Utah Toxics Report June 1, 2014

Introduction

The Division of Air Quality (DAQ) has been monitoring ambient concentrations of Hazardous Air Pollutants (HAPs) in the Salt Lake Valley for over a decade. There is an urgent need for additional analysis of Utah's HAPs data. Trace amounts of toxic compounds have been linked to such adverse health effects as cancer, ribosomal damage, birth defects, and other serious conditions. However, HAPs have received little attention over the years. A new study is required to locate sources of HAPs, accurately estimate human health impacts, and enact measures that provide adequate protection for the public. For this report, HAPs data was retrieved from the original National Air Toxics Trends Station (NATTS) monitor in West Valley, Utah. The station operated between the years, 2000 and 2002. Additional HAPs data was gathered from the newer Bountiful NATTS monitor, which has been in operation since 2007.

Toxics data from Phoenix, Arizona was also obtained in order to compare the composition of toxics between the Salt Lake and Phoenix urban areas. Phoenix is situated in a region similar in topography to Salt Lake City. It also conducts the HAPs monitoring comparable to Salt Lake City. Additionally, the Phoenix area lacks the local oil refining and mining industries that are abundant in the Salt Lake Valley. Therefore, contrasting the differences in organic toxics and metals of the two regions should help determine the impact oil refining and mining have on the air quality in the Salt Lake Valley.

Topography

Salt Lake City is located in the northeast corner of the Salt Lake Valley, 4,327 feet above sea level. The city is situated between the Wasatch mountain range on the east and the Oquirrh Mountains to the west. The Great Salt Lake is northwest from Salt Lake City and surrounded by numerous marshes. The population of the Salt Lake metropolitan area is approximately 1.2 million and the climate is classified as dry-summer continental.

The major industrial sources in the Salt Lake Valley include the Rio-Tinto Copper mine and smelter located at the base of the Oquirrh Mountains and the oil refineries located between Salt Lake City and Bountiful, to the north. There are three major arterial roadways located in the Salt Lake Valley. Interstate 15 spans the length of the valley from north to south, I-80 cuts east to west across the valley and through Salt Lake City, and I-215 loops around the northern portion of the valley.

Phoenix, Arizona is located in the northeastern Sonoran Desert. The city is surrounded by the McDowell and Superstition mountains to the northeast and east, respectively. Phoenix is set in the Salt River Valley at approximately 1,100 feet above sea level and its climate is defined as a subtropical desert. There are about 1.5 million inhabitants within the Phoenix city limits and nearly 4.3 million people living in the surrounding metropolitan area. The area is spanned by two major freeways and contains no major oil refining or mining operations.

Analysis Method

Toxics data were collected from two Utah locations: West Valley (2000-2002), and Bountiful (2007-2012). A third set of data was collected from Phoenix, Arizona (2007-2012). Each of the three datasets contained 69 different HAPs, including ten metals.

HAPs from the West Valley station were collected according to EPA Method TO-15, using specially prepared steel canisters to collect the volatile organic compound (VOC) component of the the HAPs. The metals portion of the HAPs was gathered using a total suspended particles (TSP) sampler. The site was discontinued on December 31st, 2002 and relocated to a mainly residential area in Bountiful, Utah. Upon relocation, samplers were added for Polycyclic Hydrocarbons, Chromium(VI) (TSP method), and aldehydes. Metal sampling shifted from the TSP method to the PM_{10} fraction of ambient particulate matter. A Photochemical Assessment Monitoring Station (PAMS) was also added to the station.

Phoenix data was gathered at Arizona's JLG Supersite, located in a residential area, four miles north of downtown. HAPs sampling and analysis methods conducted at JLG were identical to those employed at the two Utah locations. The Bountiful and Phoenix sites are both located within 1.5 km of a major freeway.

Reference Concentrations

To better assess public exposure to HAPs in the Salt Lake Valley, two reference concentrations (screening levels) were used in this report. Both levels relate to the concentrations at which particular health effects are manifest from a lifetime exposure to each individual HAP.

