0.03	0.54	0.12
1,2,4-TRIMETHYLBENZENE	0.09	1.05	0.32	0.05	1.73	0.37
m - DICHLOROBENZENE	ND	ND	ND	ND	ND	ND
CHLOROMETHYLBENZENE	ND	ND	ND	ND	ND	ND
p - DICHLOROBENZENE	0.01	0.08	0.05	0.01	0.08	0.06
o - DICHLOROBENZENE	ND	ND	ND	ND	ND	ND
1,2,4-TRICHLOROBENZENE	ND	ND	ND	ND	ND	ND
HEXACHLORO-1,3-BUTADIENE	ND	ND	ND	ND	ND	ND

Table 3.7, completed

Figure 3.1 - Weekday Vs. Weekend Mean For VOCs At Grand Junction - MCHD



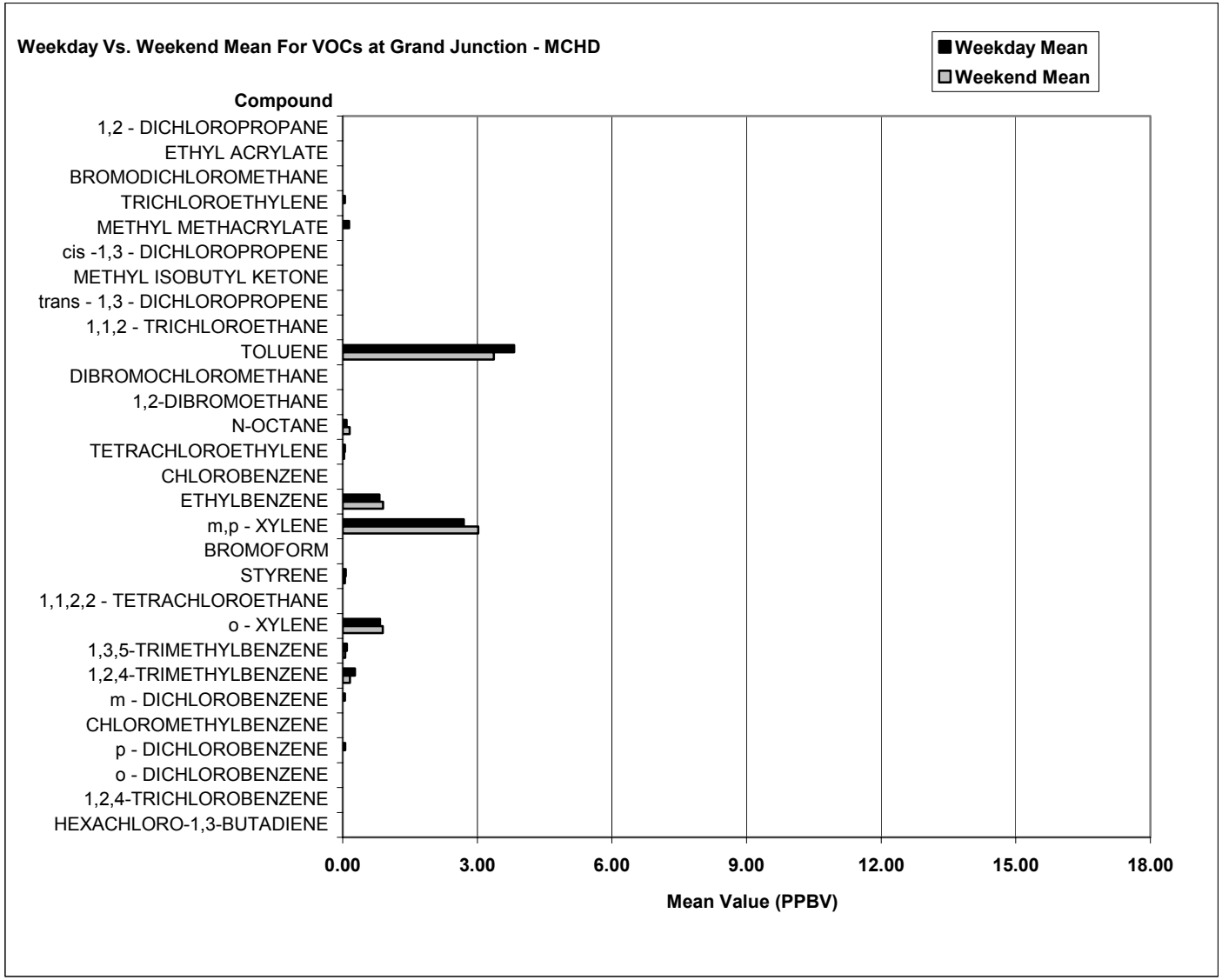
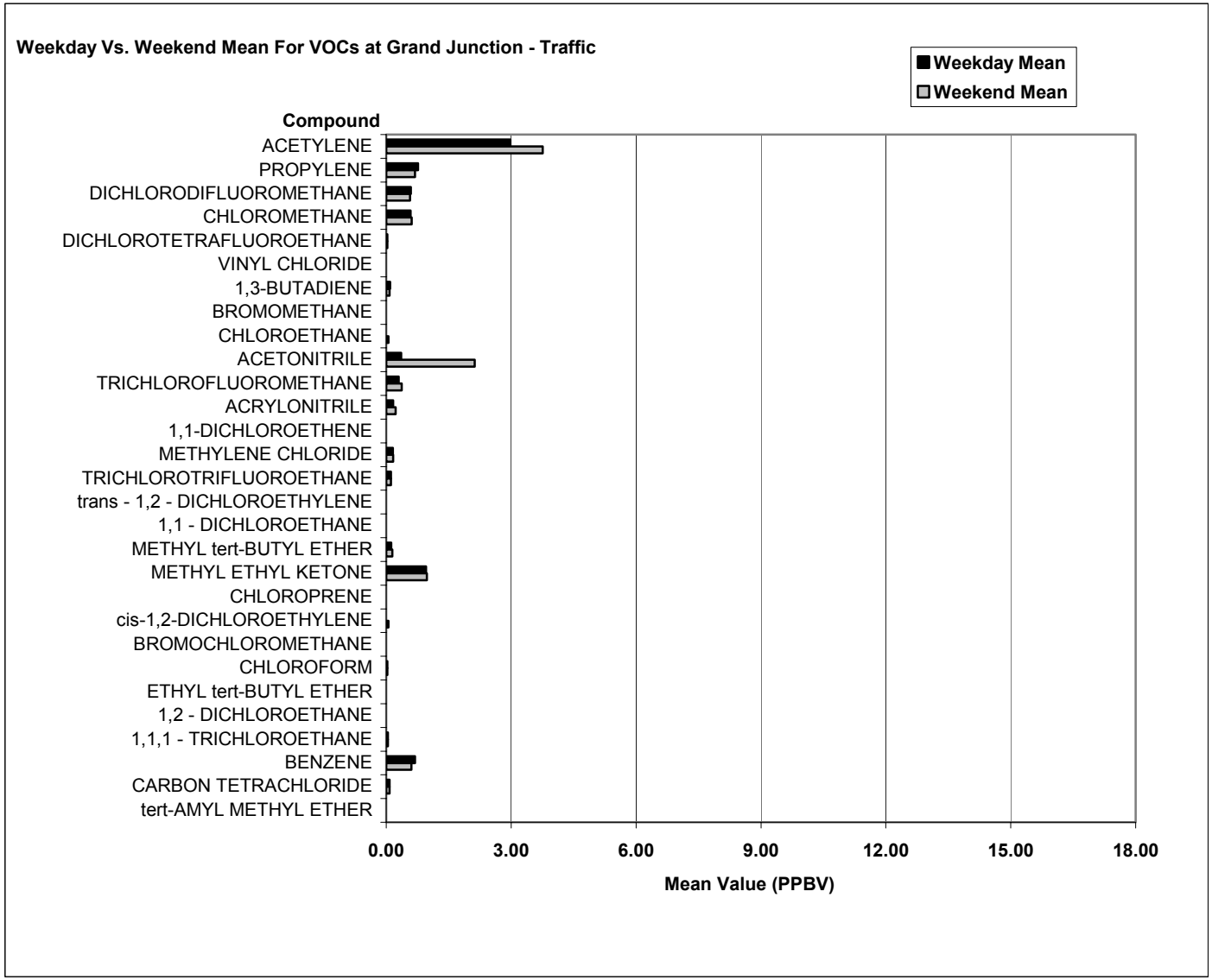


Figure 3.1, completed.

Figure 3.2 - Weekday Vs. Weekend Mean For VOCs At Grand Junction - Traffic



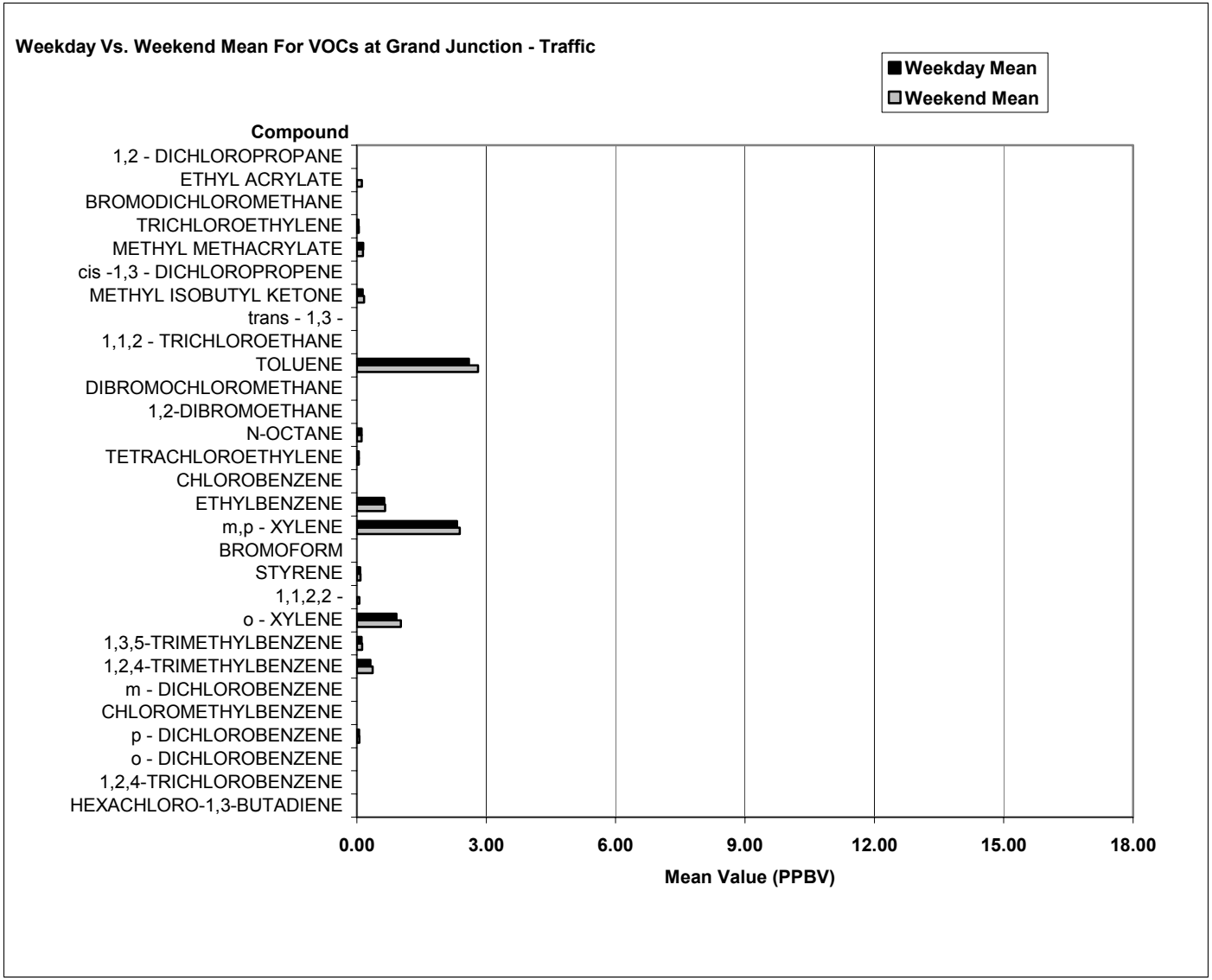


Figure 3.2, completed.