One-in-One-Million Cancer Risk Threshold

The one-in-one-million cancer risk threshold is the minimum pollutant concentration at which person would have a one-in-one-million chance of developing cancer.[1] Because sufficient human carcinogenicity data for most HAPs is extremely scarce, most one-in-one-million cancer risk thresholds were developed using values extrapolated from animal studies. The method used to approximate human exposure limits from such studies applies the most conservative method in calculating human exposure levels. Thus, the actual risk to human health is not likely going to exceed the upper-bound estimates of human exposure levels used as the screening levels in this report.

The figures presented in this report display the one-in-one-million cancer risk threshold as a blue dashed line in the relevant graphs. The absence of a blue dashed line signifies that either, the HAP in question has no known carcinogenic effects or that there is insufficient data to determine a one-in-one-million cancer risk threshold.

Non-Cancer Effect Chronic Exposure Threshold

The values for the chronic exposure thresholds used in this report were based on the Reference Concentration (RfC) derived by the EPA. The RfC represents the concentrations at which a

[1] U.S. EPA. Guidelines for Carcinogen Risk Assessment, EPA/630/P-03/001F, March 2005

"continuous exposure to the human population (including sensitive sub populations)… is likely to be without an appreciable risk of deleterious effects during a lifetime".[2] These values are usually derived for effects other than cancer and their uncertainties are usually within one order of magnitude. For this report, the reference concentrations derived for inhalation exposure were used.[3] Although reference concentrations are generally reported in milligrams per cubic meter (mg/m^3), threshold units were converted to ppb for gases and micrograms per cubic meter ($\mu g/m^3$) for aerosols. These conversions were done to conform to industry standards for reporting gaseous and PM monitoring data.

To accommodate the possibly compounding health effects from the interaction of various pollutants, RfC values were multiplied by 0.1 to construct even stricter thresholds. In other words, chronic exposure levels stated in this report are one-tenth of the RfCs established by the EPA.

The chronic exposure threshold is represented by a solid red line in figures throughout this report. In cases where the solid red line is absent, it is because the scale of the figure is too small to visually accommodate both, the data and threshold level.

Results

Organics

Most of the monitored organic compounds were measured at or below the limit of detection. The HAPs that had over 5% of their measurements above one of the two risk thresholds were considered significant contributors to the local environment. In the years between 2000 and 2002 at the West Valley site, nine organic HAPs were frequently detected at exceeding the 5% threshold. Appendix 1 contains boxplots summarizing the organic HAPs observed at the Bountiful and West Valley sites.

Table 1, below, shows the percentage of all collected measurements that were above the one-in-one-million cancer risk threshold or chronic exposure levels.

[2] U.S. EPA. Methods for Derivation of Inhalation Reference Concentrations (RfCs) and Application of Inhalation Dosimetry. U.S. Environmental Protection Agency, Office of Research and Development, Office of Health and Environmental Assessment, Washington, DC, EPA/600/8-90/066F.
3 U.S. EPA. Dose-Response Assessment for Assessing Health Risks Associated With Exposure to Hazardous Air Pollutants, Table 1, Nov 2013.

Table 1.

	BV		WV		PHX	
	% 1/1mil	% Chronic	% 1/1mil	% Chronic	% 1/1mil	% Chronic
1,3-Butadiene	85.11%	13.20%	73.75%	53.75%	95.34%	56.64%
1,4-Dichlorobenzene	22.75%	0.00%	10.00%	0.00%	83.62%	0.00%
Acetaldehyde	100.00%	88.89%	100.00%	98.10%	100%	100%
Acrolein - Unverified		100.00%				100%
Acrylonitrile	13.48%	5.06%	22.50%	22.50%	19.75%	11.6%
Benzene	100.00%	3.09%	100.00%	48.13%	96.8%	24.24%
Carbon Tetrachloride	99.72%		86.88%	0.00%	100%	
Dichloromethane	32.02%	5.62%	5.63%	0.00%	10.63%	0.00%
Ethylbenzene	36.24%	0.00%	90.00%	0.00%	75.06%	0.23%
Ethylene Dichloride	20.22%	0.00%			29.89%	0.00%
Formaldehyde	100.00%	97.44%	100.00%	100.00%	100.0%	100.0%
Tetrachloroethylene	32.30%	0.00%	34.38%	0.00%	74.43%	0.00%
M/P Xylene			0.00%	6.88%		
Propionaldehyde		10.54%	0.00%	8.23%		10.71%