Figure 3.3 - Largest Concentration Volatile Organic Compounds At GJ - MCHD

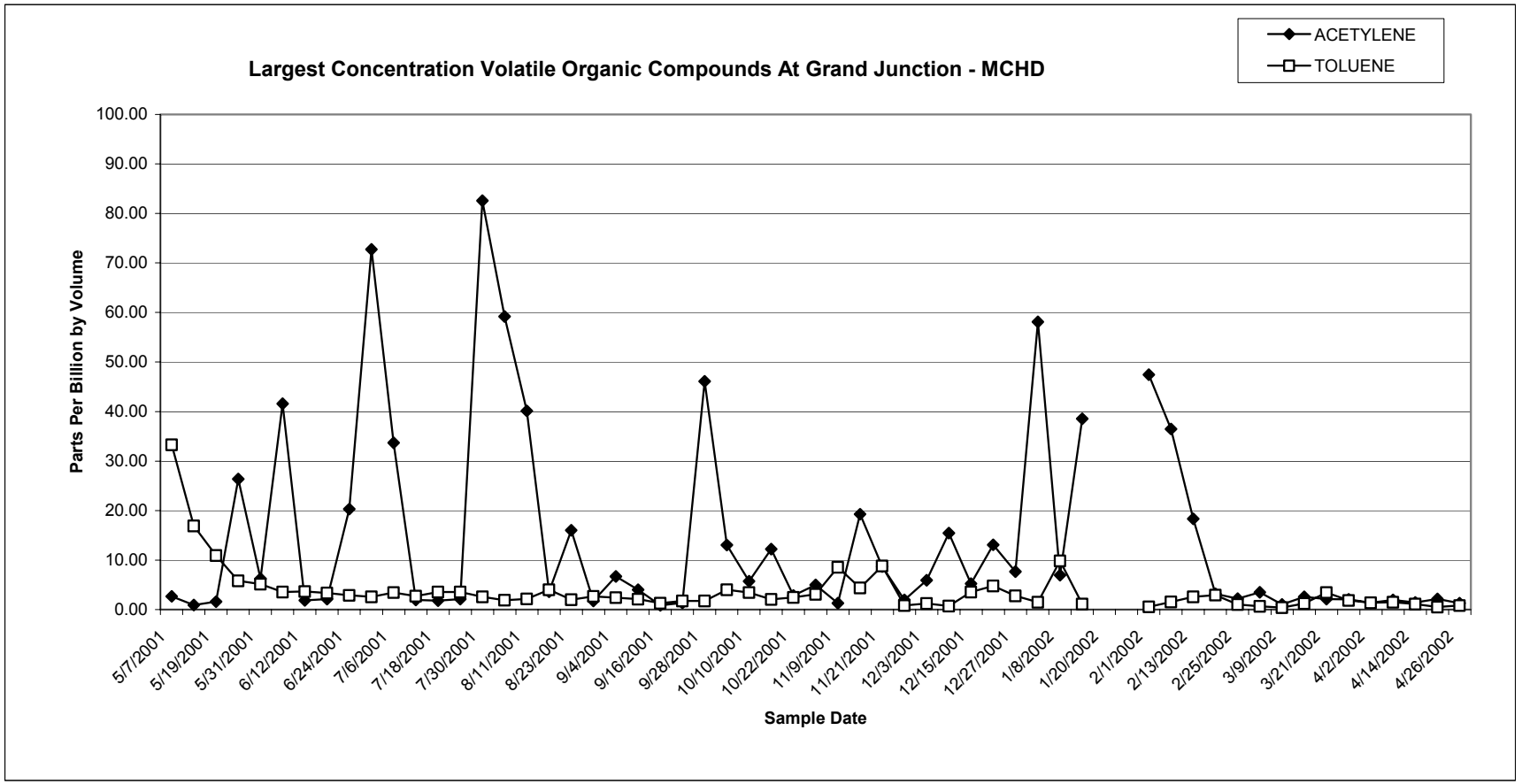


Figure 3.4 - Largest Concentration Volatile Organic Compounds At GJ - Traffic

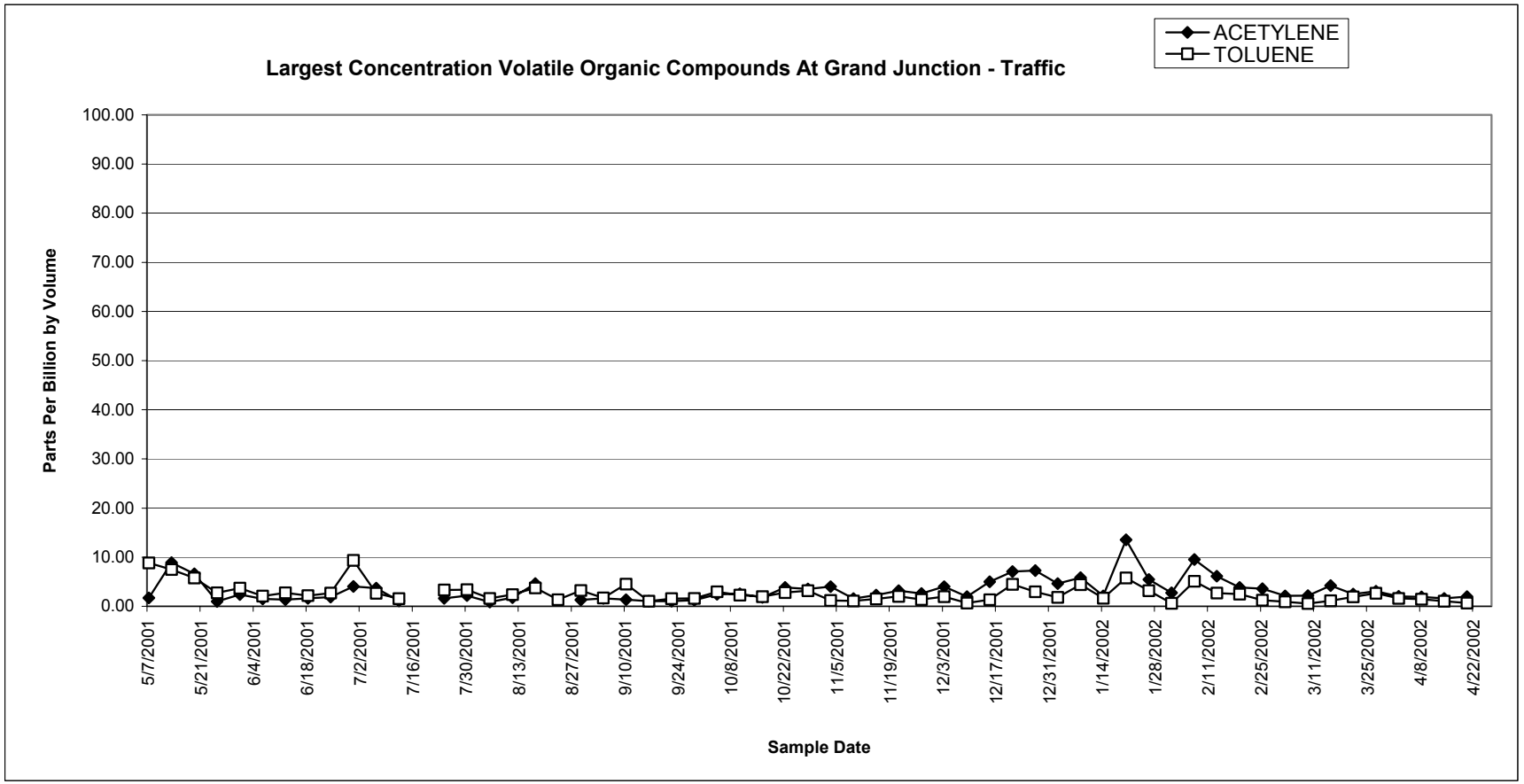


Figure 3.5 - Largest Concentration Volatile Organic Compounds At GJ - MCHD

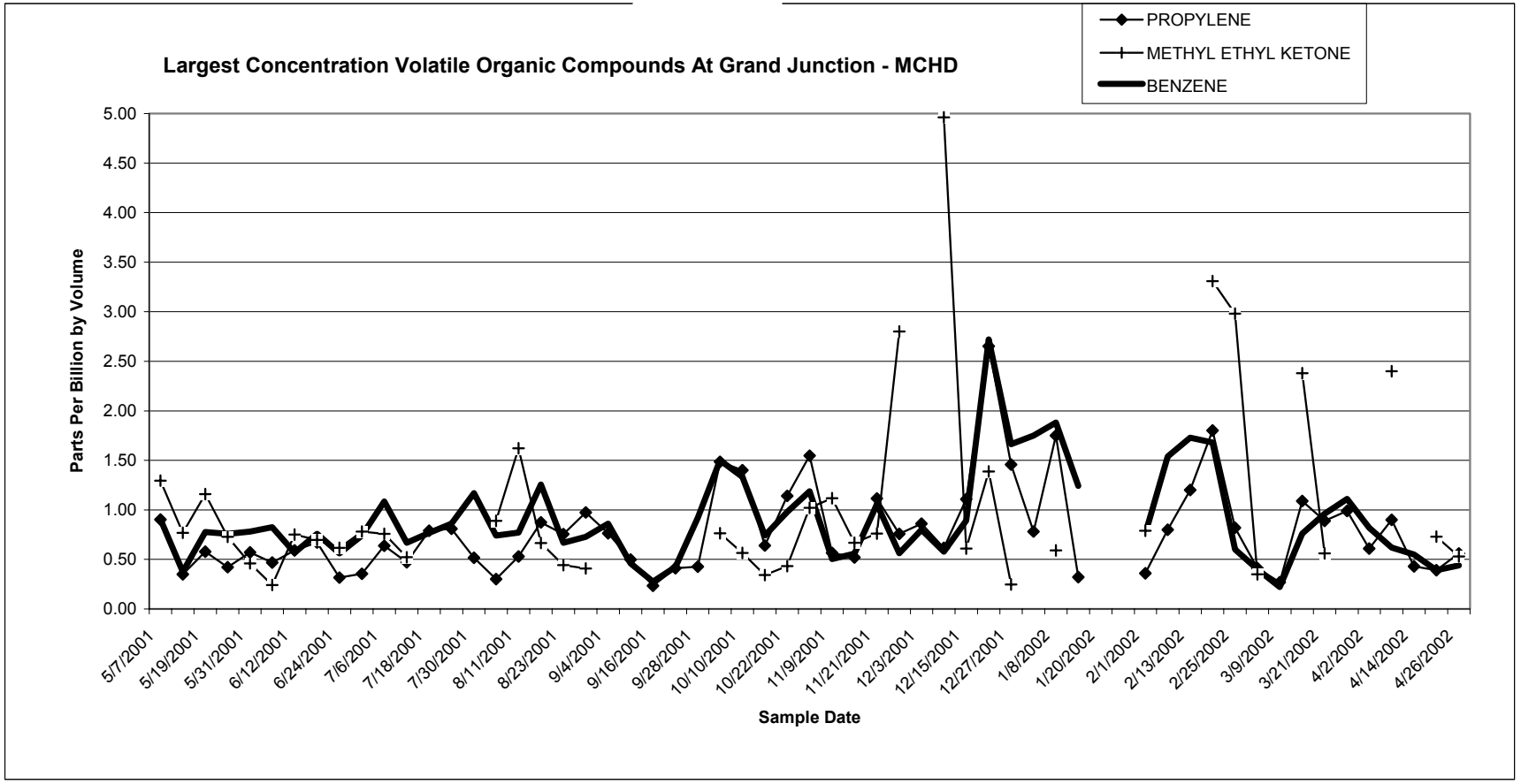


Figure 3.6 - Largest Concentration Volatile Organic Compounds At GJ - Traffic

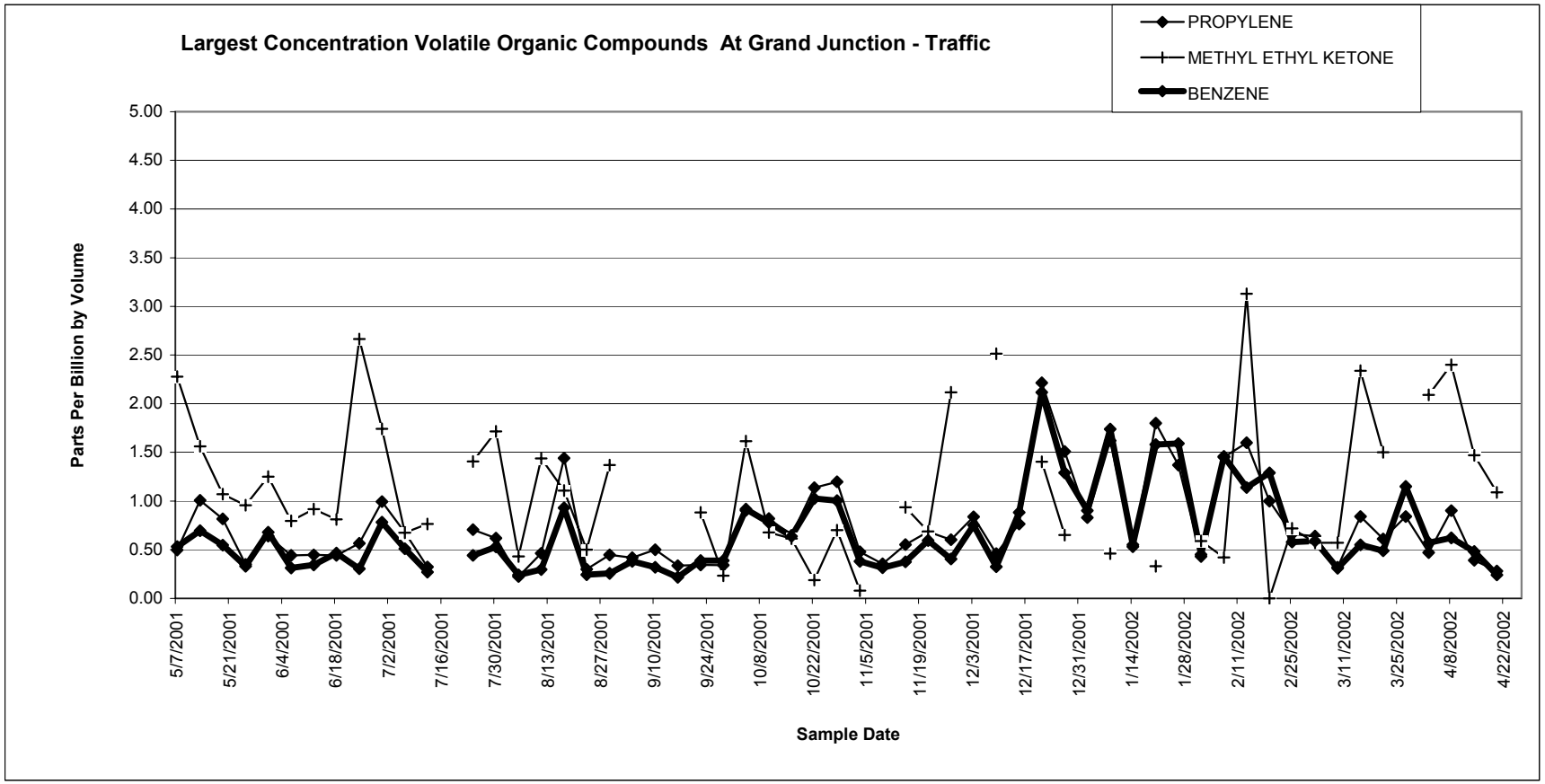


Figure 3.7 – Dichlorodifluoromethane and Chloromethane At GJ - MCHD

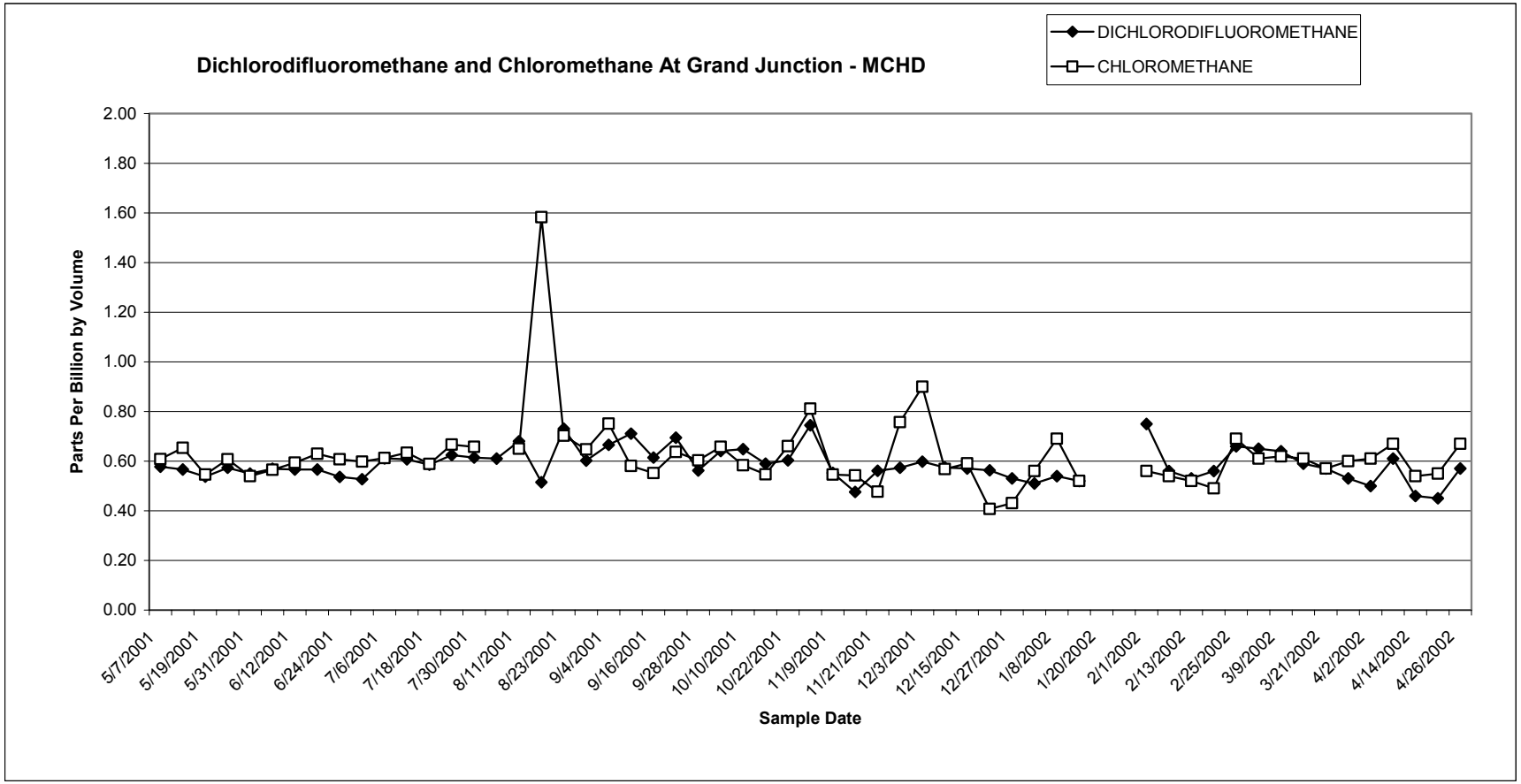


Figure 3.8 – Dichlorodifluoromethane and Chloromethane At GJ - Traffic

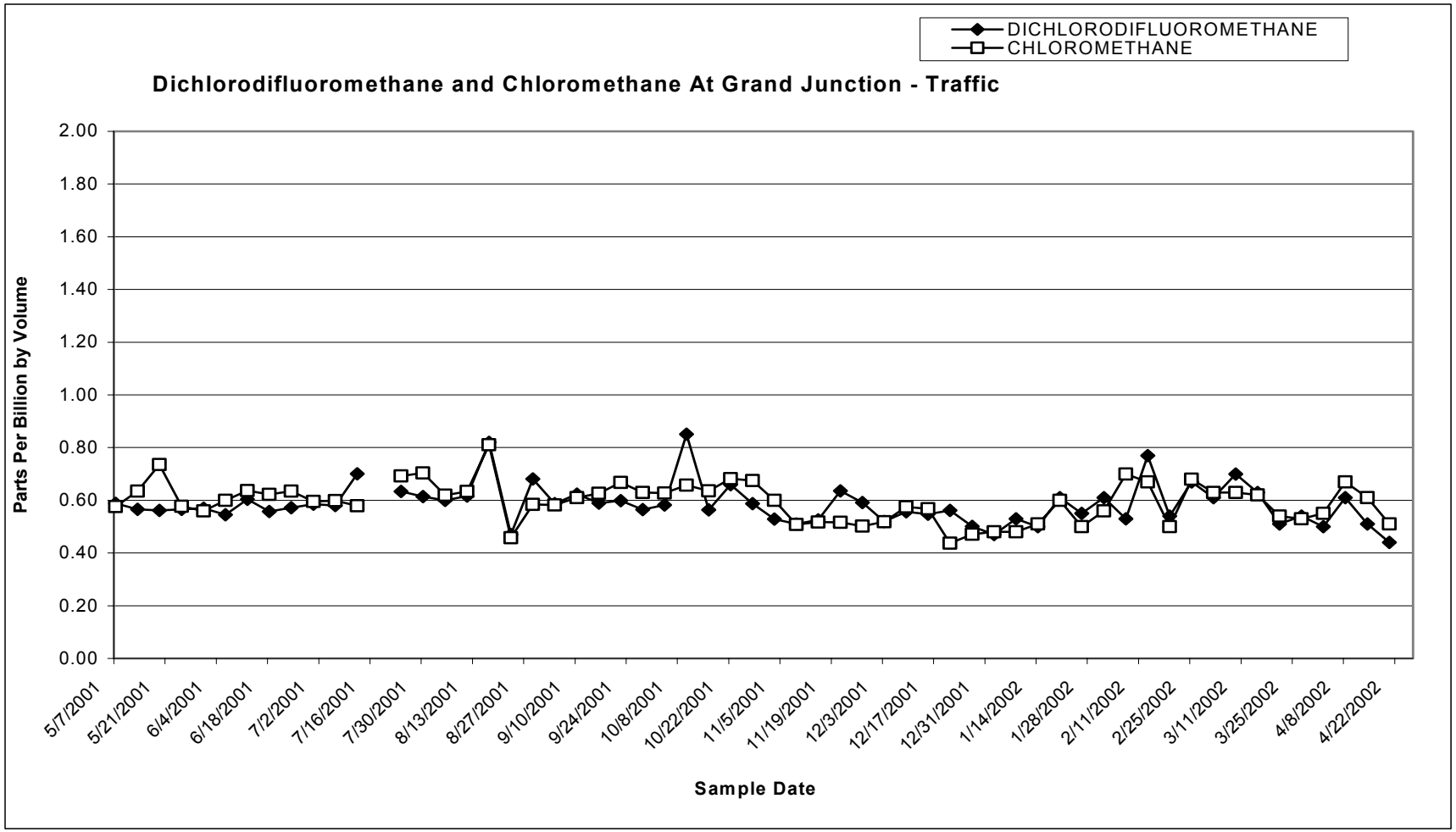


Figure 3.9 – Trichlorofluoromethane, Methylene Chloride and Trichlorotrifluoroethane At GJ - MCHD

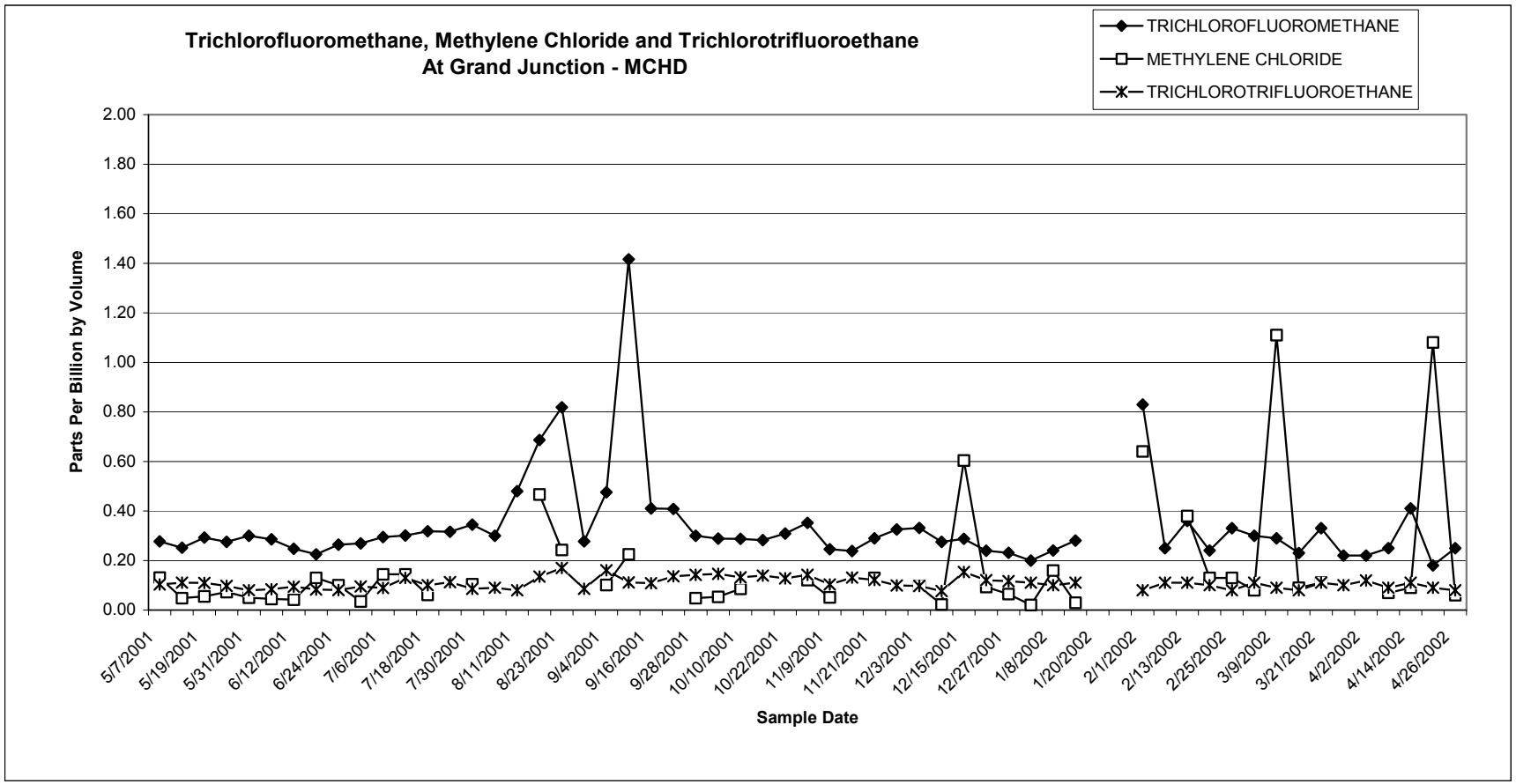


Figure 3.10 – Trichlorofluoromethane, Methylene Chloride and Trichlorotrifluoroethane At GJ - Traffic