Ignoring differences in sample collection periods, some trends in the observations could be related to the dissimilar industrial and residential emission sources in each area. Trends may also appear due to how close sampling stations are to major highways. For instance, the increase in 1,3-Butadiene (detected in high concentrations around oil refineries and in gasoline engine combustion) could be related to the short distance between the Bountiful station, I-15, and multiple oil refineries. However, benzene, also a common component of fugitive gasoline vapors and diesel engine emissions, was observed more frequently and at higher concentrations at West Valley.

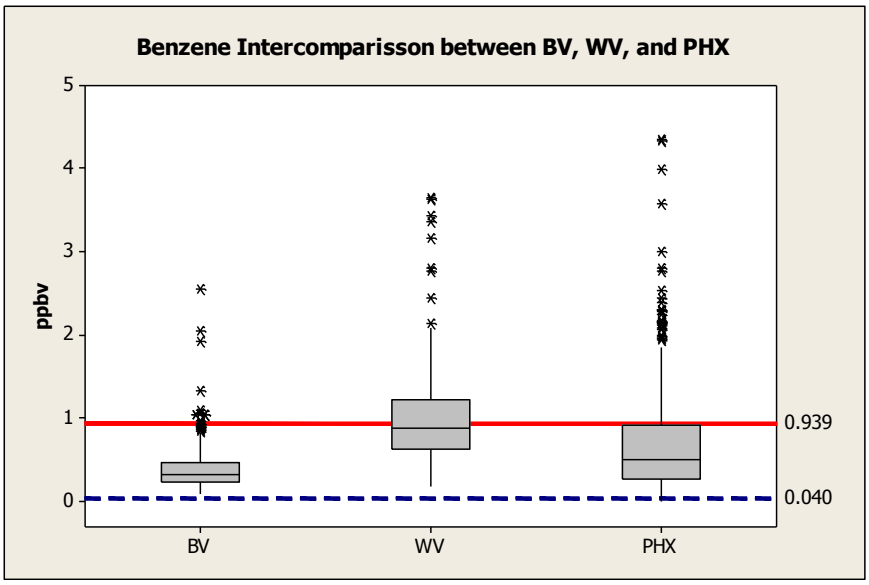
The increase in chlorinated carbon species could be attributed to the close proximity of the Great Salt Lake and the lake's surrounding salt marshes. These areas are known to produce higher than normal levels of chlorine.[4] The rest of the organic HAPs tend to display little variance between the two monitoring sites, suggesting that they are likely well mixed across the valley. Phoenix HAPs tended to exceed the one-in-one-million risk and the chronic exposure thresholds more frequently than Salt Lake City for almost all species except dichloromethane. The boxplots in Appendix 1 show the distribution of observed values with respect to the one-in-one-million risk threshold and chronic exposure level.

4 Rhew, R.C., B.R. Miller, and R.F. Weiss. 2000. Natural methyl bromide and methyl chloride emissions from coastal salt marshes. Nature 403:292-295.

Benzene

Benzene is found in the air from emissions from burning coal, gasoline and oil, evaporation from service stations, and motor vehicle exhaust. Acute (short-term) inhalation exposure to benzene may cause drowsiness, dizziness, headaches, as well as eye, skin, and respiratory tract irritation. At high enough levels, unconsciousness can occur. Chronic (long-term) inhalation exposure has caused various disorders in the blood in occupational settings. These disorders include reduced red blood cell counts and aplastic anemia. Adverse reproductive effects have been reported in women exposed to high levels of benzene. Adverse effects on developing fetuses have been observed in animal tests. Increased incidences of leukemia (cancer of the tissues that form white blood cells) have been observed in humans occupationally exposed to benzene. The EPA has classified benzene as a known human carcinogen for all routes of exposure. Barring benzene manufacturing facilities, primary sources of ambient benzene are from motor vehicles, coal burning, gasoline, oil, as well as evaporation at automobile service stations.[5,6]

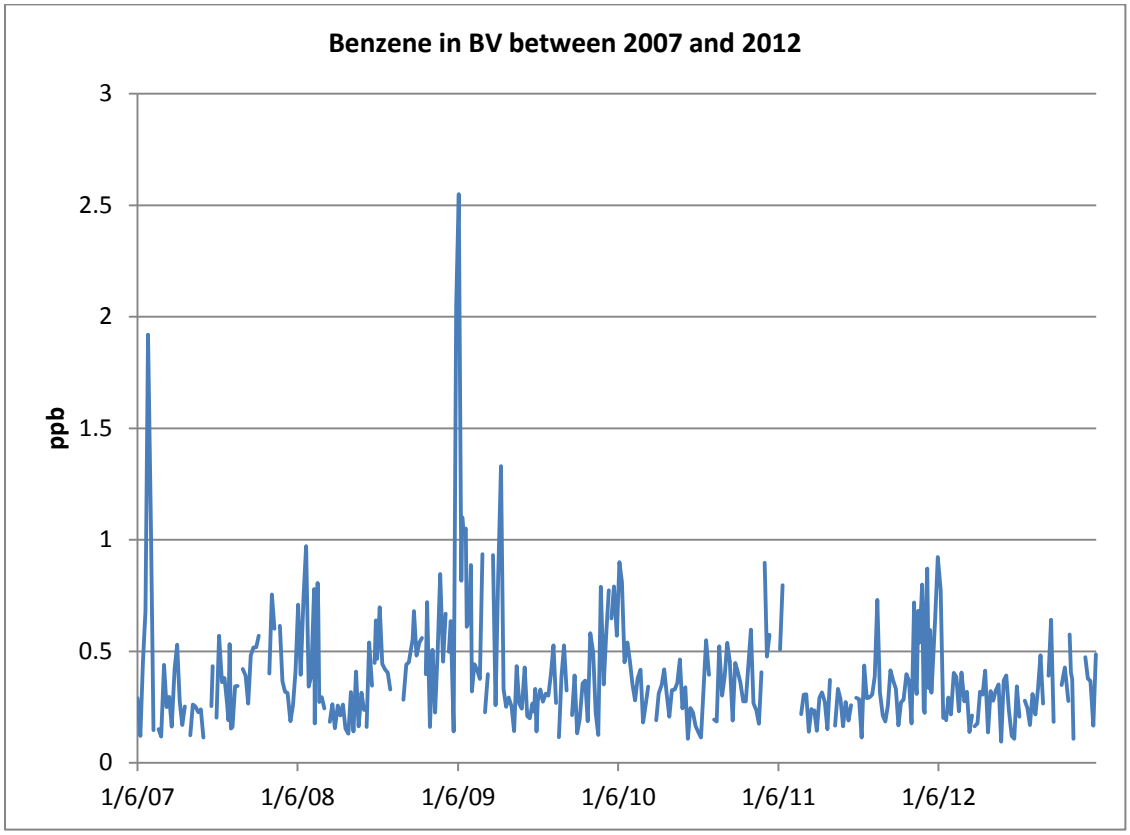
Figure 1. **The data distribution of benzene between the Bountiful (BV), West Valley (WV), and Phoenix (PHX) sampling sites.**



[5] Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for Benzene. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA. 2007.

[6] M. Sittig. Handbook of Toxic and Hazardous Chemicals and Carcinogens. 2nd ed. Noyes Publications, Park Ridge, NJ. 1985.