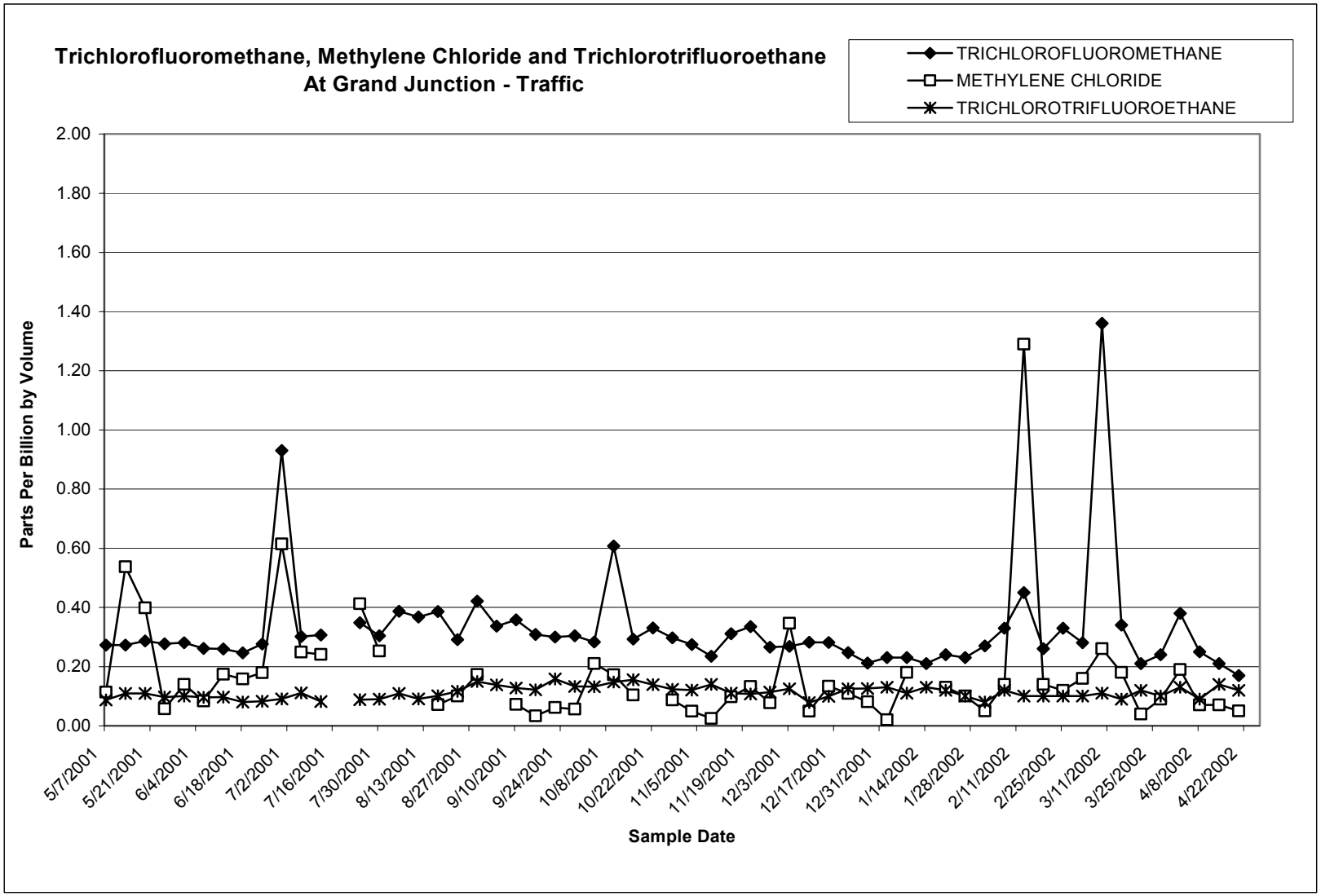


Figure 3.11 – Carbon Tetrachloride and 1,1,1- Trichloroethane At GJ - MCHD

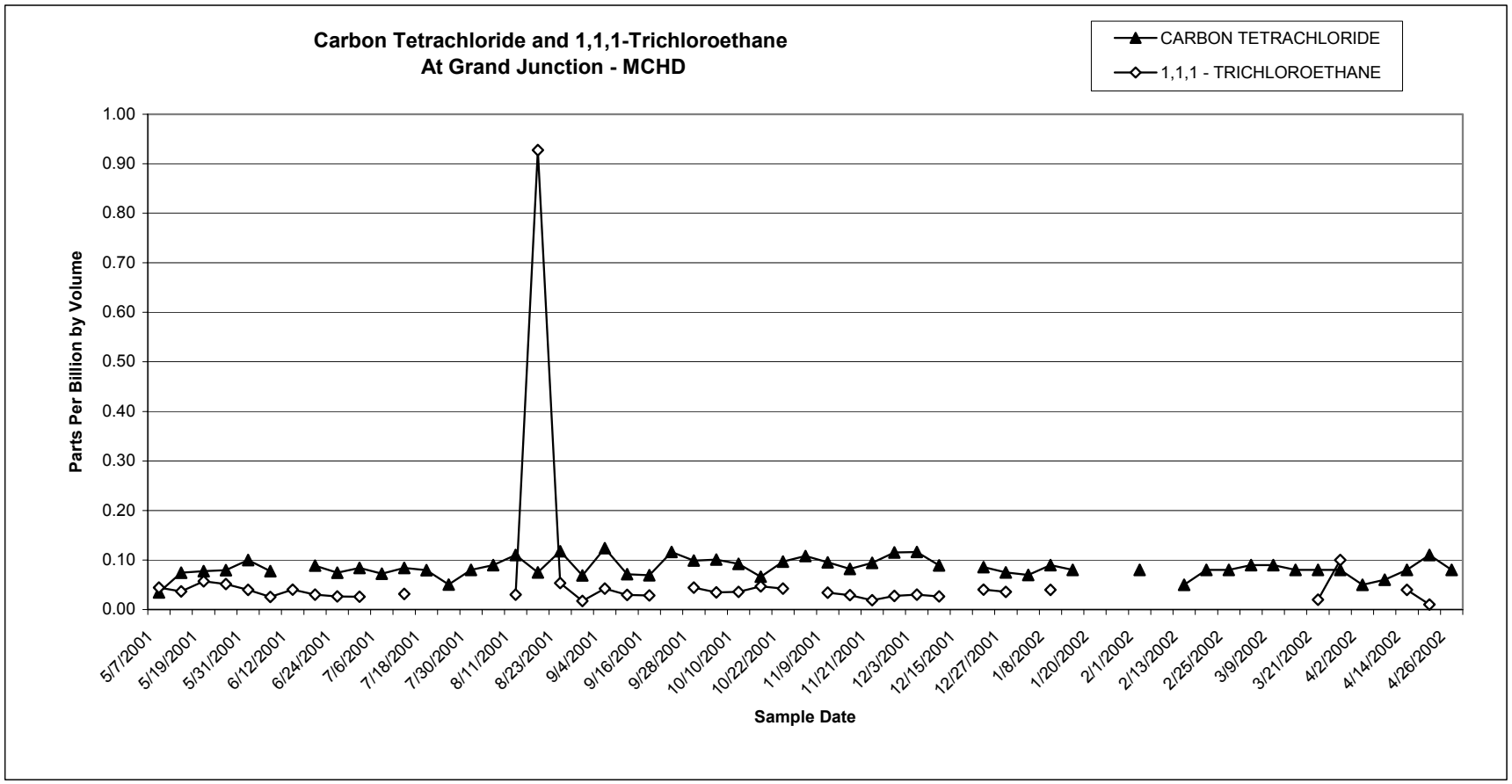


Figure 3.12 – Carbon Tetrachloride and 1,1,1- Trichloroethane At GJ – Traffic

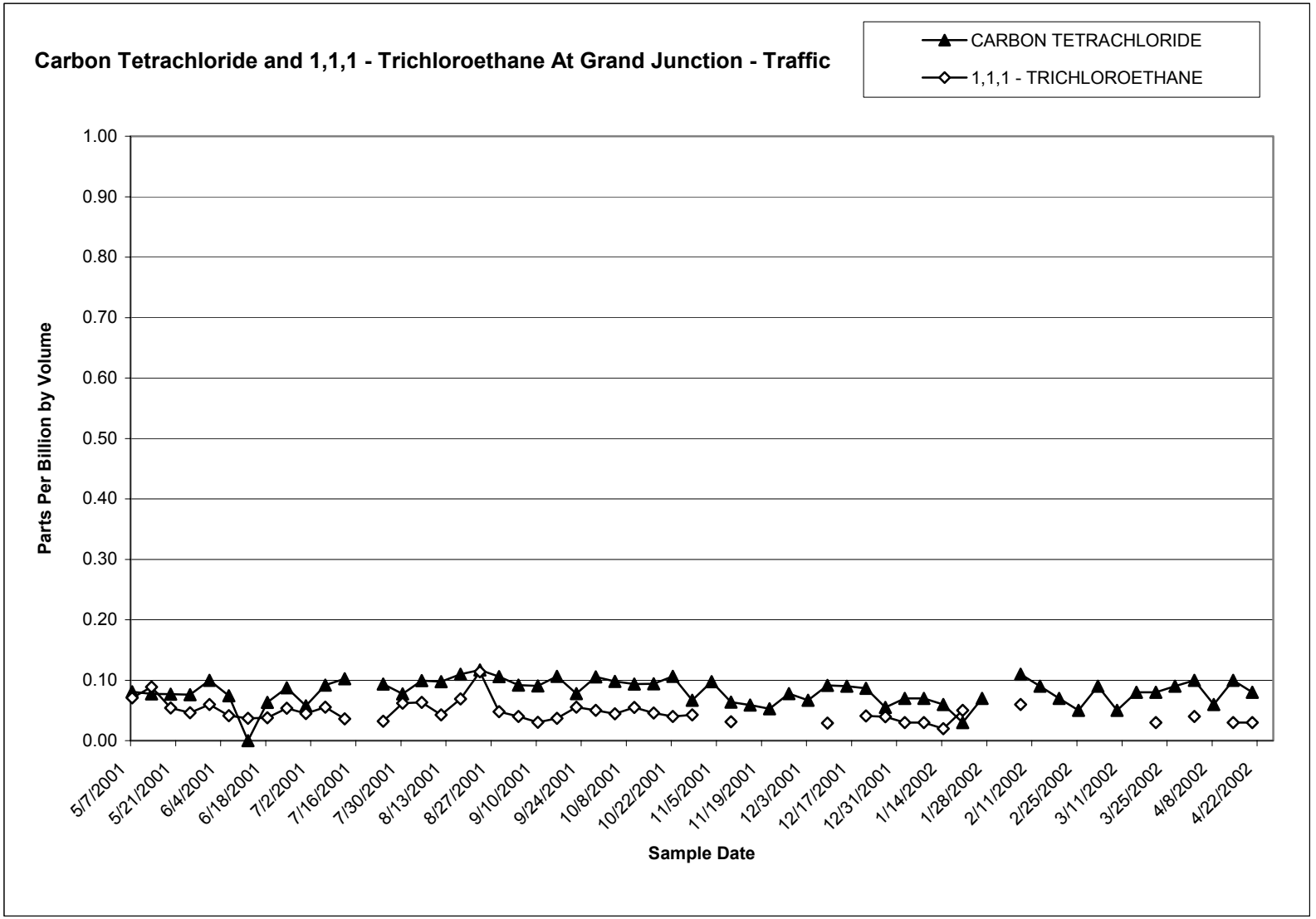


Figure 3.13 – Acetonitrile At GJ – MCHD

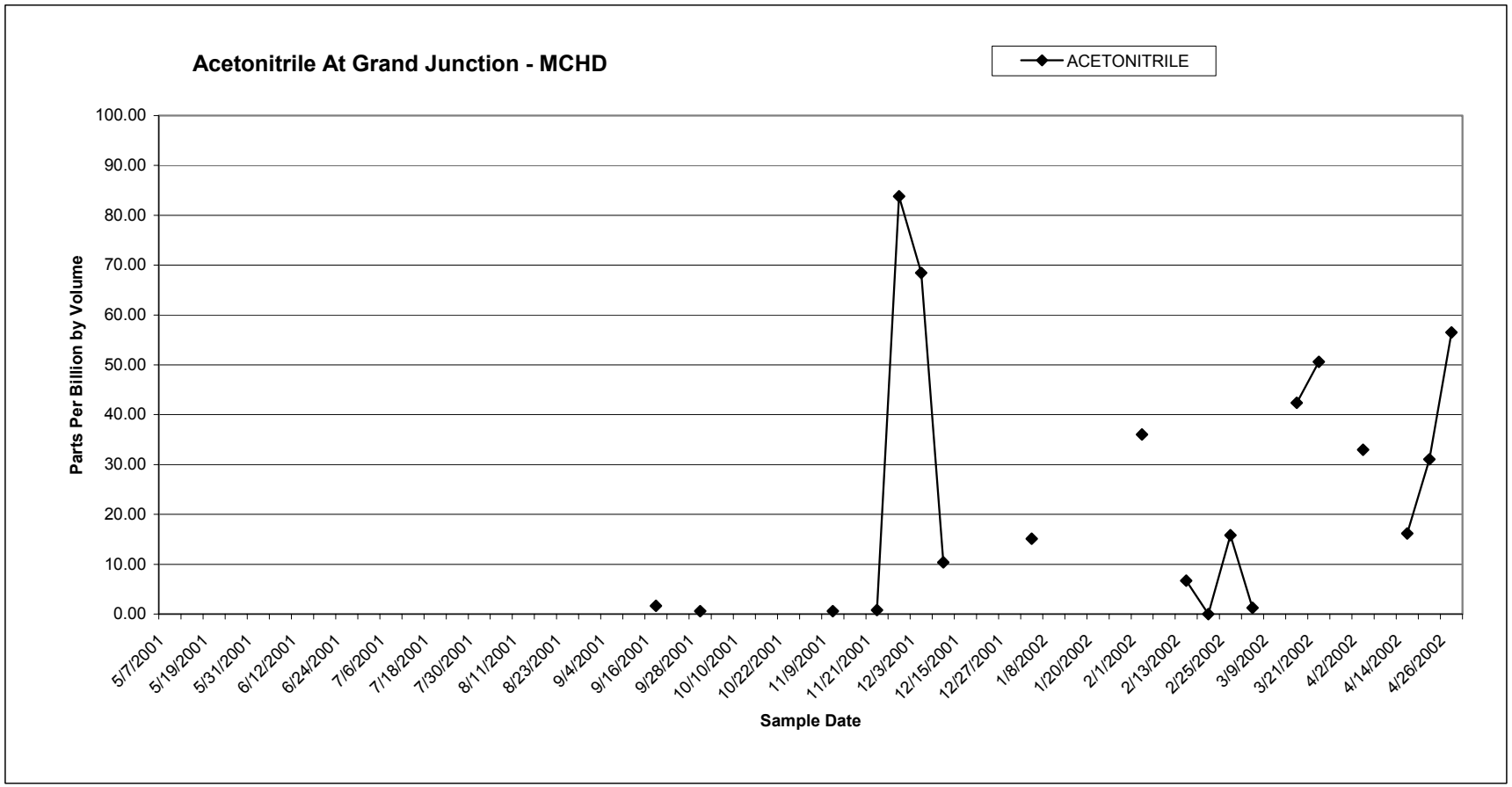


Figure 3.14 – Acetonitrile At GJ – Traffic

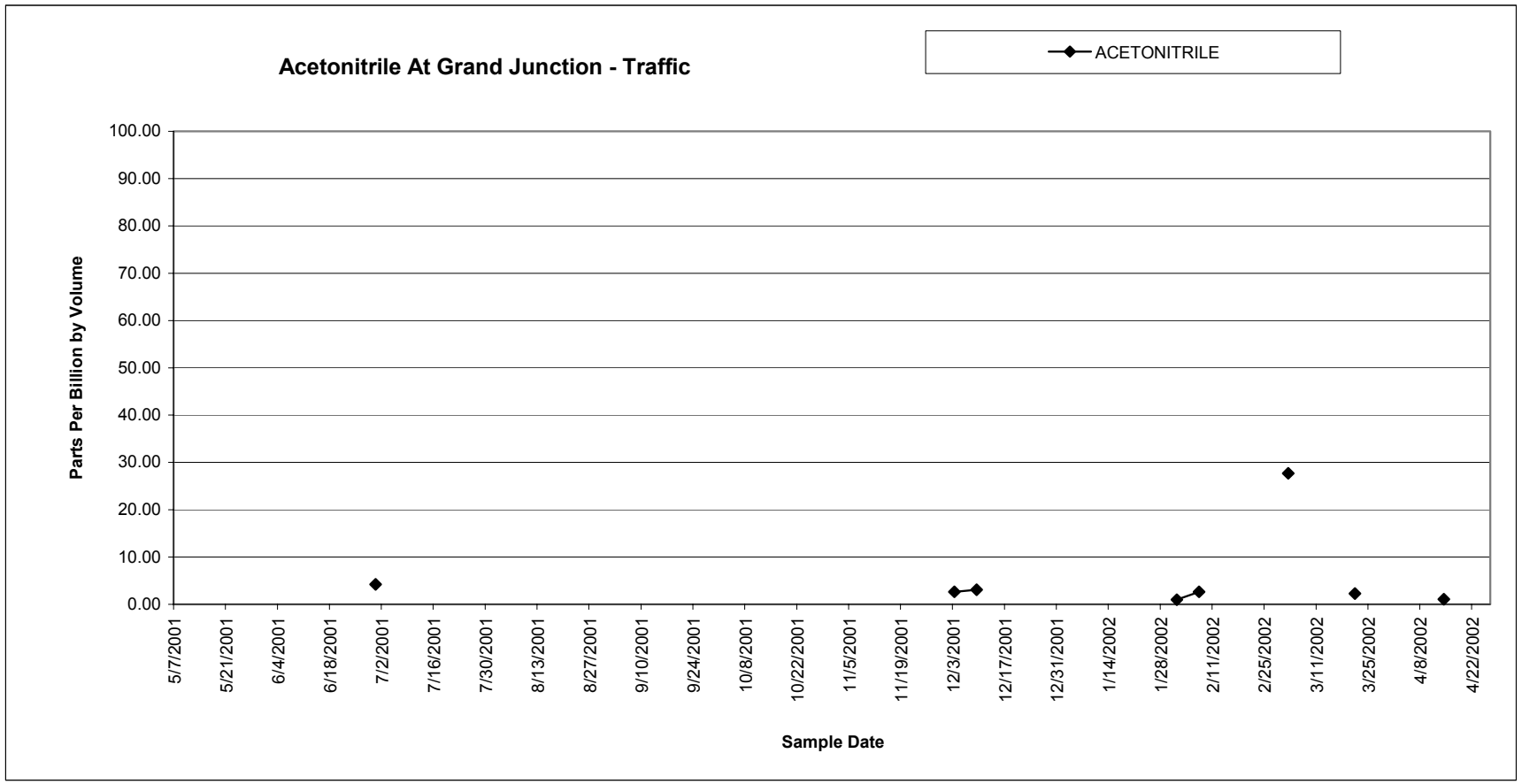


Figure 3.15 – 1,3-Butadiene At GJ – MCHD

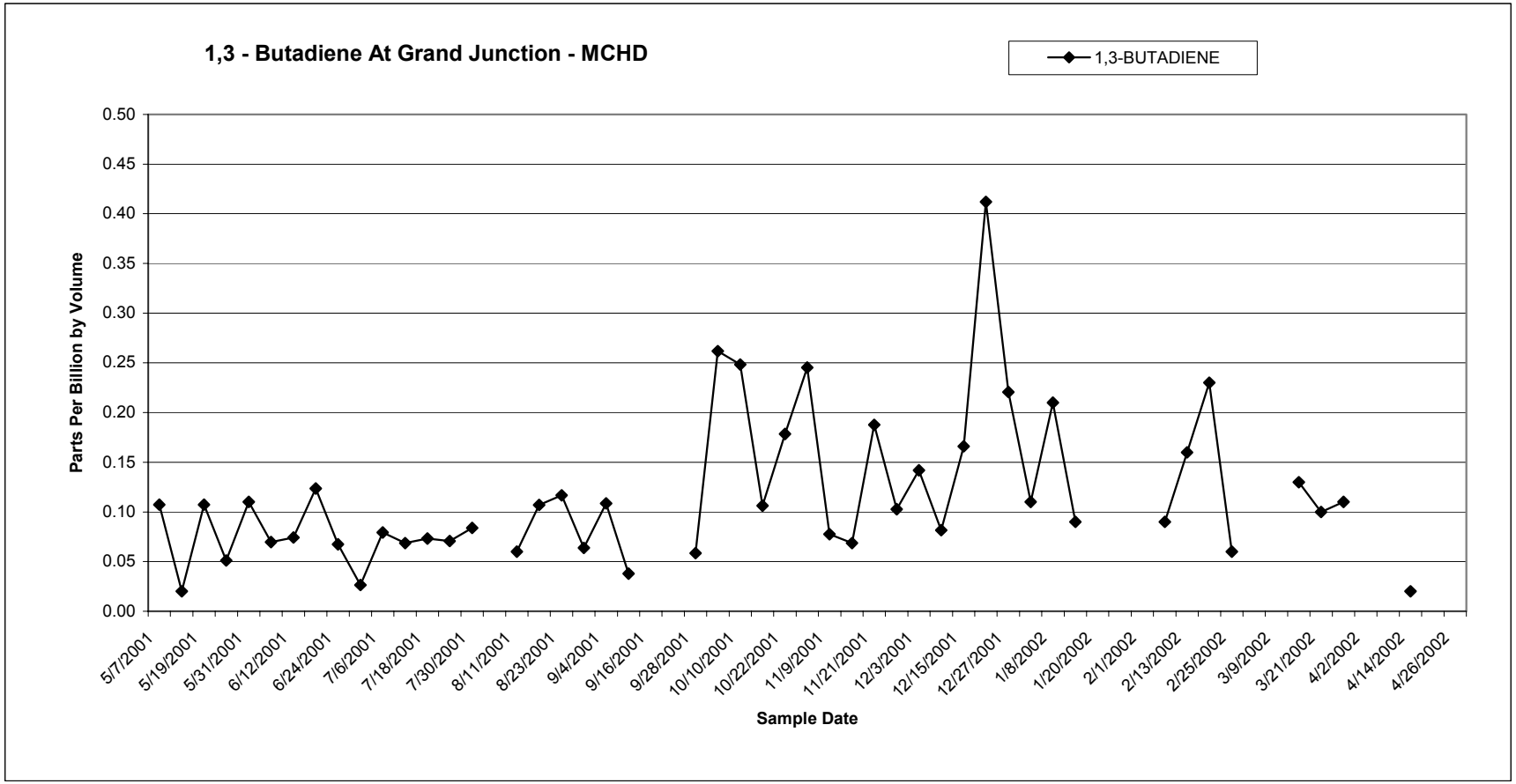


Figure 3.16 – 1,3-Butadiene At GJ – Traffic

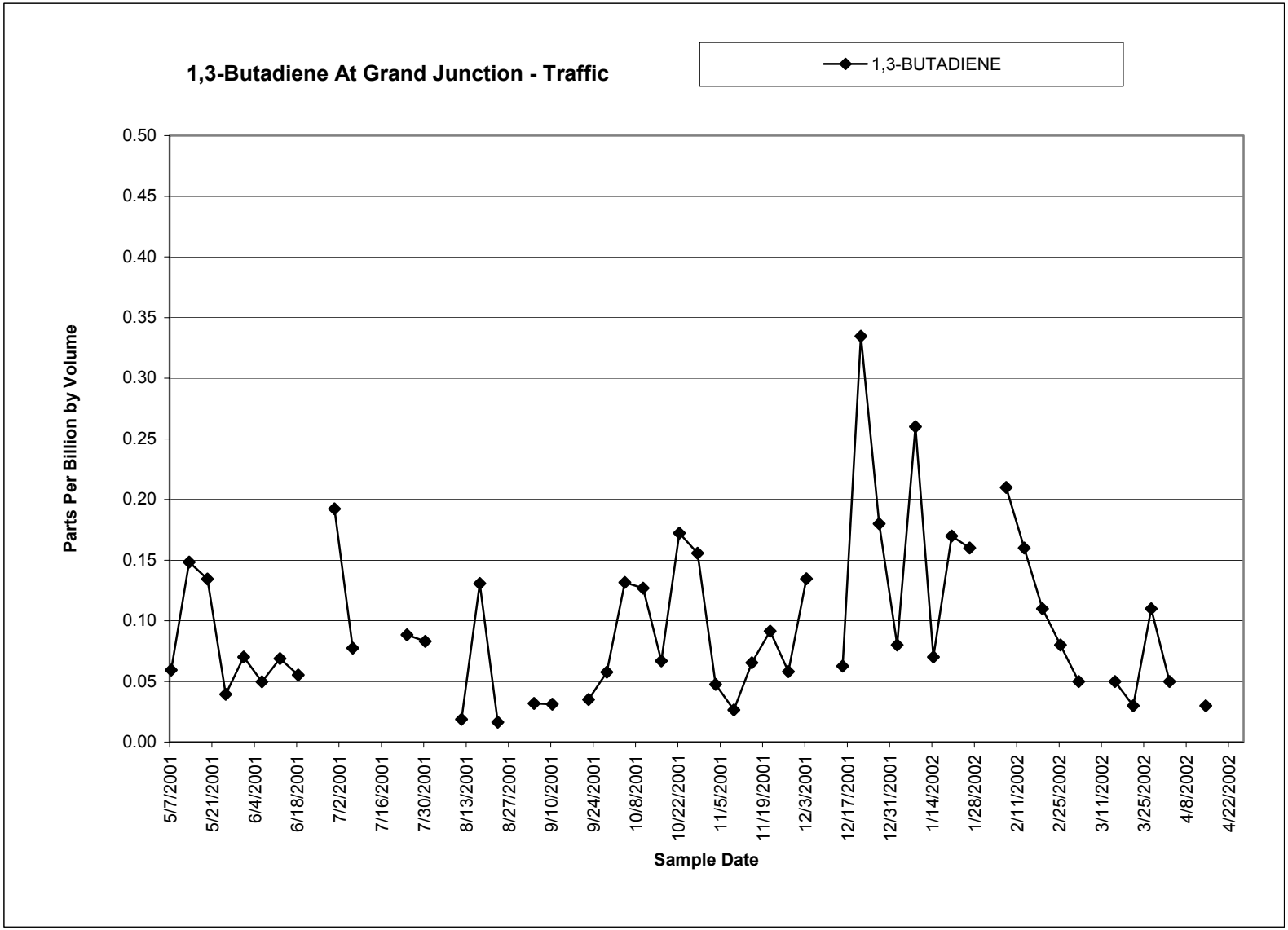


Figure 3.17 – BTEX Compounds At GJ – MCHD

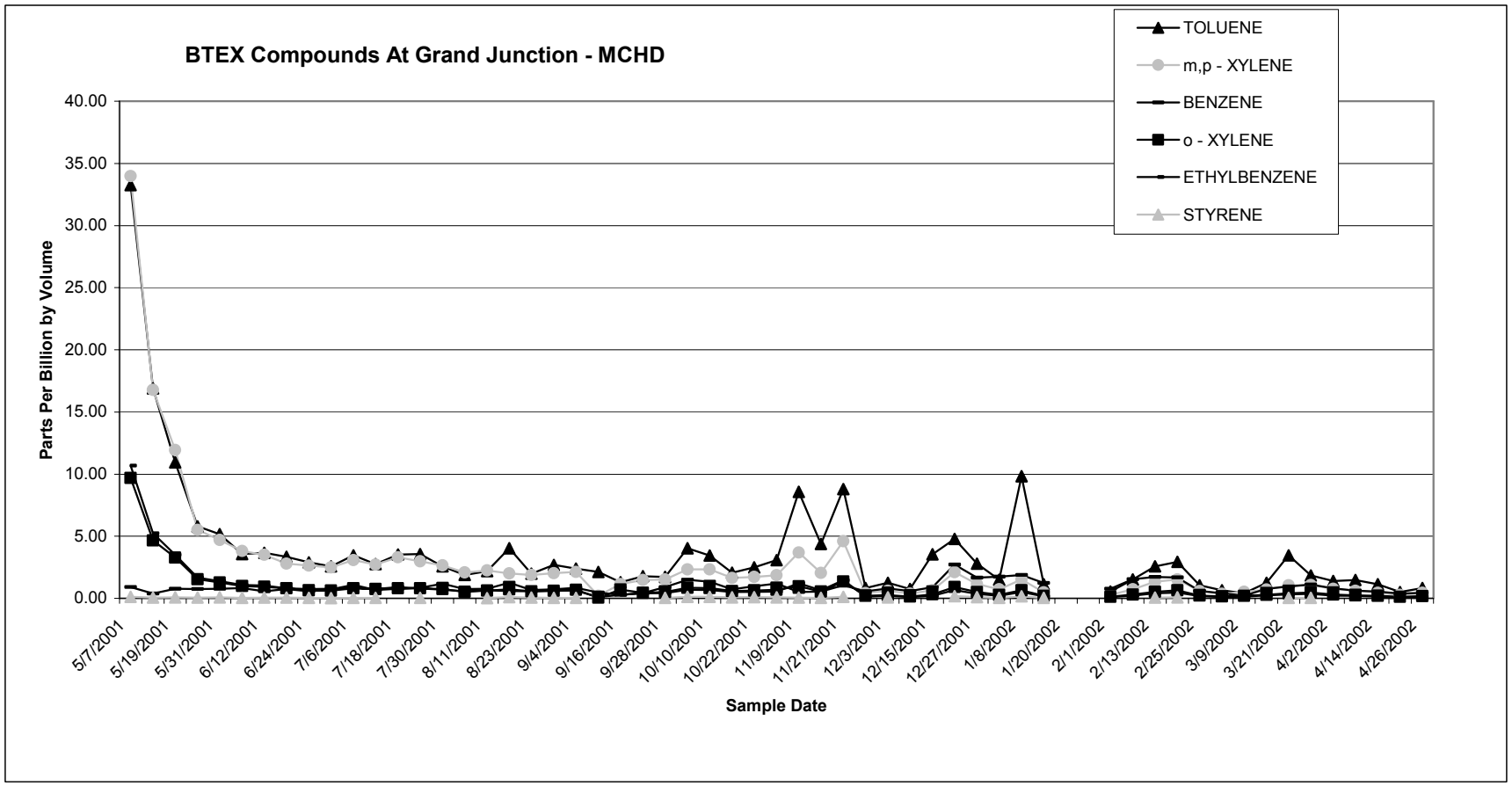


Figure 3.18 – BTEX Compounds At GJ – Traffic

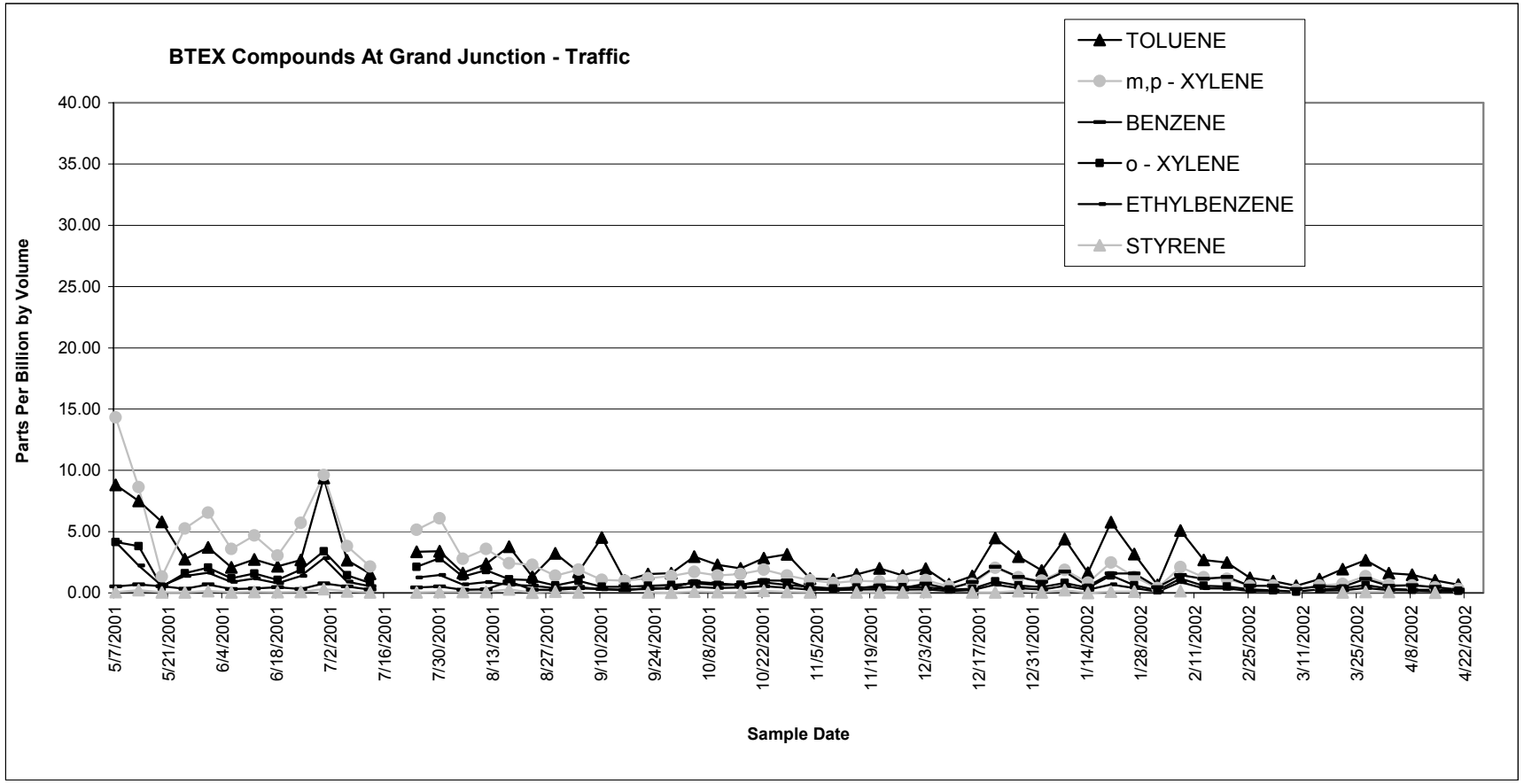


Figure 3.19 – 1,2,4-Trimethylbenzene and 1,3,5-Trimethylbenzene At GJ – MCHD

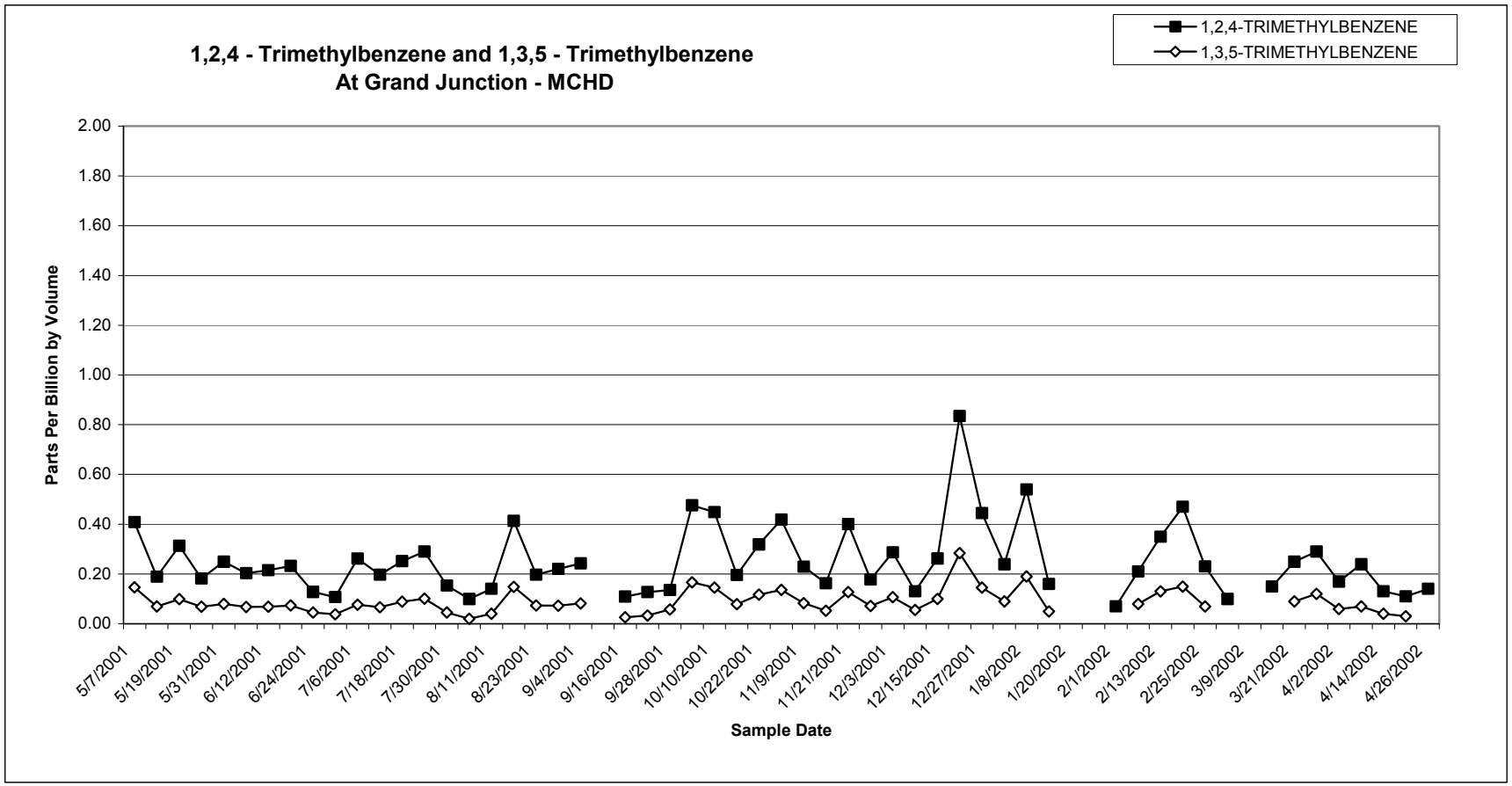


Figure 3.20 – 1,2,4-Trimethylbenzene and 1,3,5-Trimethylbenzene At GJ – Traffic

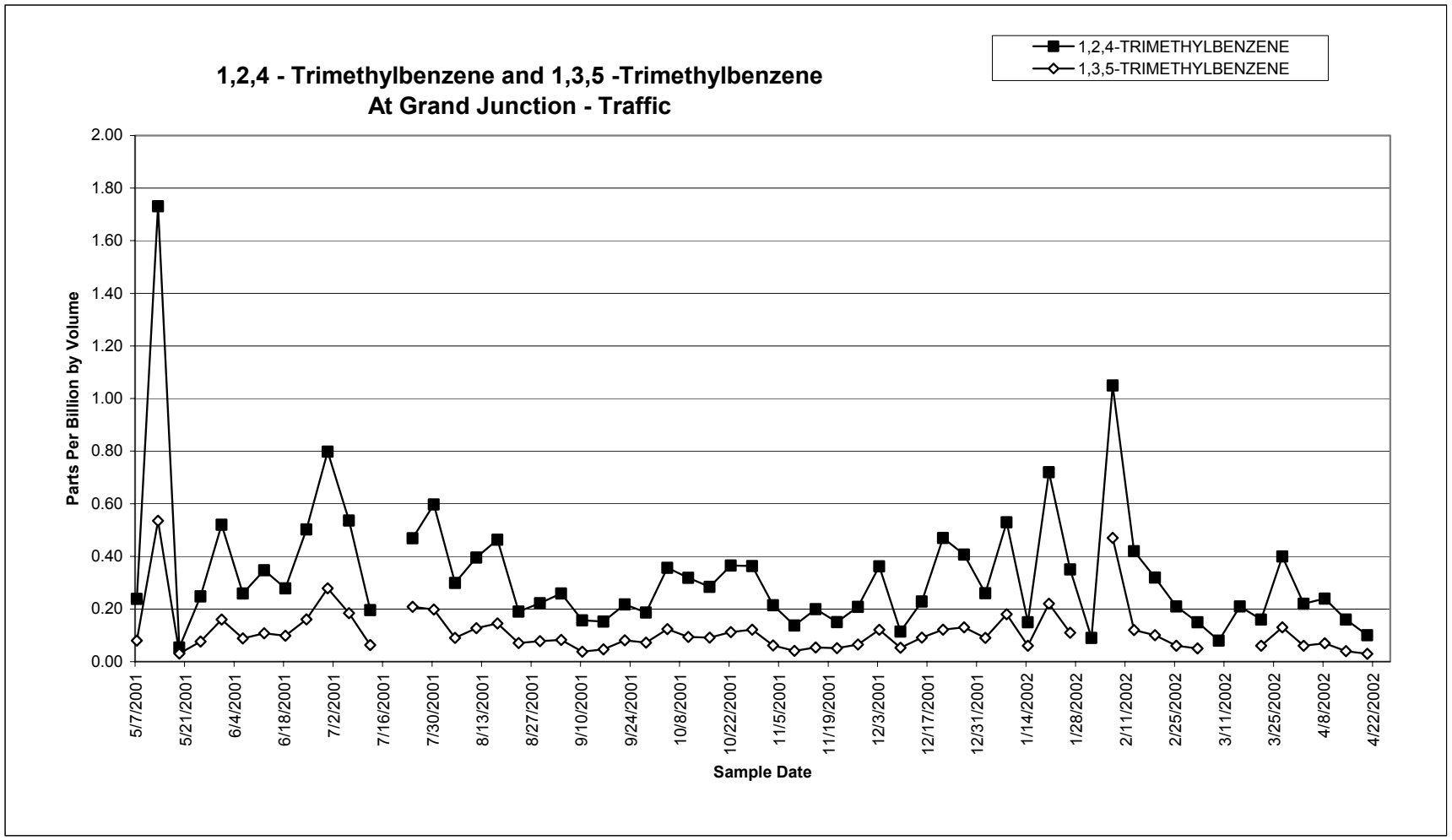


Figure 3.21 – Methyl tert-Butyl Ether At GJ – MCHD

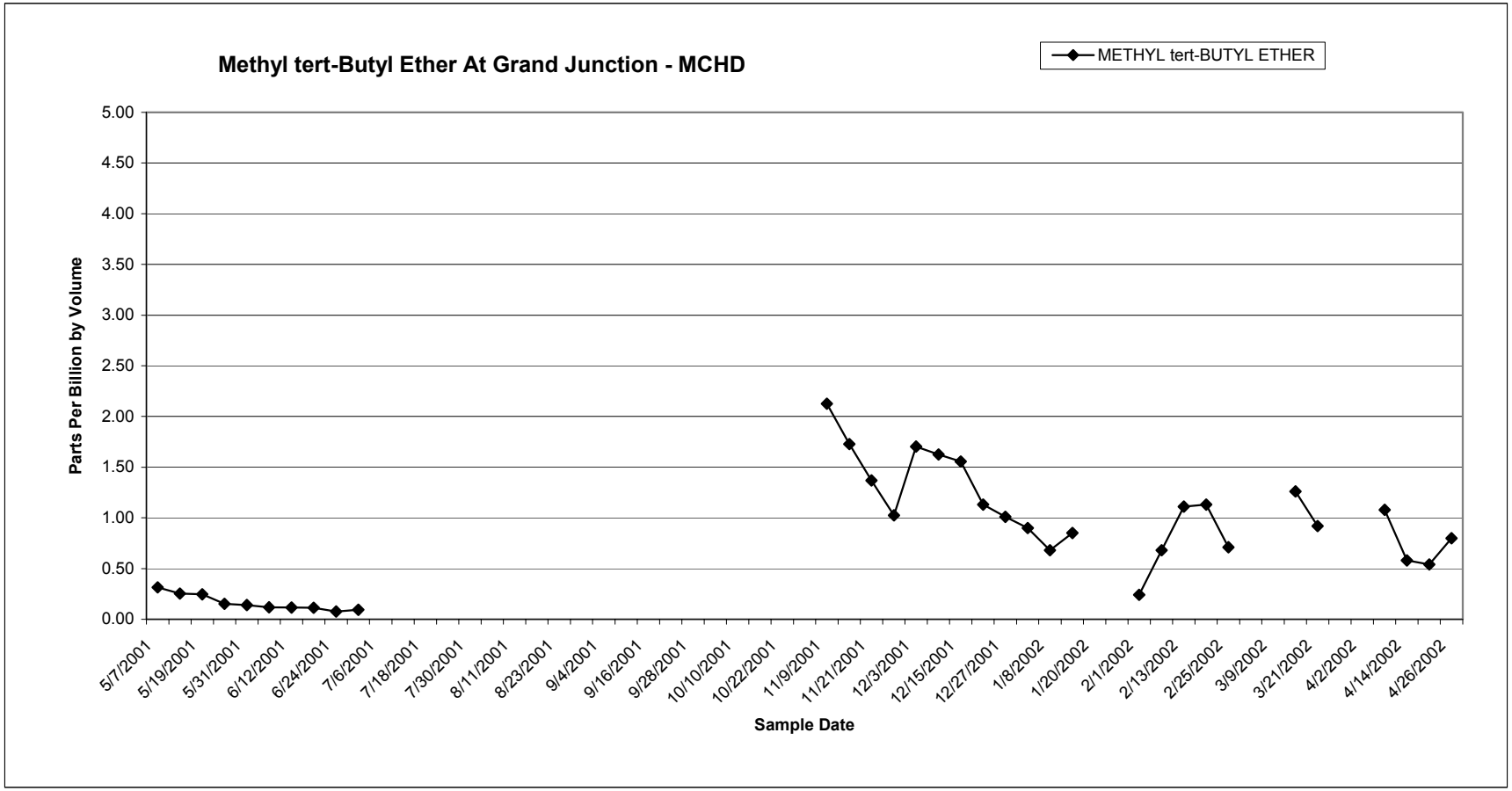
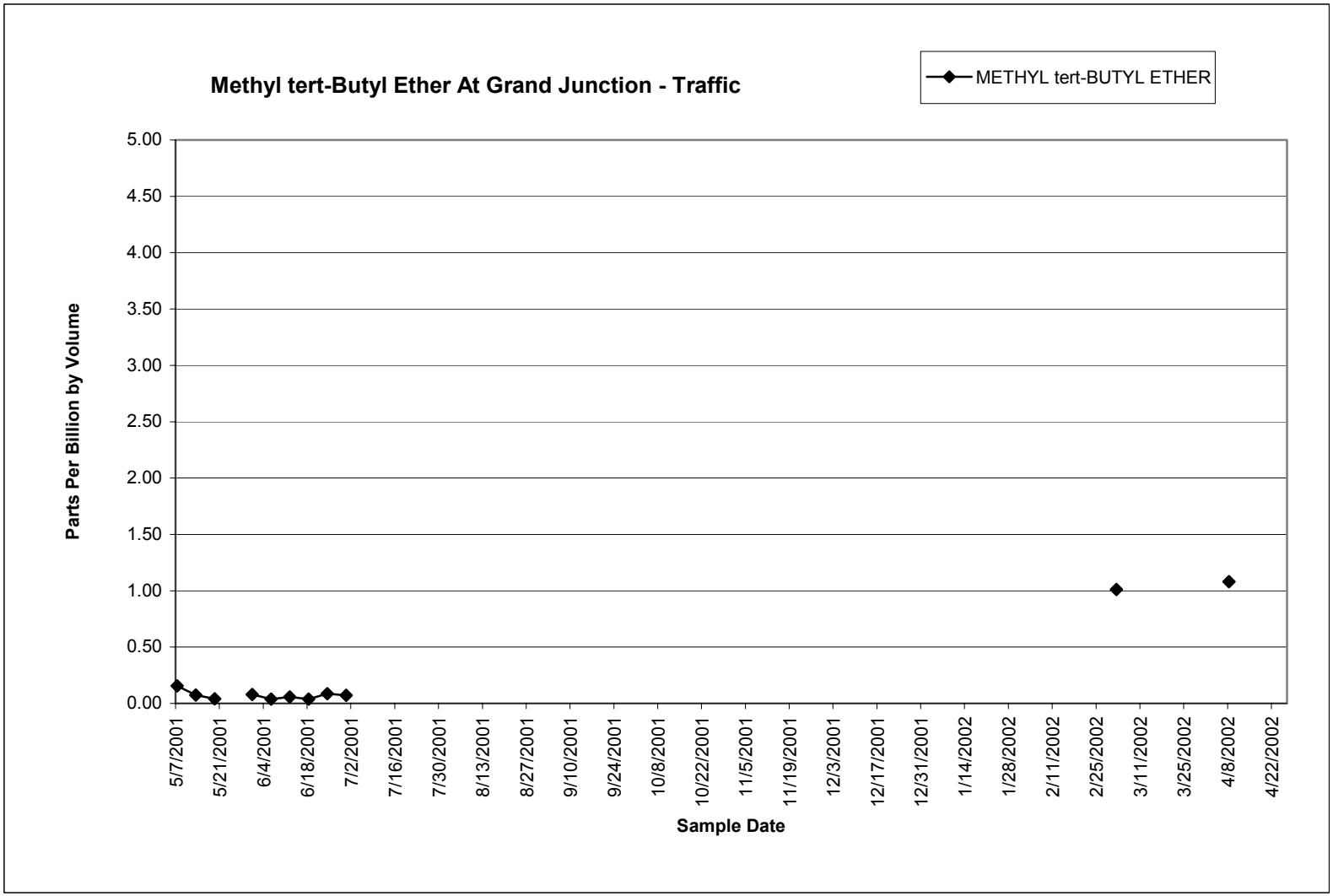


Figure 3.22 – Methyl tert-Butyl Ether At GJ – Traffic



Correlation Coefficients Between Compounds – Volatile Organic Compounds

A correlation coefficient analysis was conducted for the volatile organic compounds. To simplify the calculations, only VOCs detected in over 75% of the air samples were analyzed for correlation to other compounds. At the MCHD site, propylene showed strong correlation to 1,3-butadiene, benzene, styrene, 1,3,5-trimethylbenzene, and 1,2,4-trimethylbenzene. 1,3-butadiene was strongly correlated to benzene, n-octane, styrene, and the two trimethylbenzene isomers. These relationships suggest that vehicular traffic is the source of these compounds. Chlorofluorocarbons showed little correlation to other compounds, or to each other.

Correlations at the Traffic site (Table 3.9) were similar to MCHD (Table 3.8), but weaker. Acetylene, propylene, 1,3-butadiene, benzene, toluene, ethylbenzene and xylenes correlated well to one another.

Table 3.10 calculates correlations for each compound at the Traffic site, versus all the compounds at the MCHD site. BTEX compounds, propylene, and 1,3-butadiene show good inter-correlation across the two sites. This suggests that mobile source inputs to the two locations are similar.

Precision of Sample Results – Volatile Organic Compounds

Periodically throughout the year, a second canister was sampled simultaneously with the main 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 of the analytical process by injecting two samples of each canister's air into the gas chromatograph/mass spectrometer. These samples are known as the laboratory replicates. Thus, this project collected two types of precision data – duplicate data, which assesses both sampling and analysis procedures, and replicate data, which assesses laboratory analytical method repeatability. 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.