Figure 2. **The trend of benzene observations between 2007 and 2012 at the Bountiful site.**



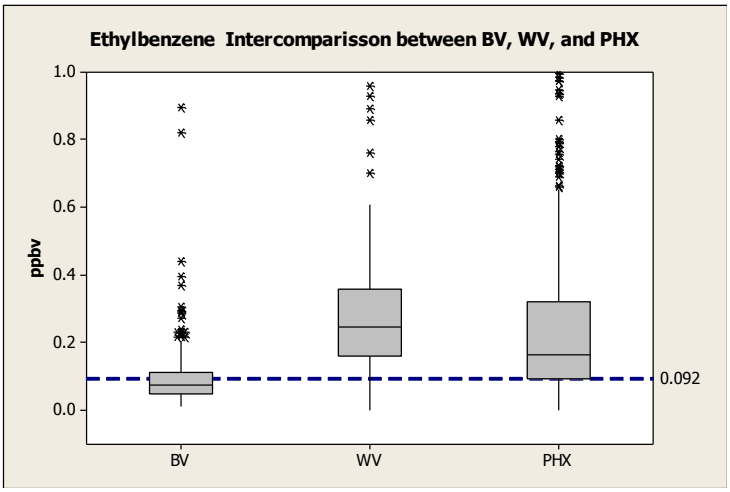
It is difficult to identify the reason behind higher levels of benzene at the West Valley site. Proper investigation is further complicated by the older time-period of the data. However, in spite of its closer location to the refineries, the Bountiful site systematically recorded lower mean values of benzene than what was seen in Phoenix or West Valley. Additionally, there was a downward trend in the magnitude and the frequency of high benzene measurements at the Bountiful site. The lower benzene levels at Bountiful, in comparison to West Valley observations, could be the result of a decade of emission control requirements and improvements in automobile efficiency.

Benzene is moderately reactive and its removal from the atmosphere is strongly dependent on photochemical processes. Therefore, benzene tends to follow a trend common to most of the organics observed in Utah: Benzene concentrations tend to be elevated during winter and much lower during warm periods of the year. This pattern has less to do with the occurrence of persistent wintertime inversions than it does with the compound's increased lifespan and decreased reactivity in cold temperatures.

Ethylbenzene

Ethylbenzene is primarily used as a solvent and in styrene production. It is also a constituent of asphalt and is found in some fuels. Acute exposure to Ethylbenzene leads to irritation of the eyes and throat, chest constriction, and dizziness. Chronic exposure to Ethylbenzene has inconclusive effects on human health, but animal studies have shown detrimental effects on the kidneys, liver, and blood composition of test subjects. Currently, ethylbenzene is classified as a Group D pollutant; it is unclassifiable with respect to human carcinogenicity.[7,8]

Figure 3. **The relative levels of ehtylbenzene detected in Bountiful, West Valley, and Phoenix, AZ.**



As with benzene, observed values at the West Valley site were higher on average than those seen in PHX or BV. However, a reliable discovery of the possible sources of ethylbenzene at the West Valley location is difficult due to the age of the sampling period. A special study would be useful in determining the spatial distribution of ethylbenzene across the Salt Lake Valley.

The values of ethylbenzene observed at the Bountiful site were significantly lower than those recorded at PHX. Less that 50% of the BV measurements were above the one-in-one-million risk exposure level, whereas over 75% of the PHX measurements were above that level. Additionally, the PHX monitor recorded far more outlier measurements above that level when compared to the other two sites. This indicates that local emission sources specific to the Phoenix area are likely involved.

In Figure 4, the time series between 2007 and 2012, show ethylbenzene levels tended to be below 0.1 ppb in summertime and generally below 0.2 ppb during winters. These levels are much lower than the 0.3 ppb of ethylbenzene normally expected in urban areas. Aside from a few exceptions in 2008 and 2010, ethylbenzene follows the “high during winter, low during summer” trend.