Table 3.8 - Correlation Coefficients For VOCs Detected In Over 75% of the Samples – GJ MCHD

MCHD site (GJCO)	ACETYLENE	PROPYLENE	DICHLORODI-FLUOROMETHANE	CHLOROMETHANE	1,3-BUTADIENE	TRICHLORO-FLUOROMETHANE
ACETYLENE	**1.00**					
PROPYLENE	-0.25	**1.00**				
DICHLORODIFLUOROMETHANE	0.01	0.01	**1.00**			
CHLOROMETHANE	-0.12	-0.04	0.12	**1.00**		
1,3-BUTADIENE	-0.22	**0.93**	0.12	-0.11	**1.00**	
TRICHLOROFLUOROMETHANE	0.02	-0.16	0.53	0.26	-0.19	**1.00**
METHYLENE CHLORIDE	-0.12	-0.14	0.03	0.13	0.12	0.18
TRICHLOROTRIFLUOROETHANE	-0.17	0.26	0.17	0.17	0.33	0.19
METHYL ETHYL KETONE	-0.10	0.14	0.05	-0.03	-0.01	-0.10
BENZENE	0.21	**0.81**	-0.17	-0.08	**0.78**	-0.17
CARBON TETRACHLORIDE	0.00	0.01	0.30	0.15	0.19	0.08
TOLUENE	-0.16	0.12	-0.12	-0.03	0.01	-0.12
N-OCTANE	-0.16	0.11	0.24	-0.06	**0.82**	0.05
ETHYLBENZENE	-0.10	-0.03	-0.07	-0.03	-0.11	-0.11
m,p - XYLENE	-0.10	-0.04	-0.07	-0.03	-0.11	-0.11
STYRENE	-0.42	**0.78**	0.04	0.00	**0.80**	-0.06
o - XYLENE	-0.12	0.01	-0.07	-0.02	-0.06	-0.11
1,3,5-TRIMETHYLBENZENE	-0.29	**0.93**	0.02	0.06	**0.89**	-0.07
1,2,4-TRIMETHYLBENZENE	-0.28	**0.92**	-0.04	0.04	**0.89**	-0.14

Bold = Correlation greater than 0.50

MCHD site (GJCO)	METHYLENE CHLORIDE	TRICHLOROTRI-FLUOROETHANE	METHYL ETHYL KETONE	BENZENE	CARBON TETRACHLORIDE	TOLUENE
ACETYLENE						
PROPYLENE						
DICHLORODIFLUOROMETHANE						
CHLOROMETHANE						
1,3-BUTADIENE						
TRICHLOROFLUOROMETHANE						
METHYLENE CHLORIDE	**1.00**					
TRICHLOROTRIFLUOROETHANE	-0.01	**1.00**				
METHYL ETHYL KETONE	-0.15	-0.35	**1.00**			
BENZENE	-0.20	0.21	-0.02	**1.00**		
CARBON TETRACHLORIDE	0.11	0.26	0.01	-0.11	**1.00**	
TOLUENE	-0.16	0.03	-0.10	0.07	-0.34	**1.00**
N-OCTANE	0.33	0.19	0.09	0.06	0.24	-0.02
ETHYLBENZENE	-0.15	-0.02	-0.06	-0.05	-0.36	**0.96**
m,p - XYLENE	-0.16	-0.02	-0.07	-0.05	-0.36	**0.96**
STYRENE	0.15	0.21	0.12	**0.61**	-0.01	0.37
o - XYLENE	-0.15	0.00	-0.06	-0.02	-0.36	**0.96**
1,3,5-TRIMETHYLBENZENE	-0.05	0.27	-0.04	**0.81**	-0.09	0.30
1,2,4-TRIMETHYLBENZENE	-0.10	0.28	-0.02	**0.81**	-0.07	0.32

Bold = Correlation greater than 0.50

MCHD site (GJCO)	N-OCTANE	ETHYLBENZENE	m,p - XYLENE	STYRENE	o - XYLENE	1,3,5-TRIMETHYL-BENZENE	1,2,4-TRIMETHYL-BENZENE
ACETYLENE							
PROPYLENE							
DICHLORODIFLUOROMETHANE							
CHLOROMETHANE							
1,3-BUTADIENE							
TRICHLOROFLUOROMETHANE							
METHYLENE CHLORIDE							
TRICHLOROTRIFLUOROETHANE							
METHYL ETHYL KETONE							
BENZENE							
CARBON TETRACHLORIDE							
TOLUENE							
N-OCTANE	**1.00**						
ETHYLBENZENE	-0.03	**1.00**					
m,p - XYLENE	-0.03	**1.00**	**1.00**				
STYRENE	0.73	0.23	0.22	**1.00**			
o - XYLENE	-0.02	**1.00**	**1.00**	0.26	**1.00**		
1,3,5-TRIMETHYLBENZENE	0.05	0.15	0.14	**0.88**	0.19	**1.00**	
1,2,4-TRIMETHYLBENZENE	0.09	0.17	0.17	**0.88**	0.21	**0.99**	**1.00**

Table 3.8, completed

Bold = Correlation greater than 0.50

Table 3.9 - Correlation Coefficients For VOCs Detected In Over 75% of the Samples – GJ Traffic

Traffic Services site (G2CO)	ACETYLENE	PROPYLENE	DICHLORODI-FLUOROMETHANE	CHLOROMETHANE	1,3-BUTADIENE	TRICHLORO-FLUOROMETHANE
ACETYLENE	**1.00**					
PROPYLENE	**0.81**	**1.00**				
DICHLORODIFLUOROMETHANE	-0.04	0.14	**1.00**			
CHLOROMETHANE	-0.03	-0.02	**0.60**	**1.00**		
1,3-BUTADIENE	**0.69**	**0.91**	0.13	-0.06	**1.00**	
TRICHLOROFLUOROMETHANE	-0.07	-0.08	0.45	0.23	0.16	**1.00**
METHYLENE CHLORIDE	0.26	0.29	0.35	0.26	0.30	0.33
TRICHLOROTRIFLUOROETHANE	0.02	0.03	-0.10	-0.10	0.01	-0.03
METHYL ETHYL KETONE	-0.12	0.04	0.08	0.04	-0.06	-0.02
BENZENE	**0.74**	**0.93**	-0.01	-0.19	**0.88**	-0.12
CARBON TETRACHLORIDE	-0.30	-0.22	0.13	0.23	-0.17	-0.13
TOLUENE	0.48	0.46	0.07	0.15	**0.50**	0.12
N-OCTANE	0.42	0.38	-0.07	0.10	0.45	0.41
ETHYLBENZENE	0.05	0.02	0.06	0.14	0.11	0.31
m,p - XYLENE	0.01	-0.01	0.04	0.14	0.05	0.09
STYRENE	0.37	0.48	0.26	0.24	**0.51**	0.44
o - XYLENE	0.12	0.06	0.06	0.20	0.11	0.09
1,3,5-TRIMETHYLBENZENE	**0.59**	0.44	0.03	0.23	0.47	0.21
1,2,4-TRIMETHYLBENZENE	**0.60**	0.48	0.03	0.19	0.49	0.02

Bold = Correlation greater than 0.50

Traffic Services site (G2CO)	METHYLENE CHLORIDE	TRICHLOROTRI-FLUOROETHANE	METHYL ETHYL KETONE	BENZENE	CARBON TETRACHLORIDE	TOLUENE
ACETYLENE						
PROPYLENE						
DICHLORODIFLUOROMETHANE						
CHLOROMETHANE						
1,3-BUTADIENE						
TRICHLOROFLUOROMETHANE						
METHYLENE CHLORIDE	**1.00**					
TRICHLOROTRIFLUOROETHANE	-0.20	**1.00**				
METHYL ETHYL KETONE	0.42	-0.35	**1.00**			
BENZENE	0.13	0.08	-0.09	**1.00**		
CARBON TETRACHLORIDE	-0.02	0.15	0.02	-0.21	**1.00**	
TOLUENE	0.34	-0.13	0.14	0.38	-0.13	**1.00**
N-OCTANE	0.15	0.06	-0.08	0.39	0.05	0.48
ETHYLBENZENE	0.26	-0.35	0.23	-0.02	-0.03	**0.79**
m,p - XYLENE	0.24	-0.37	0.25	-0.06	0.01	**0.75**
STYRENE	0.45	-0.19	0.06	0.37	-0.02	**0.60**
o - XYLENE	0.29	-0.33	0.21	-0.01	0.03	**0.76**
1,3,5-TRIMETHYLBENZENE	0.35	-0.14	0.00	0.37	-0.01	**0.61**
1,2,4-TRIMETHYLBENZENE	0.37	-0.09	0.05	0.40	-0.02	**0.64**

Bold = Correlation greater than 0.50

Traffic Services site (G2CO)	N-OCTANE	ETHYLBENZENE	m,p - XYLENE	STYRENE	o - XYLENE	1,3,5-TRIMETHYL-BENZENE	1,2,4-TRIMETHYL-BENZENE
ACETYLENE							
PROPYLENE							
DICHLORODIFLUOROMETHANE							
CHLOROMETHANE							
1,3-BUTADIENE							
TRICHLOROFLUOROMETHANE							
METHYLENE CHLORIDE							
TRICHLOROTRIFLUOROETHANE							
METHYL ETHYL KETONE							
BENZENE							
CARBON TETRACHLORIDE							
TOLUENE							
N-OCTANE	**1.00**						
ETHYLBENZENE	0.24	**1.00**					
m,p - XYLENE	0.17	**0.99**	**1.00**				
STYRENE	0.43	0.39	0.38	**1.00**			
o - XYLENE	0.25	**0.95**	**0.97**	0.45	**1.00**		
1,3,5-TRIMETHYLBENZENE	**0.65**	0.47	0.47	**0.60**	**0.61**	**1.00**	
1,2,4-TRIMETHYLBENZENE	**0.52**	**0.50**	**0.51**	**0.63**	**0.65**	**0.97**	**1.00**

Table 3.9, completed

Bold = Correlation greater than 0.50

Table 3.10 - Correlation Coefficients For VOCs Detected In Over 75% of the Samples – GJ MCHD VS. GJ Traffic

MCHD Site Versus Traffic Site Correlations	ACETYLENE TRAFFIC	PROPYLENE TRAFFIC	DICHLORODI-FLUOROMETHANE TRAFFIC	CHLOROMETHANE TRAFFIC	1,3-BUTADIENE TRAFFIC	TRICHLORO-FLUOROMETHANE TRAFFIC
ACETYLENE - MCHD	0.00	-0.05	-0.12	0.02	0.05	0.12
PROPYLENE - MCHD	0.46	**0.76**	0.10	-0.26	**0.68**	-0.15
DICHLORODIFLUOROMETHANE - MCHD	-0.23	-0.18	0.31	0.22	-0.20	0.15
CHLOROMETHANE - MCHD	-0.01	0.11	0.40	0.44	-0.02	0.07
1,3-BUTADIENE - MCHD	0.36	**0.67**	0.08	-0.28	**0.62**	-0.10
TRICHLOROFLUOROMETHANE - MCHD	-0.16	-0.14	0.19	0.12	-0.26	0.02
METHYLENE CHLORIDE - MCHD	-0.02	-0.13	0.14	0.02	0.00	0.42
TRICHLOROTRIFLUOROETHANE - MCHD	0.10	0.14	0.02	-0.02	0.02	-0.07
METHYL ETHYL KETONE - MCHD	-0.02	-0.01	0.00	-0.02	-0.06	-0.07
BENZENE - MCHD	**0.55**	**0.79**	0.01	-0.24	**0.73**	-0.17
CARBON TETRACHLORIDE - MCHD	-0.11	-0.15	-0.15	-0.20	-0.07	-0.01
TOLUENE - MCHD	0.18	0.09	-0.02	-0.03	0.09	-0.12
N-OCTANE - MCHD	-0.04	0.04	0.02	0.03	0.06	-0.08
ETHYLBENZENE - MCHD	0.11	-0.03	0.00	0.06	-0.01	-0.07
m,p - XYLENE - MCHD	0.10	-0.04	0.01	0.08	-0.01	-0.07
STYRENE - MCHD	0.42	**0.62**	0.15	-0.14	**0.63**	-0.13
o - XYLENE - MCHD	0.12	0.00	0.01	0.07	0.02	-0.08
1,3,5-TRIMETHYLBENZENE - MCHD	0.49	**0.78**	0.19	-0.20	**0.71**	-0.09
1,2,4-TRIMETHYLBENZENE - MCHD	0.45	**0.75**	0.18	-0.18	**0.71**	-0.07

Bold = Correlation greater than 0.50

MCHD Site Versus Traffic Site Correlations	METHYLENE CHLORIDE TRAFFIC	TRICHLOROTRI-FLUOROETHANE TRAFFIC	METHYL ETHYL KETONE TRAFFIC	BENZENE TRAFFIC	CARBON TETRACHLORIDE TRAFFIC	TOLUENE TRAFFIC
ACETYLENE - MCHD	0.12	-0.18	-0.07	-0.04	-0.02	0.15
PROPYLENE - MCHD	0.03	0.15	0.03	**0.81**	-0.06	0.15
DICHLORODIFLUOROMETHANE - MCHD	-0.12	0.02	-0.28	-0.20	0.14	-0.13
CHLOROMETHANE - MCHD	-0.04	-0.06	-0.02	-0.04	0.20	0.05
1,3-BUTADIENE - MCHD	-0.04	0.23	-0.11	**0.73**	-0.08	-0.03
TRICHLOROFLUOROMETHANE - MCHD	-0.09	0.04	-0.16	-0.21	0.30	0.00
METHYLENE CHLORIDE - MCHD	0.03	-0.07	-0.15	-0.13	-0.03	-0.27
TRICHLOROTRIFLUOROETHANE - MCHD	-0.05	**0.51**	-0.32	0.17	0.31	-0.03
METHYL ETHYL KETONE - MCHD	-0.15	-0.33	**0.57**	0.00	-0.21	-0.18
BENZENE - MCHD	0.14	0.11	-0.01	**0.85**	0.00	0.24
CARBON TETRACHLORIDE - MCHD	-0.28	0.26	-0.43	-0.09	0.01	-0.32
TOLUENE - MCHD	0.09	-0.15	0.16	0.08	-0.12	**0.65**
N-OCTANE - MCHD	-0.10	0.37	-0.06	0.09	-0.05	-0.06
ETHYLBENZENE - MCHD	0.11	-0.19	0.19	-0.05	-0.06	**0.65**
m,p - XYLENE - MCHD	0.12	-0.19	0.19	-0.06	-0.05	**0.65**
STYRENE - MCHD	-0.15	0.23	-0.14	**0.69**	-0.03	0.24
o - XYLENE - MCHD	0.11	-0.17	0.19	-0.02	-0.04	**0.65**
1,3,5-TRIMETHYLBENZENE - MCHD	0.07	0.08	-0.04	**0.81**	-0.07	0.29
1,2,4-TRIMETHYLBENZENE - MCHD	0.07	0.14	-0.05	**0.78**	-0.12	0.32

Bold = Correlation greater than 0.50

MCHD Site Versus Traffic Site Correlations	N-OCTANE TRAFFIC	ETHYL BENZENE TRAFFIC	m,p - XYLENE TRAFFIC	STYRENE TRAFFIC	o - XYLENE TRAFFIC	1,3,5-TRIMETHYL-BENZENE TRAFFIC	1,2,4-TRIMETHYL-BENZENE TRAFFIC
ACETYLENE - MCHD	0.34	0.23	0.25	0.11	0.32	0.25	0.19
PROPYLENE - MCHD	0.06	-0.13	-0.15	0.07	-0.15	0.02	0.07
DICHLORODIFLUOROMETHANE - MCHD	-0.08	-0.07	-0.06	-0.19	-0.02	-0.05	-0.11
CHLOROMETHANE - MCHD	-0.03	0.02	0.04	0.44	0.08	0.08	0.10
1,3-BUTADIENE - MCHD	-0.03	-0.23	-0.27	-0.06	-0.28	-0.11	-0.08
TRICHLOROFLUOROMETHANE - MCHD	-0.04	-0.12	-0.10	0.06	-0.07	-0.14	-0.15
METHYLENE CHLORIDE - MCHD	-0.13	-0.21	-0.24	0.13	-0.26	-0.15	-0.23
TRICHLOROTRIFLUOROETHANE - MCHD	0.05	-0.18	-0.18	-0.20	-0.15	-0.09	-0.05
METHYL ETHYL KETONE - MCHD	-0.16	-0.17	-0.18	-0.18	-0.19	-0.17	-0.17
BENZENE - MCHD	0.26	-0.03	-0.05	0.12	-0.02	0.18	0.20
CARBON TETRACHLORIDE - MCHD	0.08	-0.31	-0.30	-0.10	-0.24	-0.11	-0.10
TOLUENE - MCHD	-0.08	**0.72**	**0.69**	0.14	**0.61**	0.19	0.26
N-OCTANE - MCHD	-0.02	-0.11	-0.12	-0.12	-0.12	-0.08	-0.09
ETHYLBENZENE - MCHD	-0.08	**0.78**	**0.75**	0.08	**0.67**	0.20	0.25
m,p - XYLENE - MCHD	-0.08	**0.78**	**0.76**	0.07	**0.68**	0.20	0.25
STYRENE - MCHD	-0.03	0.02	-0.03	0.16	-0.07	-0.04	0.01
o - XYLENE - MCHD	-0.08	**0.77**	**0.74**	0.08	**0.66**	0.19	0.25
1,3,5-TRIMETHYLBENZENE - MCHD	0.04	0.02	-0.03	0.14	-0.06	0.06	0.09
1,2,4-TRIMETHYLBENZENE - MCHD	0.02	0.05	0.01	0.13	-0.01	0.04	0.11

Table 3.10, completed

Bold = Correlation greater than 0.50

Health Implications – Volatile Organic Compounds

As part of its national air toxics analysis effort, EPA has developed recommended benchmark concentrations for various hazardous air pollutants. For each hazardous air pollutant the EPA has tried to develop an "acute" benchmark, as well as "chronic" and "cancer risk" benchmarks. The acute benchmark value represents a concentration that an individual may be exposed to for a short period of time, without risk of health effects. The period of time may vary for each pollutant, but for the purposes of the analysis here, one compares the highest twenty-four hour daily value observed over the year with the "acute" benchmark. The "chronic" and "cancer risk" benchmarks represent concentrations to which an individual may be exposed over a lifetime without a large risk of incurring health effects. For the purposes of the analysis here, one compares the annual mean to the "chronic" and "cancer risk" benchmarks. EPA "benchmark" concentrations are used to evaluate whether areas are meeting national EPA goals for reducing concentrations of hazardous air pollutants. However, unlike national ambient air quality standards governing pollutants such as carbon monoxide or ozone, these EPA "benchmark" values do not have the force of law or regulation. They are simply levels at which EPA believes these pollutants may begin to cause health effects on sensitive members of the population. It should be noted that the "unit risk" factors for cancer assume a lifetime (70-year) exposure. As this study collected only one year of data, it is not known whether the levels measured here are representative of the lifetime exposure of current area residents. It is likely that concentrations of many of these air pollutants were higher in the past. This would suggest that risk of health effects may be higher than that shown here. Conversely, concentrations of many of these pollutants are expected to decrease in the future, due to planned regulatory actions by EPA. Thus, these discussions of health risk from air pollution are best viewed as a "snapshot" in time, rather than as indications of past or future risk.

The benchmarks for the hazardous air pollutants may be found on the following EPA web page:

http://www.epa.gov/ttn/atw/toxsource/summary.html

Four tables comparing compounds measured in this study with EPA "benchmark" values were developed. Tables 3.1 through 3.14 summarize the EPA benchmarks available for volatile organic compounds. As seen from the tables, not all of the compounds measured have benchmark values. These compounds have benchmarks for long-exposure period health effects (cancer and chronic), but "acute" benchmarks for a 24 hour period have yet to be developed.

Tables 3.11 and 3.12 compare the annual mean values of these compounds to the EPA "unit risk factor" for developing cancer. Columns two and three give the annual mean of the compound, as measured in parts per billion volume and then converted to micrograms per cubic meter (ug/m3). Column four gives the cancer risk associated with breathing an average one microgram concentration of the compound, over a lifetime. Column five, Cancer Risk in Ambient Air, relates annual concentrations observed at the stations to the risk of contracting cancer. EPA's goal is for the risk in column five to be 1 X 10-6 or less. Thus, 1,3-butadiene, benzene, carbon tetrachloride, tetrachloroethylene, and p-dichloro-benzene exceed the risk goals at both sites. Ethyl acrylate, 1,1,2,2-tetrachloroethane and acrylonitrile exceed the risk goals at Traffic, but not at MCHD. However, these three compounds were only detected at Traffic for 9 % or less of the time. All of these compounds are discussed in more detail in the next section of the report.

Tables 3.13 and 3.14 compare the annual mean values of these compounds to the EPA "Hazard Quotient" value for the risk of chronic (non-cancer) health effects. Column four, Non-cancer Chronic, of the tables gives the value at which EPA believes chronic health effects to the population will not occur. Column five is a ratio of the annual mean (column 3) to the Non-cancer chronic value in column four. EPA's goal is that this "Hazard Quotient" be less than 1.0. (That is, the annual concentration should be less than the Non-cancer chronic value for the pollutant). For all compounds, the risk is well below 1.0.

Table 3.11 - Annual Mean Versus Cancer Risk for VOCs at GJ - MCHD

Annual Mean Versus Cancer Risk – GJ-MCHD Site				
Compound	**Annual Mean ppbv**	**Annual Mean ug/m3**	**Cancer Risk Factor Per ug/m3 (1/(ug/m3))**	**Cancer Risk In Ambient Air**
Chloromethane	**0.61**	**1.26**	**No Factor**	
Vinyl Chloride	**ND**	**ND**	**0.0000088**	
1,3-Butadiene	**0.10**	**0.22**	**0.00003**	**6.64E-06**
Bromomethane	**ND**	**ND**	**No Factor**	
1,1-Dichloroethene	**ND**	**ND**	**No Factor**	
Methylene Chloride	**0.14**	**0.49**	**0.00000047**	**2.29E-07**
1,1-Dichloroethane	**ND**	**ND**	**0.0000016**	
Methyl Tert-Butyl Ether	**0.5**	**1.80**	**No Factor**	
Methyl Ethyl Ketone	**0.78**	**2.30**	**No Factor**	
Chloroform	**0.03**	**0.15**	**No Factor**	
1,2-Dichloroethane	**ND**	**ND**	**0.000026**	
1,1,1-Trichloroethane	**0.05**	**0.27**	**No Factor**	
Benzene	**0.9**	**2.88**	**0.0000078**	**2.24E-05**
Carbon Tetrachloride	**0.08**	**0.50**	**0.000015**	**7.55E-06**
1,2-Dichloropropane	**ND**	**ND**	**0.000019**	
Ethyl Acrylate	**ND**	**ND**	**0.000014**	
Trichloroethylene	**0.04**	**0.21**	**0.000002**	**4.30E-07**
Methyl Methacrylate	**0.1**	**0.35**	**No Factor**	
Cis-1,3-Dichloropropene	**ND**	**ND**	**No Factor**	
Trans-1,3-Dichloropropene	**ND**	**ND**	**0.000004**	
1,1,2-Trichloroethane	**ND**	**ND**	**0.000016**	
Toluene	**3.7**	**13.94**	**No Factor**	
1,2-Dibromoethane	**ND**	**ND**	**0.00022**	
Tetrachloroethylene	**0.04**	**0.27**	**0.0000059**	**1.60E-06**
Chlorobenzene	**ND**	**ND**	**No Factor**	
Ethyl Benzene	**0.84**	**3.65**	**No Factor**	
M,P-Xylene	**2.78**	**12.07**	**No Factor**	
Bromoform	**ND**	**ND**	**0.0000011**	
Styrene	**0.06**	**0.26**	**No Factor**	
1,1,2,2-Tetrachloroethane	**ND**	**ND**	**0.000058**	
O-Xylene	**0.85**	**3.69**	**No Factor**	
P-Dichlorobenzene	**0.04**	**0.24**	**0.000011**	**2.65E-06**
1,2,4-Trichlorobenzene	**ND**	**ND**	**No Factor**	
Hexachloro-1,3-Butadiene	**ND**	**ND**	**0.000022**	
Acrylonitrile	**ND**	**ND**	**0.000068**	
Acetonitrile	**8.35**	**14.02**	**No Factor**	
Chloroprene	**ND**	**ND**	**No Factor**	
Methyl Isobutyl Ketone	**ND**	**ND**	**No Factor**	

All compounds listed in the reference, even those having "no factor", are listed here.
ND = Compound not detected during the study.

Table 3.12 - Annual Mean Versus Cancer Risk for VOCs at GJ – Traffic

Annual Mean Versus Cancer Risk – GJ-Traffic Site				
Compound	**Annual Mean ppbv**	**Annual Mean ug/m3**	**Cancer Risk Factor Per ug/m3 (1/(ug/m3))**	**Cancer Risk In Ambient Air**
Chloromethane	**0.59**	**1.22**	**No Factor**	
Vinyl Chloride	**ND**	**ND**	**0.0000088**	
1,3-Butadiene	**0.09**	**0.20**	**0.00003**	**5.97E-06**
Bromomethane	**ND**	**ND**	**No Factor**	
1,1-Dichloroethene	**ND**	**ND**	**No Factor**	
Methylene Chloride	**0.16**	**0.56**	**0.00000047**	**2.61E-07**
1,1-Dichloroethane	**ND**	**ND**	**0.0000016**	
Methyl Tert-Butyl Ether	**0.12**	**0.00**	**No Factor**	
Methyl Ethyl Ketone	**0.95**	**2.80**	**No Factor**	
Chloroform	**0.03**	**0.15**	**No Factor**	
1,2-Dichloroethane	**ND**	**ND**	**0.000026**	
1,1,1-Trichloroethane	**0.04**	**0.22**	**No Factor**	
Benzene	**0.66**	**2.11**	**0.0000078**	**1.64E-05**
Carbon Tetrachloride	**0.08**	**0.50**	**0.000015**	**7.55E-06**
1,2-Dichloropropane	**ND**	**ND**	**0.000019**	
Ethyl Acrylate	**0.08**	**0.33**	**0.000014**	**4.59E-06**
Trichloroethylene	**0.06**	**0.32**	**0.000002**	**6.45E-07**
Methyl Methacrylate	**0.11**	**0.39**	**No Factor**	
Cis-1,3-Dichloropropene	**ND**	**ND**	**No Factor**	
Trans-1,3-Dichloropropene	**ND**	**ND**	**0.000004**	
1,1,2-Trichloroethane	**ND**	**ND**	**0.000016**	
Toluene	**2.66**	**10.02**	**No Factor**	
1,2-Dibromoethane	**ND**	**ND**	**0.00022**	
Tetrachloroethylene	**0.05**	**0.34**	**0.0000059**	**2.00E-06**
Chlorobenzene	**ND**	**ND**	**No Factor**	
Ethyl Benzene	**0.64**	**2.78**	**No Factor**	
M,P-Xylene	**2.34**	**10.16**	**No Factor**	
Bromoform	**ND**	**ND**	**0.0000011**	
Styrene	**0.07**	**0.30**	**No Factor**	
1,1,2,2-Tetrachloroethane	**0.03**	**0.21**	**0.000058**	**1.19E-05**
O-Xylene	**0.95**	**4.12**	**No Factor**	
P-Dichlorobenzene	**0.04**	**0.24**	**0.000011**	**2.65E-06**
1,2,4-Trichlorobenzene	**ND**	**ND**	**No Factor**	
Hexachloro-1,3-Butadiene	**ND**	**ND**	**0.000022**	
Acrylonitrile	**0.12**	**0.26**	**0.000068**	**1.77E-05**
Acetonitrile	**0.88**	**1.48**	**No Factor**	
Chloroprene	**ND**	**ND**	**No Factor**	
Methyl Isobutyl Ketone	**0.13**	**0.53**	**No Factor**	

All compounds listed in the reference, even those having "no factor", are listed here.
ND = Compound not detected during the study.

Table 3.13 - Annual Mean Versus Non-Cancer Chronic Risk for VOCs at GJ – MCHD

Annual Mean Versus Non-Cancer Chronic Risk – GJ-MCHD Site				
Compound	**Annual Mean ppbv**	**Annual Mean ug/m3**	**Noncancer Chronic Factor, ug/m3**	**Noncancer Chronic Hazard Quotient**
Chloromethane	**0.61**	**1.26**	**90**	**0.014**
Vinyl Chloride	**ND**	**ND**	**100**	
1,3-Butadiene	**0.10**	**0.22**	**2**	**0.111**
Bromomethane	**ND**	**ND**	**5**	
1,1-Dichloroethene	**ND**	**ND**	**200**	
Methylene Chloride	**0.14**	**0.49**	**1000**	**0.000**
1,1-Dichloroethane	**ND**	**ND**	**500**	
Methyl Tert-Butyl Ether	**0.5**	**1.80**	**3000**	**0.001**
Methyl Ethyl Ketone	**0.78**	**2.30**	**1000**	**0.002**
Chloroform	**0.03**	**0.15**	**98**	**0.001**
1,2-Dichloroethane	**ND**	**ND**	**2400**	
1,1,1-Trichloroethane	**0.05**	**0.27**	**1000**	**0.000**
Benzene	**0.9**	**2.88**	**30**	**0.096**
Carbon Tetrachloride	**0.08**	**0.50**	**40**	**0.013**
1,2-Dichloropropane	**ND**	**ND**	**4**	
Ethyl Acrylate	**ND**	**ND**	**No Factor**	
Trichloroethylene	**0.04**	**0.21**	**600**	**0.000**
Methyl Methacrylate	**0.1**	**0.35**	**700**	**0.001**
Cis-1,3-Dichloropropene	**ND**	**ND**	**No Factor**	
Trans-1,3-Dichloropropene	**ND**	**ND**	**20**	
1,1,2-Trichloroethane	**ND**	**ND**	**400**	
Toluene	**3.7**	**13.94**	**400**	**0.035**
1,2-Dibromoethane	**ND**	**ND**	**0.8**	
Tetrachloroethylene	**0.04**	**0.27**	**270**	**0.001**
Chlorobenzene	**ND**	**ND**	**1000**	
Ethyl Benzene	**0.84**	**3.65**	**1000**	**0.004**
M,P-Xylene	**2.78**	**12.07**	**100**	**0.121**
Bromoform	**ND**	**ND**	**No Factor**	
Styrene	**0.06**	**0.26**	**1000**	**0.000**
1,1,2,2-Tetrachloroethane	**ND**	**ND**	**No Factor**	
o-Xylene	**0.85**	**3.69**	**100**	**0.037**
p-Dichlorobenzene	**0.04**	**0.24**	**800**	**0.000**
1,2,4-Trichlorobenzene	**ND**	**ND**	**200**	
Hexachloro-1,3-Butadiene	**ND**	**ND**	**90**	
Acrylonitrile	**ND**	**ND**	**2**	
Acetonitrile	**8.35**	**14.02**	**60**	**0.234**
Chloroprene	**ND**	**ND**	**7**	
Methyl Isobutyl Ketone	**ND**	**ND**	**80**	

All compounds listed in the reference, even those having "no factor", are listed here.
ND = Compound not detected during the study.

Table 3.14 - Annual Mean Versus Non-Cancer Chronic Risk for VOCs at GJ – Traffic

Annual Mean Versus Non-Cancer Chronic Risk – GJ-Traffic Site				
Compound	**Annual Mean ppbv**	**Annual Mean ug/m3**	**Noncancer Chronic Factor, ug/m3**	**Noncancer Chronic Hazard Quotient**
Chloromethane	**0.59**	**1.22**	**90**	**0.014**
Vinyl Chloride	**ND**	**ND**	**100**	
1,3-Butadiene	**0.09**	**0.20**	**2**	**0.100**
Bromomethane	**ND**	**ND**	**5**	
1,1-Dichloroethene	**ND**	**ND**	**200**	
Methylene Chloride	**0.16**	**0.56**	**1000**	**0.001**
1,1-Dichloroethane	**ND**	**ND**	**500**	
Methyl Tert-Butyl Ether	**0.12**	**0.43**	**3000**	**0.000**
Methyl Ethyl Ketone	**0.95**	**2.80**	**1000**	**0.003**
Chloroform	**0.03**	**0.15**	**98**	**0.001**
1,2-Dichloroethane	**ND**	**ND**	**2400**	
1,1,1-Trichloroethane	**0.04**	**0.22**	**1000**	**0.000**
Benzene	**0.66**	**2.11**	**30**	**0.070**
Carbon Tetrachloride	**0.08**	**0.50**	**40**	**0.013**
1,2-Dichloropropane	**ND**	**ND**	**4**	
Ethyl Acrylate	**0.08**	**0.33**	**No Factor**	
Trichloroethylene	**0.04**	**0.21**	**600**	**0.000**
Methyl Methacrylate	**0.11**	**0.39**	**700**	**0.001**
Cis-1,3-Dichloropropene	**ND**	**ND**	**No Factor**	
Trans-1,3-Dichloropropene	**ND**	**ND**	**20**	
1,1,2-Trichloroethane	**ND**	**ND**	**400**	
Toluene	**2.66**	**10.02**	**400**	**0.025**
1,2-Dibromoethane	**ND**	**ND**	**0.8**	
Tetrachloroethylene	**0.05**	**0.34**	**270**	**0.001**
Chlorobenzene	**ND**	**ND**	**1000**	
Ethyl Benzene	**0.64**	**2.78**	**1000**	**0.003**
M,P-Xylene	**2.34**	**10.16**	**100**	**0.102**
Bromoform	**ND**	**ND**	**No Factor**	
Styrene	**0.07**	**0.30**	**1000**	**0.000**
1,1,2,2-Tetrachloroethane	**0.03**	**0.21**	**No Factor**	
o-Xylene	**0.95**	**4.12**	**100**	**0.041**
p-Dichlorobenzene	**0.04**	**0.24**	**800**	**0.000**
1,2,4-Trichlorobenzene	**ND**	**ND**	**200**	
Hexachloro-1,3-Butadiene	**ND**	**ND**	**90**	
Acrylonitrile	**0.12**	**0.26**	**2**	**0.130**
Acetonitrile	**0.88**	**1.48**	**60**	**0.025**
Chloroprene	**ND**	**ND**	**7**	
Methyl Isobutyl Ketone	**0.13**	**0.53**	**80**	**0.007**

All compounds listed in the reference, even those having "no factor", are listed here.
ND = Compound not detected during the study.

Compounds of Significance: Sources and Health Effects

Of the fifty-eight volatile organic compounds sampled, four showed annual mean concentrations greater than 1 part per billion (ppb) in Grand Junction air. These are: acetonitrile (MCHD only), acetylene, m,p – xylenes, and toluene. Eight of the compounds whose annual means were less than 1 ppb, had concentrations that were above the EPA "benchmark" level for one-in-a-million increased risk of cancer health effects. The most significant ones were 1,3-butadiene, carbon tetrachloride, benzene, tetrachloroethylene, and p-dichlorobenzene. 1,1,2,2-tetrachloroethane and ethyl acetate were above the benchmark at Traffic, but they were only detected in one sample during the year. Acrylonitrile was also above the benchmark at Traffic, where it was detected in 9 % of the samples. Information regarding the nature, sources, and potential health effects of each of 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). Thus, 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. 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 maximum observed in this study, 5.5 ppb for a 24-hour average, fits right within this range. Unfortunately, EPA has not developed "benchmark" levels for this compound. However, a 1999 analysis for the EPA's Integrated Risk Information System indicated a reference concentration of .06 mg/m^3 (36 ppb) acetonitrile in air. This reference concentration is described by EPA as "an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious noncancer effects during a lifetime." Thus, the levels of acetonitrile seen in Grand Junction and urban US air are below the EPA Reference Concentration. Acetonitrile was detected in 32% of the MCHD and 14% of the Traffic samples.

Acetylene

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

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

Acetylene is an asphyxiant that can decrease the amount of available oxygen. Thus, the health effects of exposure to large concentrations of this compound involve oxygen deprivation and include headache, dizziness, lightheadedness, unconsciousness, and death. These concerns generally apply to workers using acetylene-powered

welding torches in confined spaces. In outdoor air, acetylene is at much lower concentrations. According to the National Institute for Occupational Safety and Health, acetylene is not believed to have any toxic health effects beyond its asphyxiant properties. In fact, during the early twentieth century acetylene was used as an anesthetic for surgical patients. (NIOSH Criteria Document on Acetylene). Acetylene has not been investigated for carcinogenic effects, or ability to cause birth defects (New Jersey Hazardous Substance Fact Sheet on Acetylene).

The EPA AIRS system lists data from the state of California. Annual concentrations of acetylene in California typically range from 1 to 5.5 ppbv. The annual mean of the GJ – Traffic data is 3.28 ppb, while MCHD showed a higher mean of 14.50. Thus the Traffic site is within the California range, while the MCHD site shows higher levels. The MCHD site may be influenced by local sources not present at the Traffic site.

The EPA national air toxics analysis effort has not developed any recommended benchmark values for acetylene. Therefore, it is not known whether the 24-hour maximum value of 83 ppb observed at MCHD has any health significance.

Acrylonitrile

Acrylonitrile is a volatile organic compound with the formula C_3H_3N. In the atmosphere, it exists as a gas. Acrylonitrile is used in the chemical industry for making acrylic fibers, nitrile rubber, plastics, and resins. It has also been used in pesticides and pharmaceuticals.

Acrylonitrile emissions may come from automobiles and manufacturers of acrylic fiber and plastics. The California Air Resources Board indicates that producers of synthetics, paint, and furniture are the main stationary sources of the compound in California (CARB Fact Sheet on Acrylonitrile).

Acrylonitrile, also known as vinyl cyanide, can have health effects similar to those of poisoning by cyanide (NIOSH Recommended Standard for Occupational Exposure to Acrylonitrile). Thus, health reactions to an exposure to acrylonitrile may be delayed. Acrylonitrile 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. High levels (over 85 ppm) can cause pulmonary edema, leading to death (New Jersey Hazardous Substance Fact Sheet on Acrylonitrile). In some cases, air concentrations that were mildly irritating to nearby adults have proved fatal to children. Studies have indicated that acrylonitrile can cause birth defects in animals. However, most research studies involved concentrations thousands of times higher than those seen in outdoor air. Health studies of factory workers suggest that long-term exposure can lead to lung and colon cancer. Therefore, EPA classifies acrylonitrile as Class B1, a probable human carcinogen.

Acrylonitrile does not occur naturally. Generally, measurable concentrations are not seen in outdoor air. Areas near industrial sources are an exception. 43 measurements taken near chemical plants indicated that 2.1 ug/m3 (about 1 ppb) was an average for these areas. (ATSDR Toxicological Profile for Acrylonitrile). In Grand Junction, acrylonitrile was not detected at MCHD. The mean concentration at the Traffic site was 0.30 ppb, for the 9% of samples in which it was detected. This suggests the presence of an intermittent source in the Traffic site area.

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, service stations, refineries, and chemical plants. Burning of vegetative matter in forest fires and woodstoves is also a source. In ambient air, benzene reacts with hydroxyl (OH^-) radicals within a few hours. This chemical transformation prevents the build-up of large concentrations in outdoor air.

From a toxicological standpoint, benzene is a serious concern. 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). Thus, 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 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 GJ – MCHD site mean of 0.9 ppb observed in this study is somewhat lower. The Traffic site mean was 0.7 ppb. These levels may reflect recent national progress in reducing benzene emissions from motor vehicle fuel.

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.

1,3-Butadiene is of concern toxicologically because it is a probable carcinogen that 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. Generally, these 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.

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 averages at the two Grand Junction sites, about 0.1 ppb, are within this range.

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). 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. Carbon tetrachloride has been associated with liver and kidney cancer in animals, but EPA considers it a Class B2 Carcinogen (probable human carcinogen).

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 observed at both sites in this study is at the same level.

1,4-Dichlorobenzene

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

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

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

The Environmental Protection Agency has monitored 1,4-dichlorobenzene at a number of locations, and found a mean value of 0.17 ppb during 1976 – 1986 (California Air Resources Board Toxic Air Contaminant Identification List Summary for 1,4-Dichlorobenzene). The 0.03 ppb mean observed at GJ – MCHD and the 0.02 ppb mean at GJ – Traffic are significantly lower.

Ethyl Acrylate

Ethyl acrylate is a hydrocarbon with the formula $C_5H_8O_2$. Other names for this compound include ethyl propenoate and ethyl ester of acrylic acid. It volatilizes into air and has a fruit-like odor. It is used in the manufacture of latex-based paints, glues, textile coatings, and paper coatings. It also is employed in the production of acrylic fiber.

Ethyl acrylate is an industrial compound that is rarely detected in outdoor air. EPA notes that ethyl acrylate can be released from industrial smokestacks and wastewater (EPA TTN Health Effects Worksheet for Ethyl Acrylate).

Ethyl acrylate is a strong irritant. It can cause chemical conjunctivitis to eyes, skin irritation and sensitization, and adverse affects on the respiratory system, such as chemical pneumonia and pulmonary edema. It also irritates the gastrointestinal tract. Breathing concentrated vapor can lead to central nervous system effects such as headache, tiredness, and convulsions. Studies have noted liver and kidney changes in animals exposed by inhalation. Levels over 300 ppm are considered to be immediately dangerous to life and health (NIOSH IDLH

Documentation for Ethyl Acrylate). These health effects are generally seen in workers with many years of exposure, or exposure to levels much higher than those seen in outdoor air.

As the compound is rarely detected in outdoor air, estimates of "typical" urban concentrations are not available. Ethyl Acrylate was not detected at GJ – MCHD. At the GJ – Traffic site, ethyl acrylate was detected in a single sample at the level of 0.03 ppb.

Tetrachloroethane

Tetrachloroethane, also known as 1,1,2,2-tetrachloroethane or acytylene tetrachloride, is a chlorinated hydrocarbon with the formula $C_2H_2Cl_4$. It exists in the atmosphere as a gas. It has an odor similar to chloroform. One historic use of tetrachloroethane was as a metal degreasing solvent. It was also used in paints, pesticides, and cleaning solvents. The chemical production industry also used tetrachloroethane. In recent years, direct production of tetrachloroethane has halted in both the United States and Canada. Tetrachloroethane is still produced by some plants, as an intermediate compound in the production of other chemicals.

The decline of tetrachloroethane production means that large-scale industrial emissions are no longer common. Tetrachloroethane is emitted from plants that produce vinyl chloride and ethylene dichloride. Landfills and wastewater treatment plants may also be emission sources. Tetrachloroethane is still a common trace constituent in many household products, such as glues, greases, and oils (ATSDR Toxicological Profile For Tetrachloroethane). Tetrachloroethane is a man-made chemical.

As is true for many of the chlorinated hydrocarbons, breathing large concentrations of tetrachloroethane has central nervous system effects including lightheadedness, coma, convulsions, double vision, intoxication, and death. It can cause vomiting, and it also is an irritant to eyes, lungs, and skin. In animal studies, it had effects on the central nervous system, liver and kidney. It is particularly damaging to the liver. It has been associated with "fatty liver", jaundice, hepatitis, and liver enlargement. However, many of these health effects were observed in occupational settings, where exposure is much higher than in outdoor air. In animals, it has been associated with liver cancer. EPA considers it a Class C Carcinogen (possible human carcinogen).

The EPA has monitored tetrachloroethane at a number of locations, and found a mean value of 0.07 ppb during 1976 - 1986 (California Air Resources Board Toxic Air Contaminant Identification List Summary for Tetrachloroethane). Tetrachloroethane was not detected at GJ-MCHD. At the GJ – Traffic site, one daily detection (out of 58 samples) measured 0.06 ppb. Evidently, emissions of this compound are very sporadic and localized.

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 Tetrachloroethyelene).

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, but EPA considers it a Class B2 or C Carcinogen (possible human carcinogen).

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 annual mean at both Grand Junction sites was 0.07 ppb. This is greater than the network-wide mean value for California.

Toluene

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

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

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

ATSDR indicates that toluene occurs in polluted air at levels of 0.3 to 7.98 ppb (ATSDR Toxicological Profile on Toluene). Thus, the GJ - MCHD mean level of 3.7 ppb and the Traffic site mean of 2.7 are right within a typical US range. The ATSDR Toxicological Profile on Toluene indicates that children living in central urban core areas with large amounts of traffic had 56% more toluene detected in their blood than children living in rural areas. The health significance of this, if any, is not known.

Xylenes

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

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

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

As is true for many of the chlorinated hydrocarbons, breathing large concentrations of mixed xylenes has central nervous system effects including lightheadedness, coma, convulsions, double vision, intoxication, and death. It can cause vomiting, and it also is an irritant to eyes, lungs, and skin. In animal studies, it had effects on the central

nervous system, liver and kidney. It has been associated with hearing loss in some animal studies. Tests of rats that were exposed to mixed xylenes in air indicated that they had poorer performance than non-exposed rats on such tasks as finding one's way through a maze. Thus, it has been suggested that xylene exposure may result in learning deficits. Animal studies have also suggested a role in some birth defects, and that young exposed animals have delays in ossification of bone. Many of these health effects were observed at high air concentration levels typical of occupational exposures. There is little information on whether xylenes cause cancer. EPA considers mixed xylenes a Class D Carcinogen (not classifiable due to inadequate information).

California has monitored xylenes at a number of locations. In 1996, their network showed a statewide average of 0.97 ppb for m and p-xylenes, and 0.36 ppb for o-xylene (California Air Resources Board Toxic Air Contaminant Identification List Summary for Xylenes). At the GJ-MCHD site, the annual mean concentration for m and p-xylenes was 2.78 ppb, and the mean concentration for o-xylene was 0.85 ppb. The GJ-Traffic site showed 2.34 ppb for m and p-xylenes, and 0.95 ppb for o-xylene. Thus, results at the two locations were similar, with both above the California network-wide averages.

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Section 4 - Metals at Grand Junction

May 2001 to April 2002

Summary Statistics – Metals

Minimum, Maximum, Mean – All Samples

Metals data collected at the two Grand Junction stations from May 2001 through April 2002 are presented in this section of the Grand Junction Air Toxics Monitoring Report. For the year-long period, metals were sampled on a one-in-six day basis, for a total of 60 samples attempted. Of these, the laboratory successfully processed 59 from each site, for a percentage data recovery rate of 98%. (See Table 4.1).

Tables 4.2 and 4.3 summarize the annual minimum, 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 "ND" reported for non-detect samples. Results show that manganese, lead, chromium, and nickel were the compounds with the highest concentrations in ambient air. Antimony was higher at the MCHD site than at the Traffic site, while arsenic was highest at the Traffic location. These compounds all had sample mean levels at 0.0010 ug/m3 or greater, and were detected in 100% of the samples taken. In fact, the majority of the metals were detected consistently. Of the eleven compounds sampled, ten were present more than 90% of the time. The exception was mercury. However, mercury in air tends to be volatile. Thus, extraction from a TSP filter is probably not a good method for characterization of this compound.