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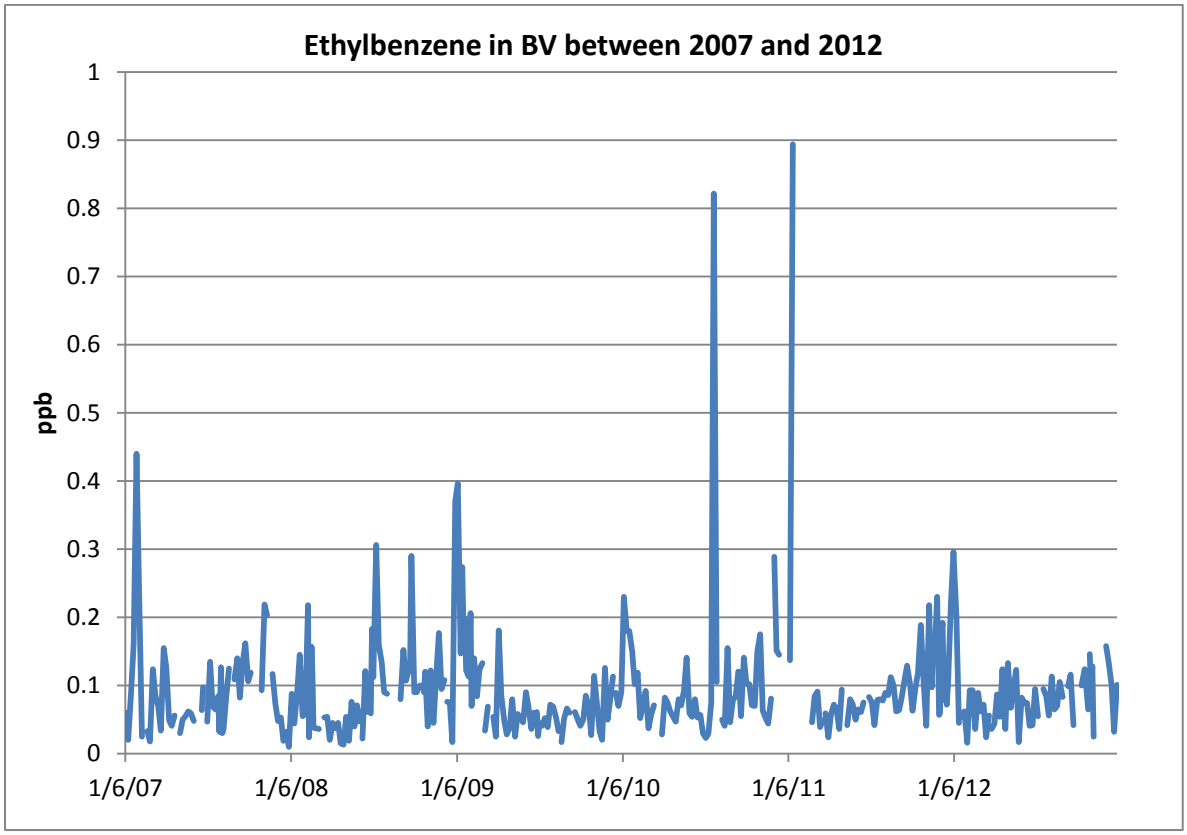
[7] Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for Ethylbenzene (Update). Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA. 1999.

[8] E.J. Calabrese and E.M. Kenyon. Air Toxics and Risk Assessment. Lewis Publishers, Chelsea, MI. 1991.

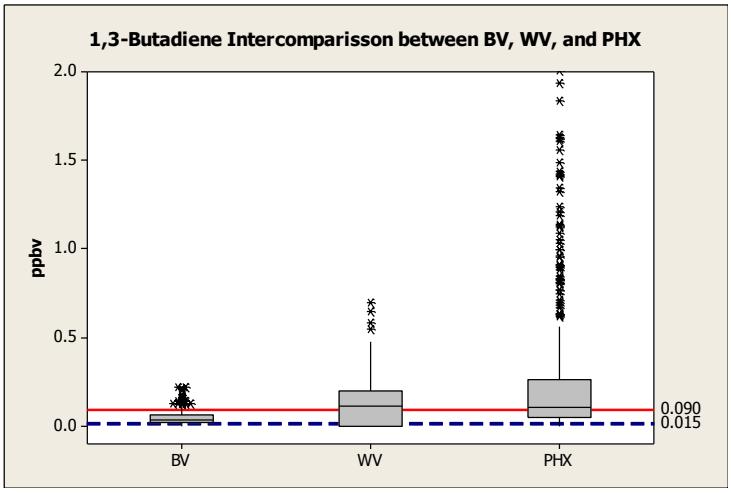
Figure 4. **A long-term graph of ethylbenzene in Bountiful between 2007 and 2012.**