Table 4.1 - Percentage Data Recovery For Metals Samples at Grand Junction Sites

Station	Sample Days Monitored	Samples Recovered	Percentage Recovered
Grand Junction - MCHD	60	59	98
Grand Junction - Traffic	60	59	98

Weekend Vs. Weekday Results

The year of metals data was divided into two pools. One pool consisted of all samples taken on a Monday, Tuesday, Wednesday, Thursday, or Friday. The other pool consisted of all samples taken on a Saturday or Sunday. An analysis of the weekday versus the weekend pool was conducted. (In this case, values of one-half the detection limit were substituted for "ND" days). Tables 4.4 and 4.5 give summary statistics for minimum, maximum, and mean of the weekday samples versus the same statistics for the weekend samples. Figures 4.1and 4.2 are graphs of these results. For almost all metals, the weekday results are greater than the weekend ones. Manganese, lead, and selenium are higher at the Traffic site, but antimony is higher at the MCHD location.

Table 4.2 - Annual minimum, maximum, and mean concentrations for each of the metals at GJ - MCHD

MCHD Site (GJ - MCHD)	Summary Statistics (ug/m3)			Count of Non-Detects		Percentage of Samples In Which Compound Was Detected
	Minimum	Maximum	Mean	Number	Percentage	
Antimony	0.0002	0.0230	0.0015	0	0	100
Arsenic	0.0002	0.0022	0.0009	0	0	100
Beryllium	0.0000	0.0011	0.0001	1	2	98
Cadmium	0.0000	0.0006	0.0002	0	0	100
Chromium (total)	0.0003	0.0020	0.0010	0	0	100
Cobalt	0.0000	0.0108	0.0006	0	0	100
Lead	0.0004	0.0092	0.0041	0	0	100
Manganese	0.0043	0.0340	0.0154	0	0	100
Mercury	ND	ND	ND	59	100	0
Nickel	0.0003	0.0019	0.0010	0	0	100
Selenium	0.0000	0.0020	0.0006	4	7	93

Table 4.2, completed.

Table 4.3 - Annual minimum, maximum, and mean concentrations for each of the metals at GJ - Traffic

Traffic Site (GJ - Traffic)	Summary Statistics (ug/m3)			Count of Non-Detects		Percentage of Samples In Which Compound Was Detected
	Minimum	Maximum	Mean	Number	Percentage	
Antimony	0.0001	0.0015	0.0006	0	0	100
Arsenic	0.0003	0.0046	0.0018	0	0	100
Beryllium	0.0000	0.0001	0.0000	4	7	93
Cadmium	0.0001	0.0018	0.0006	0	0	100
Chromium (total)	0.0006	0.0829	0.0047	0	0	100
Cobalt	0.0000	0.0017	0.0006	0	0	100
Lead	0.0020	0.4959	0.0159	0	0	100
Manganese	0.0093	0.1062	0.0491	0	0	100
Mercury	0.0000	0.0000	0.0000	58	98	2
Nickel	0.0007	0.0087	0.0037	0	0	100
Selenium	0.0000	0.0028	0.0007	5	8	92

Mercury was detected once, but blank correction yielded a zero.

Table 4.3, completed.

Table 4.4 – Weekend Vs. Weekday Statistics for the Metals at GJ - MCHD

MCHD Site (GJCO)	Summary Statistics WEEKDAY (ug/m3)			Summary Statistics WEEKEND (ug/m3)		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Antimony	0.0003	0.0230	0.0019	0.0002	0.0013	0.0006
Arsenic	0.0003	0.0021	0.0010	0.0002	0.0022	0.0008
Beryllium	0.0000	0.0011	0.0001	0.0000	0.0001	0.0000
Cadmium	0.0001	0.0006	0.0002	0.0000	0.0005	0.0002
Chromium (total)	0.0003	0.0020	0.0011	0.0004	0.0017	0.0008
Cobalt	0.0000	0.0108	0.0007	0.0000	0.0005	0.0002
Lead	0.0022	0.0080	0.0042	0.0004	0.0092	0.0037
Manganese	0.0069	0.0318	0.0165	0.0043	0.0340	0.0129
Mercury	ND	ND	ND	ND	ND	ND
Nickel	0.0003	0.0019	0.0011	0.0004	0.0017	0.0008
Selenium	0.0000	0.0016	0.0005	0.0000	0.0020	0.0008

Table 4.4, completed

Table 4.5 – Weekend Vs. Weekday Statistics for the Metals at GJ – Traffic

Traffic Services Site (G2CO)	Summary Statistics WEEKDAY (ug/m3)			Summary Statistics WEEKEND (ug/m3)		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Antimony	0.0002	0.0015	0.0006	0.0001	0.0009	0.0004
Arsenic	0.0011	0.0046	0.0020	0.0003	0.0025	0.0012
Beryllium	0.0000	0.0001	0.0000	0.0000	0.0001	0.0000
Cadmium	0.0002	0.0018	0.0007	0.0001	0.0007	0.0003
Chromium (total)	0.0007	0.0829	0.0061	0.0006	0.0050	0.0015
Cobalt	0.0002	0.0017	0.0008	0.0000	0.0009	0.0003
Lead	0.0023	0.4959	0.0204	0.0020	0.0120	0.0057
Manganese	0.0144	0.1062	0.0599	0.0093	0.0891	0.0247
Mercury	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Nickel	0.0007	0.0087	0.0046	0.0007	0.0060	0.0016
Selenium	0.0000	0.0020	0.0007	0.0001	0.0028	0.0009

Table 4.5, completed

Mercury was detected once, but blank correction yielded a zero.

Figure 4.1 – Weekday Vs. Weekend Means For Metals At GJ - MCHD

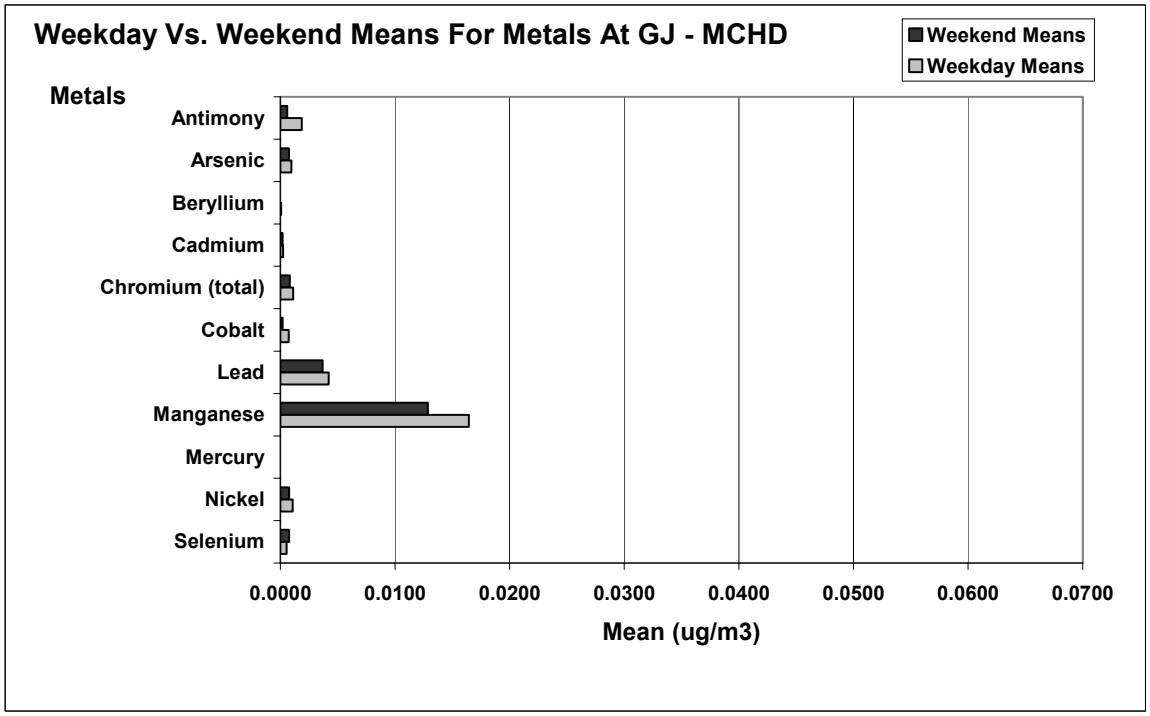
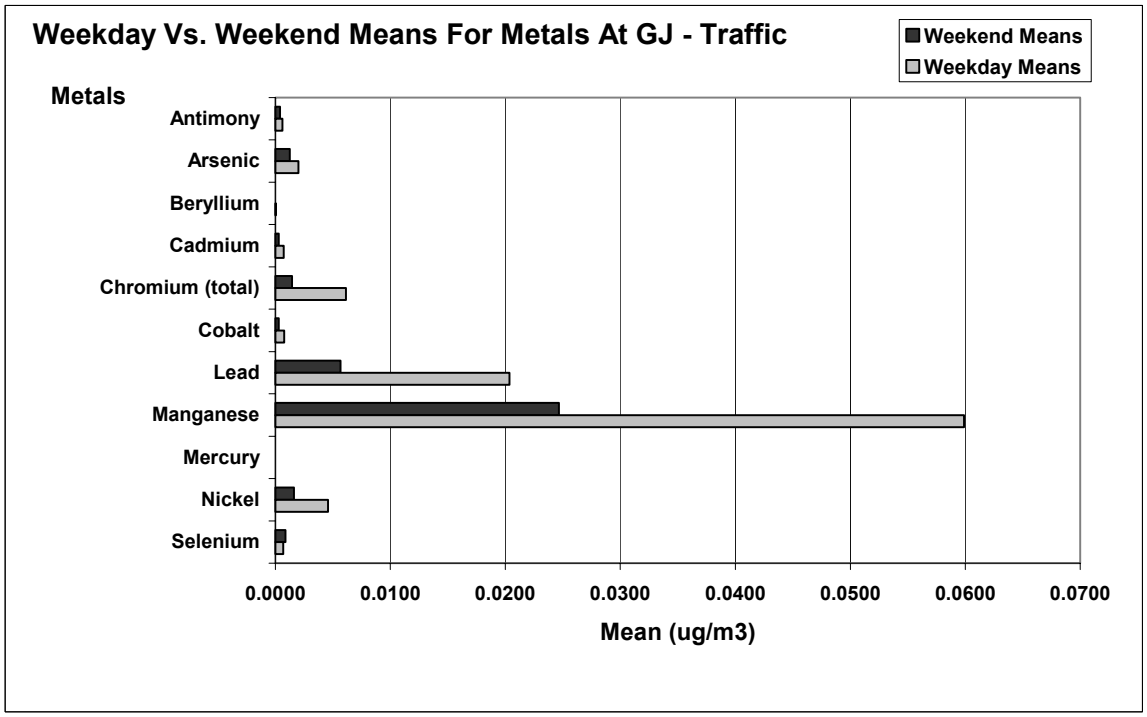


Figure 4.2 – Weekday Vs. Weekend Means For Metals At GJ – Traffic



Graphs – Metals

Figures 4.3 and 4.4 show the four metals found at highest concentration in the ambient air. These are: manganese, lead, antimony, and cobalt. Results for the Traffic site suggest that there are localized sources of manganese and lead at that location. Results for antimony and cobalt do not differ between the two sites.

Figures 4.5 and 4.6 show the other metals measured at the two locations. The MCHD site shows low concentrations for all six metals, while the Traffic site shows localized impacts of chromium and nickel.

Figure 4.3 - Highest Metals at GJ - MCHD

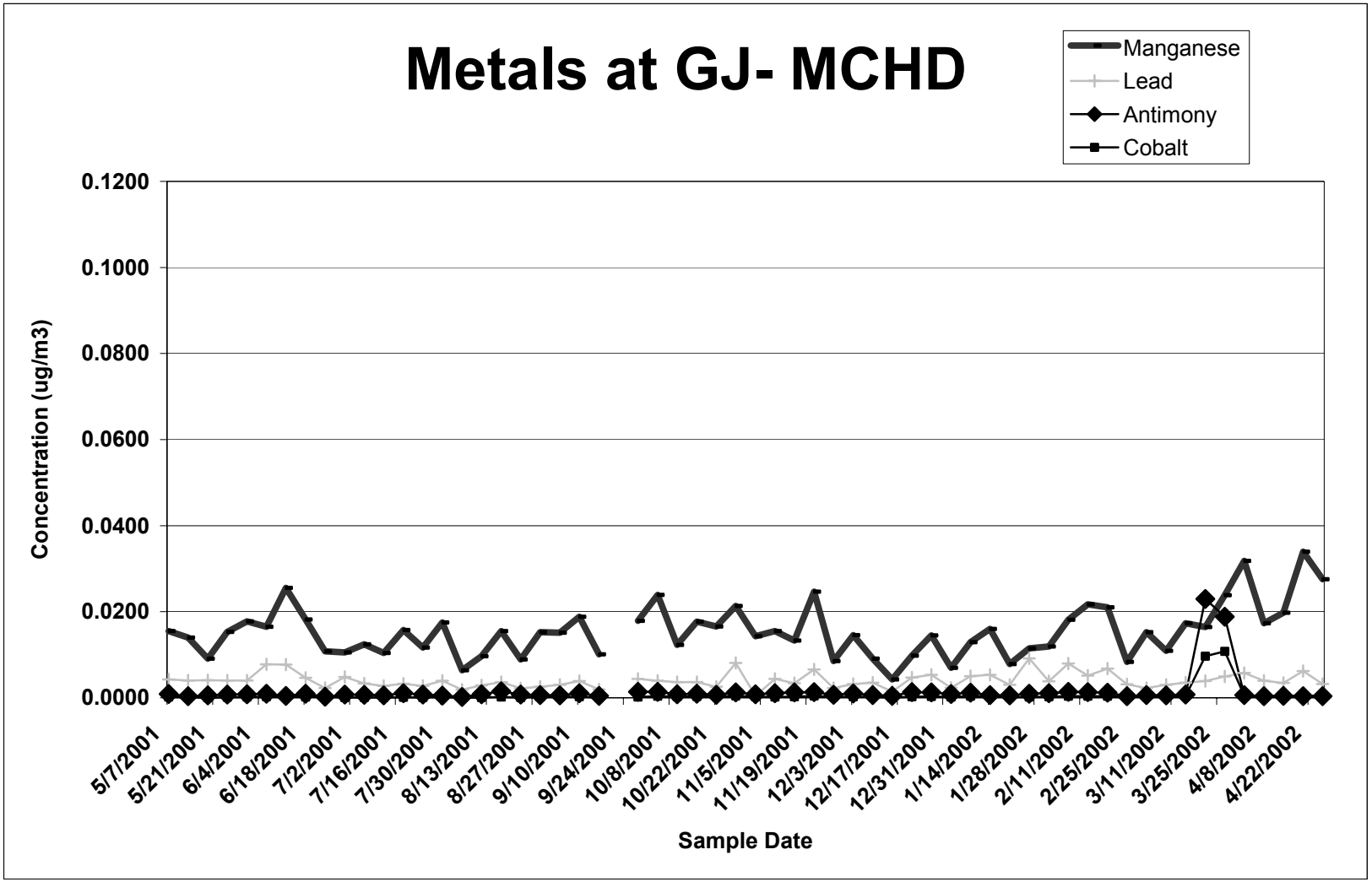


Figure 4.4 - Highest Metals at GJ – Traffic

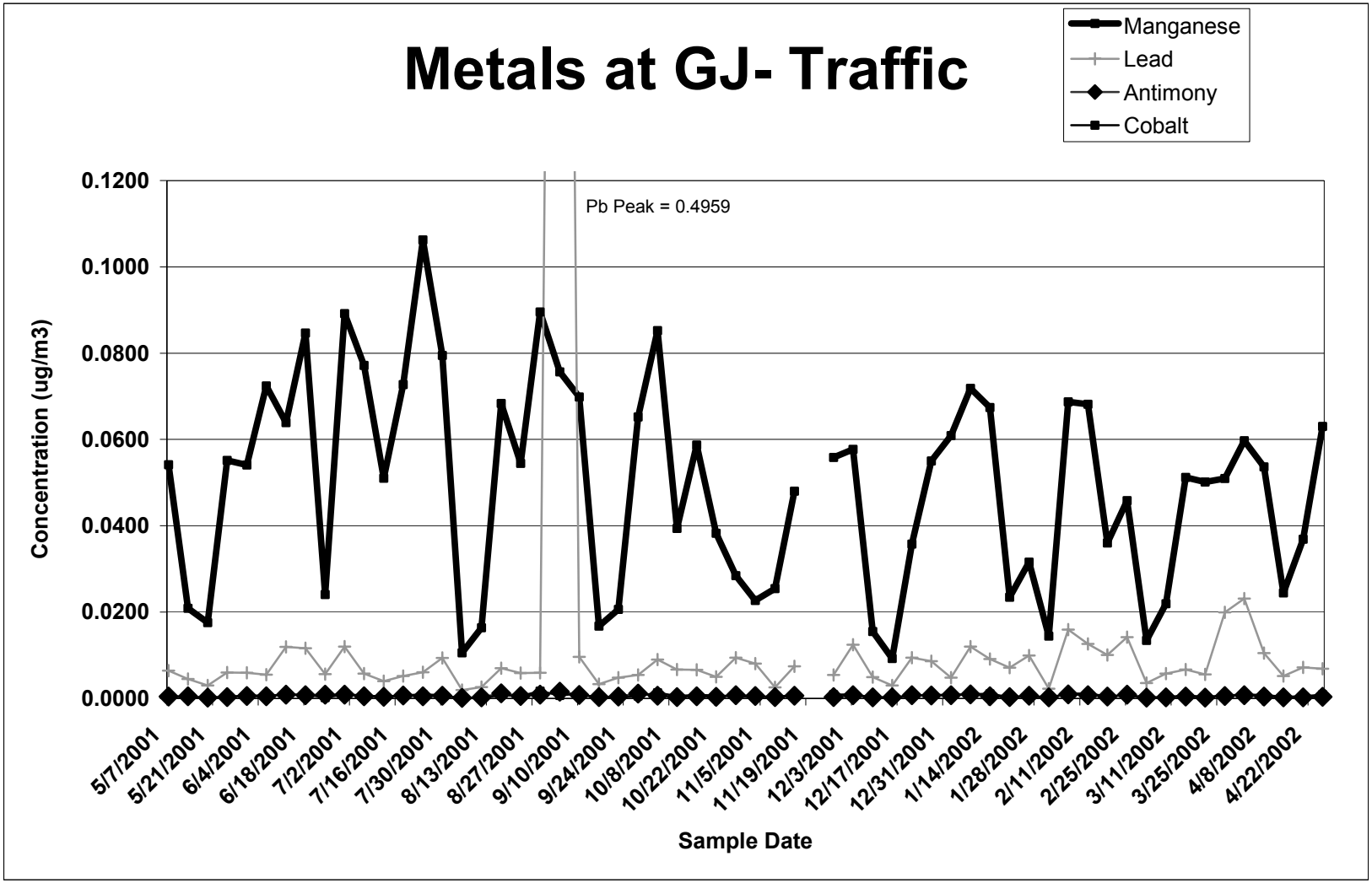


Figure 4.5 - Lower Concentration Metals at GJ - MCHD

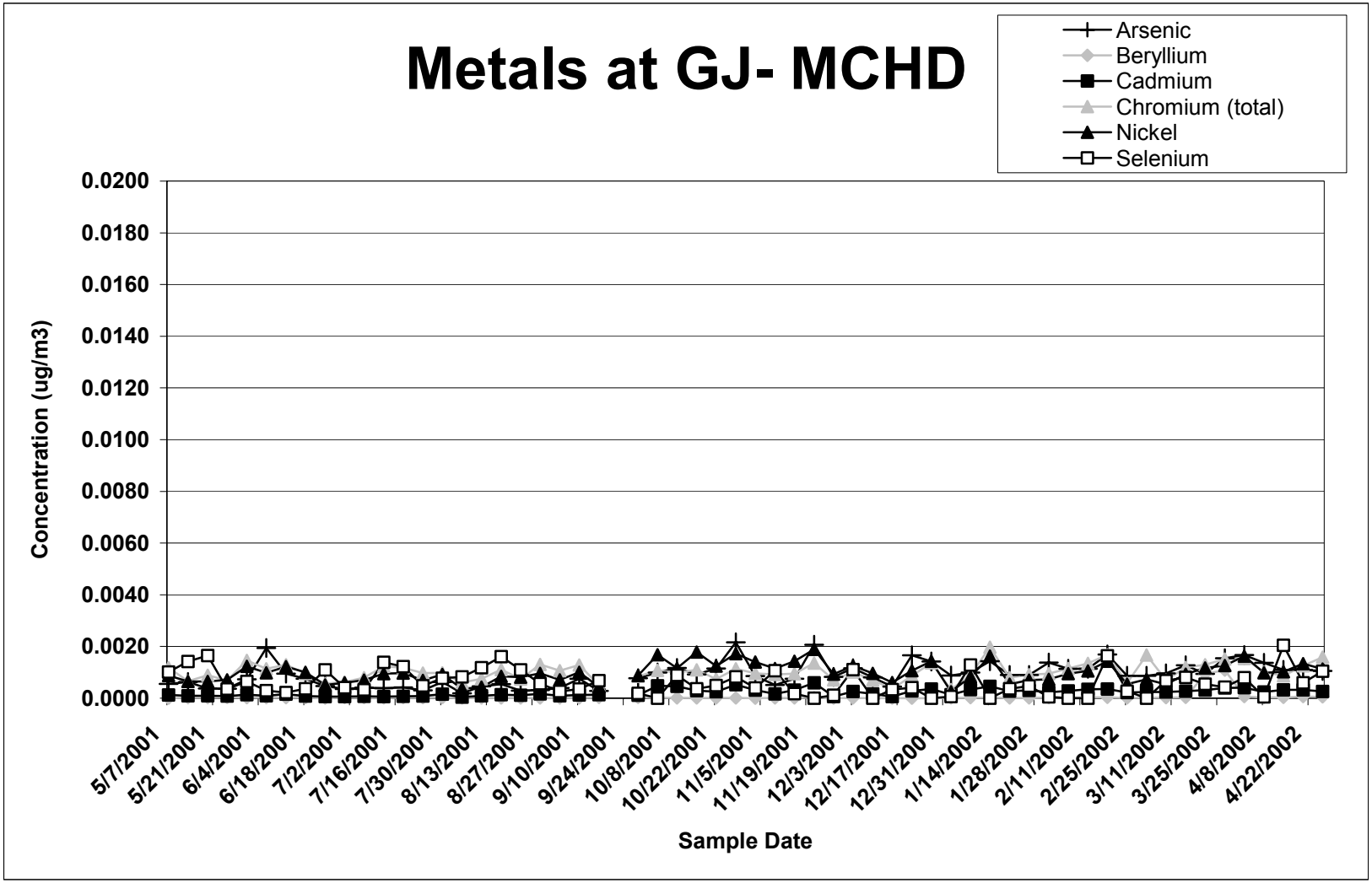
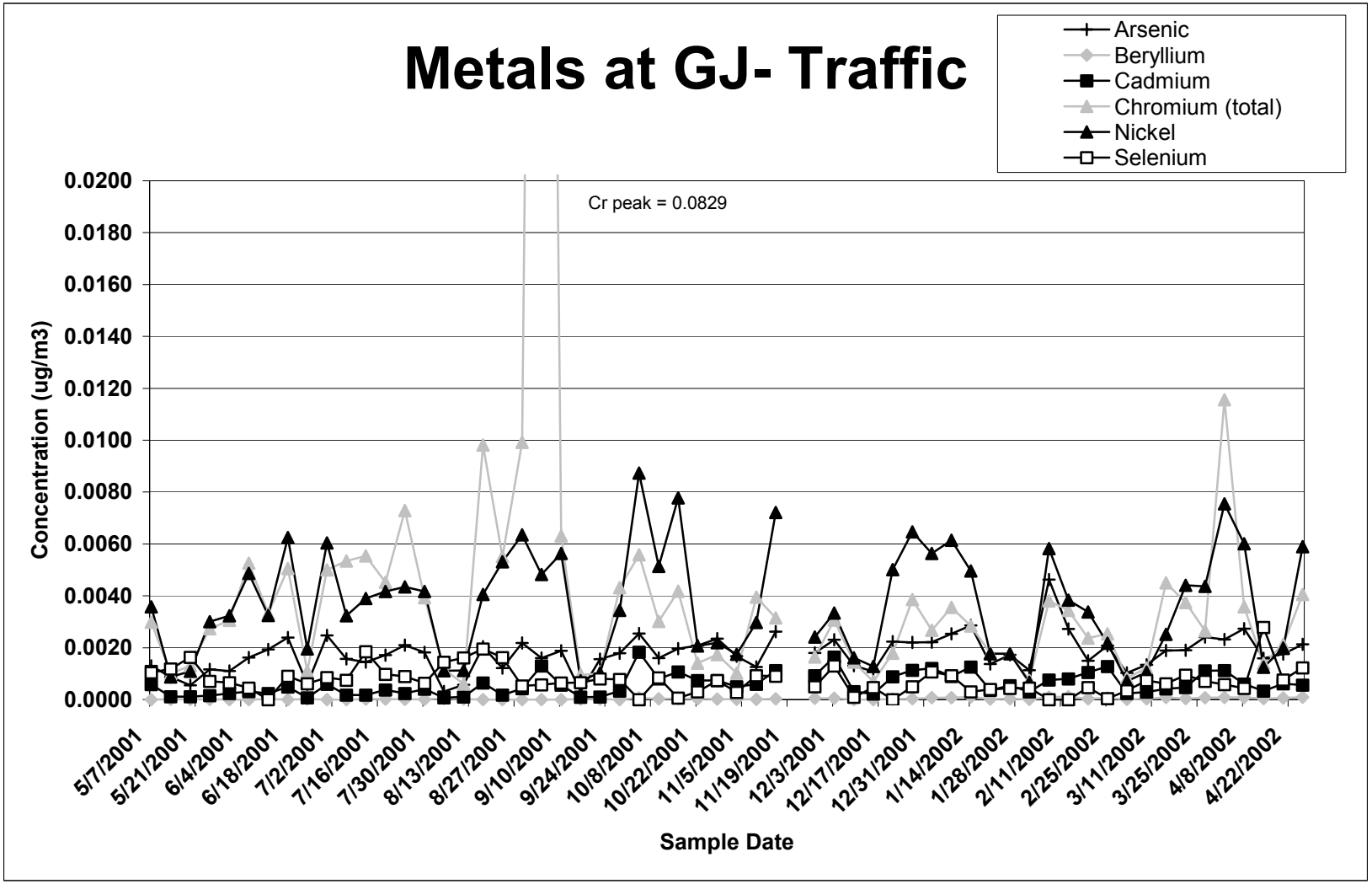