1,3-Butadiene

1,3-Butadiene is primarily released from motor vehicle exhaust, forest fires, and plastic manufacturing facilities. It is widely present in urbanized areas, and despite its short atmospheric lifetime, it may reach concentrations of 0.3 ppb. Elevated concentrations of 1,3-butadiene are generally detected in heavily urbanized areas and near oil refineries. Acute exposure to 1,3-butadiene causes irritation of the eyes, lungs, and mucous membrane. Chronic exposure to this substance is associated with increased incidences of leukemia in humans and tumors in animals. 1,3-butadiene has been classified as a human carcinogen.[9]

Figure 5. **The boxplots associated with the 1,3-butadiene data observed at Bountiful and Phoenix, AZ between 2007 and 2012, and at the West Valley site between 2000 and 2002**.



As was the case with benzene and ethylbenzene, the West Valley site recorded unusually high 1,3-butadiene values during its operation. However, mean 1,3-butadiene values observed in Phoenix, AZ tended to be higher than those in either Bountiful or West Valley. Additionally, the Phoenix dataset included a large number of outliers that spanned concentration ranges well into 1 - 2 ppb. Only 13.2% of BV measurements were recorded above chronic exposure levels, while PHX had 56.6% of its data above that range.

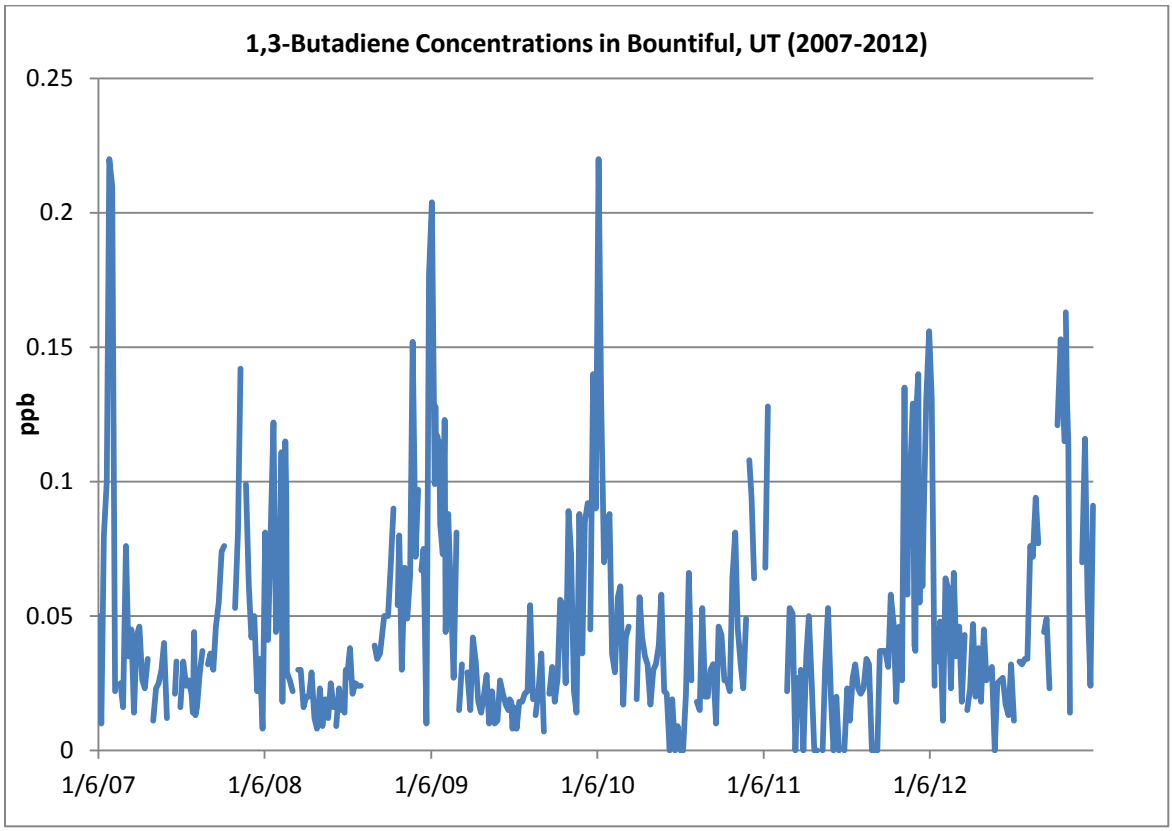
The Bountiful site recorded 85.1% of its measurements above the one-in-one-million risk level, while 95.3% of Phoenix measurements were above that level. The disparity between Bountiful and Phoenix measurements is likely associated with the higher number of automobiles in the Phoenix area. The near-proximity of the Bountiful monitoring site to oil refineries had little or no effect on 1,3-butadiene values when compared with West Valley results.