Figure 4.6 - Lower Concentration Metals at GJ - Traffic



Correlation Coefficients Between Compounds – Metals

A correlation coefficient analysis was conducted for the metals. Results (Tables 4.6 and 4.7) show that there is some inter-correlation between these compounds. This inter-correlation suggests a common source for these emissions. At MCHD, antimony is correlated to beryllium and cobalt, while arsenic, cadmium, lead and nickel are correlated to one another. Chromium is correlated to cadmium, manganese, and nickel. Selenium is not correlated to the other metals.

At the Traffic site, antimony is correlated to chromium, cobalt, and manganese. Arsenic is correlated to all the metals except lead and selenium. Beryllium is correlated to cadmium, lead, and cobalt. Unlike some of the other pollutants, metals impacts seem to vary across the city of Grand Junction.

Precision of Sample Results – Metals Compounds

Once every 12 days, a second TSP sampler was run simultaneously with the main one at GJ- Traffic. These additional samples, known as duplicates, were collected in order to assess the precision (repeatability) of the metals sampling method. In general, the duplicates showed good results, within +/- 30 % difference for individual samples. However, two samples with poor precision biased the pooled statistics. Quality assurance information regarding this project is available on request.

Field Blanks – Metals Compounds

Occasionally, a filter was transported to the field, placed on a sampler, and immediately removed, without having any air passed through it. These "field blanks" are taken to assess whether contamination in the field or the sampling materials is significant. The field blanks for this project indicated that chromium and nickel are likely contaminants within the filter media. Chromium field blanks generally had over 2000 nanograms (ng) per filter, while nickel was present at levels well above 1000 ng/filter. Manganese and arsenic showed more than 200 ng/filter in the field blanks.

Field blanks taken during 2001 were pooled and averaged. The 2002 field blanks were also averaged. These "blank levels" were subtracted from the measured concentrations for each sample date, so that levels reported in air would not include filter contamination. 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 project team for the nation-wide project plans to evaluate new filter materials and sampling methods in the future, in hopes of alleviating this problem.

Table 4.6 - Correlation Coefficients for Metals at GJ - MCHD

	Antimony	Arsenic	Beryllium	Cadmium	Chromium (total)	Cobalt
Antimony	**1.00**					
Arsenic	0.15	**1.00**				
Beryllium	**0.98**	0.15	**1.00**			
Cadmium	0.21	**0.76**	0.20	**1.00**		
Chromium (total)	0.23	0.47	0.24	**0.50**	**1.00**	
Cobalt	**0.98**	0.19	**1.00**	0.24	0.25	**1.00**
Lead	0.07	**0.59**	0.06	0.42	0.42	0.07
Manganese	0.15	0.50	0.20	**0.51**	**0.67**	0.20
Mercury						
Nickel	0.15	**0.63**	0.13	**0.73**	**0.65**	0.17
Selenium	-0.07	-0.15	-0.07	-0.05	-0.01	-0.07

Mercury was not detected. It was not included in the correlation analysis.
Correlations greater than 0.50 are in bold print.

	Lead	Manganese	Mercury	Nickel	Selenium
Antimony					
Arsenic					
Beryllium					
Cadmium					
Chromium (total)					
Cobalt					
Lead	**1.00**				
Manganese	**0.51**	**1.00**			
Mercury			**1.00**		
Nickel	0.40	**0.68**		**1.00**	
Selenium	-0.07	0.02		-0.02	**1.00**

Table 4.7 - Correlation Coefficients for Metals at GJ – Traffic

	Antimony	Arsenic	Beryllium	Cadmium	Chromium (total)	Cobalt
Antimony	**1.00**					
Arsenic	0.47	**1.00**				
Beryllium	0.11	**0.61**	**1.00**			
Cadmium	0.39	**0.61**	**0.56**	**1.00**		
Chromium (total)	**0.54**	**0.05**	0.11	0.26	**1.00**	
Cobalt	**0.54**	**0.77**	**0.50**	**0.58**	0.18	**1.00**
Lead	0.48	0.01	**0.52**	0.26	**0.98**	0.07
Manganese	**0.58**	**0.60**	0.23	0.35	0.30	**0.85**
Mercury						
Nickel	0.46	**0.65**	0.37	**0.58**	0.22	**0.78**
Selenium	-0.08	-0.23	-0.19	-0.26	-0.04	-0.20

Mercury was only detected on one day. It was not included in the correlation analysis.
Correlations greater than 0.50 are in bold print.

	Lead	Manganese	Mercury	Nickel	Selenium
Antimony					
Arsenic					
Beryllium					
Cadmium					
Chromium (total)					
Cobalt					
Lead	**1.00**				
Manganese	0.17	**1.00**			
Mercury					
Nickel	0.10	**0.75**		**1.00**	
Selenium	-0.07	-0.05		-0.08	1.00

Health Implications – Metals

As part of its national air toxics analysis effort, EPA has developed recommended benchmark concentrations for various hazardous air pollutants. For each hazardous air pollutant the EPA has tried to develop an "acute" benchmark, as well as "chronic" and "cancer risk" benchmarks. The acute benchmark value represents a value that an individual may be exposed to for a short period of time, without risk of health effects. The period of time may vary for each pollutant, but for the purposes of the analysis here, one compares the highest twenty-four hour daily value observed over the year with the "acute" benchmark. The "chronic" and "cancer risk" benchmarks represent concentrations to which an individual may be exposed over a lifetime without a large risk of incurring health effects. For the purposes of the analysis here, one compares the annual mean to the "chronic" and "cancer risk" benchmarks.

The benchmarks for the hazardous air pollutants may be found on the following EPA web page:

http://www.epa.gov/ttn/atw/toxsource/summary.html

Tables 4.8 through 4.11 summarize the EPA benchmarks available for metals compounds. As seen from the tables, many of the compounds measured have benchmark values. These compounds have benchmarks for long-exposure period health effects (cancer and chronic), but "acute" benchmarks have yet to be developed.

Tables 4.8 and 4.9 compare the annual mean values of these metals to the EPA "unit risk factor" for developing cancer. Column two of these tables gives the annual mean of the compound, as measured in micrograms per cubic meter (ug/m3). Column three of the tables gives the concentration (unit risk factor) associated with a one-in-one million risk of contracting cancer. Column four, Cancer Risk in Ambient Air, relates annual concentrations observed at the Grand Junction stations to the risk of contracting cancer. EPA's goal is for the risk in column four to be 1 X 10-6 or less. Thus, only arsenic and chromium exceed the risk goals. Cadmium at the Traffic station is just at the risk goal level.

Tables 4.10 and 4.11 compare the annual mean values of these compounds to the EPA "Hazard Quotient" value for the risk of chronic (non-cancer) health effects. Column three, Non-cancer Chronic, of the tables gives the value at which EPA believes chronic health effects to the population will not occur. Column four is a ratio of the annual mean (column 2) to the Non-cancer chronic value in column three. EPA's goal is that this "Hazard Quotient" be less than 1.0. (That is, the annual concentration should be less than the Non-cancer chronic value for the pollutant). For all compounds with "benchmarks" the risk is below 1.0. However, manganese at the Traffic site is very close to the benchmark value.

Table 4.8 - Annual Mean Versus Cancer Risk for Metals at GJ - MCHD

Compound	Annual Mean ug/m3	Cancer Risk Factor Per ug/m3 (1/(ug/m3))	Cancer Risk In Ambient Air
Antimony	0.0015	No Factor	
Arsenic	0.0009	0.0043	3.87E-06
Beryllium	0.0001	0.0024	2.40E-07
Cadmium	0.0002	0.0018	3.60E-07
Chromium (total)	0.001	0.012	1.20E-05
Cobalt	0.0006	No Factor	
Lead	0.0041	0.000012	4.92E-08
Manganese	0.0154	No Factor	
Nickel	0.001	No Factor	
Selenium	0.0006	No Factor	

Mercury not listed, as it was never above detection limit.
Chromium Cancer Factor is for Chromium (VI) compounds

Table 4.9 - Annual Mean Versus Cancer Risk for Metals At GJ - Traffic

Compound	Annual Mean ug/m3	Cancer Risk Factor Per ug/m3 (1/(ug/m3))	Cancer Risk In Ambient Air
Antimony	0.0006	No Factor	
Arsenic	0.0018	0.0043	7.74E-06
Beryllium	0.0000	0.0024	0.00E+00
Cadmium	0.0006	0.0018	1.08E-06
Chromium (total)	0.0047	0.012	5.64E-05
Cobalt	0.0006	No Factor	
Lead	0.0159	0.000012	1.91E-07
Manganese	0.0491	No Factor	
Nickel	0.0037	No Factor	
Selenium	0.0007	No Factor	

Mercury not listed, as it was detected only once.
Chromium Cancer Factor is for Chromium (VI) Compounds

Table 4.10 - Annual Mean Versus Noncancer Risk for Metals at GJ - MCHD

Compound	Annual Mean ug/m3	Noncancer Chronic Factor ug/m3	Noncancer Chronic Hazard Quotient
Antimony	0.0015	0.2	0.008
Arsenic	0.0009	0.03	0.030
Beryllium	0.0001	0.02	0.005
Cadmium	0.0002	0.02	0.010
Chromium (total)	0.001	0.1	0.010
Cobalt	0.0006	0.1	0.006
Lead	0.0041	1.5	0.003
Manganese	0.0154	0.05	0.308
Nickel	0.001	0.2	0.005
Selenium	0.0006	20	0.000

Mercury not listed, as it was never above detection limit.
Antimony Factor is for Antimony Trioxide
Chromium Factor is for Chromium (VI) Compounds

Table 4.11 - Annual Mean Versus Noncancer Risk for Metals at GJ - Traffic

Compound	Annual Mean ug/m3	Noncancer Chronic Factor ug/m3	Noncancer Chronic Hazard Quotient
Antimony	0.0006	0.2	0.003
Arsenic	0.0018	0.03	0.060
Beryllium	0.0000	0.02	0.000
Cadmium	0.0006	0.02	0.030
Chromium (total)	0.0047	0.1	0.047
Cobalt	0.0006	0.1	0.006
Lead	0.0159	1.5	0.011
Manganese	0.0491	0.05	0.982
Nickel	0.0037	0.2	0.019
Selenium	0.0007	20	0.000

Mercury not listed, as it was detected only once.
Antimony Factor is for Antimony Trioxide
Chromium Factor is for Chromium (VI) Compounds

Compounds of Significance – Sources and Health Effects

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. Arsenic exposure is known to cause lung cancer. EPA classifies arsenic in Group A, the known human carcinogens.

The Agency for Toxic Substances and Disease Registry (ATSDR) states that remote areas have concentrations of 0.001 to 0.003 ug/m3 arsenic in air, while urban locations range from 0.020 to 0.100 ug/m3 (ATSDR Toxicological Profile on Arsenic). The mean levels at the two Grand Junction sites fall within the urban range.

Chromium

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

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

Chromium's toxicity varies, depending upon its valence state. Cr^{+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 Cr^{+3} exposures, which occur largely in

industrial settings where Cr^{+6} is also present. Cr^{+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. Chromium in outdoor air is more likely to be the trivalent form, and to occur as particulate matter, rather than as a mist. Assessment of the health significance of outdoor levels is complicated by the fact that the monitoring method used in this study, chemical analysis of chromium in particulate matter collected on filters, is incapable of distinguishing between Cr^{+3} and Cr^{+6}.

The California Air Resources Board monitored chromium in 1996. They report a network-wide average of 0.0039 ug/m3 total chromium, of which 0.00013 ug/m3 was hexavalent chromium. They estimate that the hexavalent form accounts for about 3 to 8 percent of the total chromium measured (CARB Fact Sheet on Chromium). The 0.001 and 0.0047 annual means measured at the two Grand Junction sites are close to the California results. Calculations in Tables 4.8 and 4.9 imply that the cancer risk for chromium is ten to fifty times greater than the EPA guideline of one-in a million. However, these calculations assume that all of the chromium present is in the hexavalent form. This assumption probably overstates cancer risk, given the California estimates of only 8% chromium in the hexavalent form. EPA is recommending that future studies conducted for the national air toxics trends monitoring network use a more sophisticated laboratory technique that is able to distinguish between the two chromium forms.

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 used as a gasoline additive, in place of lead. Therefore, automobiles may also emit small amounts.

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.

The California Air Resources Board monitored manganese in 1996. They report a network-wide average of 0.0212 ug/m3 total manganese (CARB Fact Sheet on Manganese). The 0.0154 and 0.0491

annual means measured at the two Grand Junction sites are in the same general range as the California results. The higher concentration observed at GJ-Traffic suggests the influence of localized sources. This concentration is just below the level at which EPA believes health effects could potentially occur.

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Section 5 - Conclusion

Conclusion

This report discusses results for ambient air toxics monitoring conducted at two locations in Grand Junction during the period May 2001 through April 2002. As part of the Environmental Protection Agency's (EPA) Urban Air Toxics Pilot Project (UATPP), twenty-four hour long samples were collected on a once every six day basis for over a year. Sampling occurred at two locations in central Grand Junction. The Mesa County Health Department (MCHD) site was at 515 Patterson Road. The Traffic Engineering Department (Traffic) site was at 925 Fourth Avenue. Samples were taken with equipment provided by Eastern Research Group (ERG), a consulting firm contracted by EPA to provide support to the national network. The ERG samplers collected two different types of samples. A dinitrophenylhydrazine (DNPH) cartridge collected carbonyl samples by EPA Method TO-11A. DNPH cartridges were analyzed for twelve different carbonyls. Air was also drawn into a stainless steel canister. The canisters were analyzed for 58 volatile organic compounds (VOCs) by EPA method TO-15. In addition, High Volume samplers collected Total Suspended Particulate matter samples that were analyzed for eleven different metals. Thus, the total number of chemical compounds assessed is 81. Of the 81 chemicals assessed, 22 were never measured above the method detection limit. Nine others were detected less than 10 % of the time.

Three carbonyls were present in all samples at both sites, with annual mean concentrations greater than one part per billion. These are formaldehyde, acetaldehyde, and acetone. The other carbonyls were present in smaller amounts, and showed strong correlation to these three main ones. Formaldehyde and acetaldehyde are present at levels higher than the "EPA benchmark" goal, which is to maintain the cancer risk level from each compound at less than one in a million excess cancer cases. Automobiles are believed to be the largest emission source for these aldehydes, either as direct emissions, or as compounds forming from photochemical reactions. The impacts from aldehydes are difficult to control, because they can form as hydrocarbons emitted from automobiles and industrial processes react in the presence of sunlight. Analysis of results from the EPA national Urban Air Toxics Network indicates that formaldehyde, acetaldehyde, and acetone are problems on a nationwide scale. Thus, the situation in Grand Junction is typical of most American cities.

For the volatile organic compounds, acetylene, toluene, and m,p-xylenes were present at both sites, with annual means greater than one part per billion. These compounds were detected over 98 % of the time, at both monitoring locations. Compounds with annual means above their EPA "benchmark" concentrations, indicating greater than a one in a million risk of cancer, were 1-3 butadiene, benzene, and carbon tetrachloride. These compounds were present in more than 80 % of the samples taken. Results from EPA's national network indicate that these three are also a problem on a nationwide scale. 1-3 butadiene and benzene are believed to result from automobile emissions, while carbon tetrachloride is an industrially-emitted compound. Acetylene appears to be from a localized source, such as the hospital next to the MCHD site.

Some other VOCs were present on a more localized basis, appearing at one site, but less often at the other. These are likely emitted from local industrial operations. Acetonitrile was more common at MCHD than at the Traffic site. Conversely, acrylonitrile detections only occurred at the Traffic site. Ethyl acrylate and 1,1,2,2-tetrachloroethane were detected a single time at Traffic, but never at MCHD. Results of the single detections, with one-half the detection level substituted for the non-detects, seem to imply that ethyl acrylate and 1,1,2,2-tetrachloroethane are present at levels above their EPA "benchmark" concentrations, with a greater than one-in-a-million risk of cancer. However, the fact that only one detection occurred makes this calculation highly uncertain for these two compounds.

Tetrachloroethylene, or perchloroethylene, occurred at both sites, just under 40 % of the time. Concentrations suggest that this compound, used in dry cleaning, presents a greater than one-in-a-million risk of cancer. These results are consistent with EPA's national analyses, which indicate that levels of tetrachloroethylene are of concern in urban areas throughout the United States. p-Dichlorobenzene occurred less than 10 % of the time at the two sites, but annual averages calculated indicate this compound may be a concern. Unlike many of the others discussed, this one appears to be a local problem. However, the fact that concentrations are detected infrequently adds uncertainty to the risk calculation.

For the metals, almost every sample had very low, but measurable, levels. Mercury was an exception, as it was detected only once during the study. However, mercury is a volatile compound, and the study used a filter-

based sampling method. Thus, the lack of mercury detections is believed to be due to limitations in sampling methodology, and the true levels are not known. Lead was the metal detected at the highest concentrations. However, lead levels were well below the standards of 1.5 micrograms per meter cubed, as a monthly (Colorado standard) or a quarterly (federal standard) average. Arsenic, a known carcinogen, was present at levels greater than the EPA "benchmark" for a one-in-a-million risk of cancer. However, the levels of arsenic detected were low, were typical of other cities in Colorado, and were similar to other national air toxics monitoring sites. Chromium results also exceeded the EPA benchmark for hexavalent chromium. However, the sampling method was unable to distinguish between hexavalent chromium, which is known to cause cancer, and trivalent chromium, which is not believed to cause cancer. Thus, the assumption that all the chromium measured was in the carcinogenic form probably overestimates the risk. The Environmental Protection Agency is considering a new analytical method for the network, which will allow more accurate measurements of hexavalent chromium. Manganese levels at the Traffic site were just below the EPA threshold for health effects not involving cancer. This is believed to be related to a localized source.

In conclusion, a number of compounds related to vehicular emissions are present in Grand Junction air, at levels which may present a concern. These are formaldehyde, acetaldehyde, benzene, and 1,3-butadiene . Carbon Tetrachloride and tetrachloroethylene, which are from industrial sources, also may be a concern. These six compounds appear to be at problem levels throughout the urban areas of the United States. Arsenic, chromium, and manganese may also be of concern, but appear to be from localized sources. Acrylonitrile and acetonitrile occur sporadically and locally. Less certain are results for ethyl acrylate and 1,1,2,2-tetrachloroethane, which were detected only once during the study.

It should be noted that there are a number of limitations with the health risk conclusions in this study. The study represents only the central area of Grand Junction. The cancer risk values assume that an individual is exposed to these levels for an entire lifetime (70 years). The non-cancer health risk values are uncertain, because EPA has not calculated risk levels for short-term health effects. The 24 hour long averaging period used for sampling may not capture high levels of chemicals that occur on a very short-term basis. Finally, the cancer risk levels calculated represent an increase over the "background level" cancer risk in society. For people in the United States, the risk of contracting cancer is between one in two and one-in-three. The Environmental Protection Agency, as a policy decision, has set the goal that no one chemical present in air should contribute to this overall 0.33 – 0.50 cancer risk by more than one-in-a-million (.000001). Calculations in this report use EPA's most recent, best estimates of a one-in-a-million risk level for each chemical compound. However, EPA's risk estimates, as well as actual concentrations of chemicals in the air, change over time. Therefore, this study is best viewed as a "snapshot" in time, indicating which chemicals should be the focus of state or federal regulatory action. Results of the study indicate that the main chemicals of concern in Grand Junction air are the same as the ones upon which EPA is focusing nationally.

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