The long term trend of 1,3-butadiene displayed in figure 6, below, shows a strong winter-summer association common to most organics. Peak winter concentrations of the pollutant consistently tend to breach 0.1 ppb level annually. Summertime 1,3-butadiene concentrations tend to vary

[9] Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for 1,3-Butadiene. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA. 1992.

between 0.02 ppb and 0.05 ppb. As with most organics, this pattern is the consequence of decreased temperatures and photochemical activity during the wintertime resulting in longer lifetimes of the substance. The pattern is further exacerbated by the formation of stable inversions, compression of the mixing layer, and generally low mixing.

Figure 6. **A long-term trend graph of 1,3-butadiene in Bountiful between 2007 and 2012. A strong seasonal pattern is revealed.**

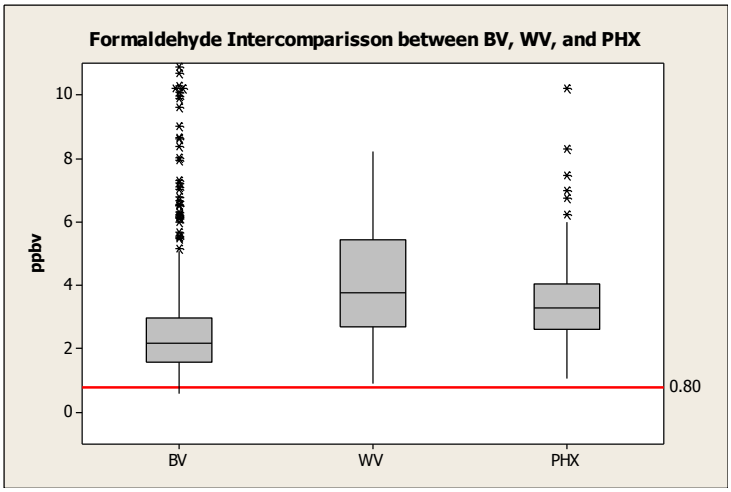


Formaldehyde

Formaldehyde is one of the most ubiquitous organic species in ambient air. It is primarily emitted from consumer products and home furnishing manufacturing. Formaldehyde is also a common byproduct of power plants, incinerators, and motor vehicle exhaust. As a terminal step in the oxidation of most organics, large quantities of formaldehyde are formed in the atmosphere through secondary chemistry. Its photoreactive nature affords formaldehyde a short lifetime on warm, sunny days and makes it an important contributor in the ozone formation process.

The effects of acute exposure to formaldehyde are irritation of the eyes, nasal pathways, and throat. Prolonged exposure to formaldehyde has been associated with some types of nasal and lung cancers. It is currently classified by the EPA as Group B1, a probable human carcinogen. Ordinary exposure levels for formaldehyde range between 0.3 – 3 ppb for indoor and 10 – 20 ppb for urban areas.

Figure 7. **Formaldehyde values for the Bountiful (2007-2012), West Valley (2000-2002), and Phoenix (2007-2012.**

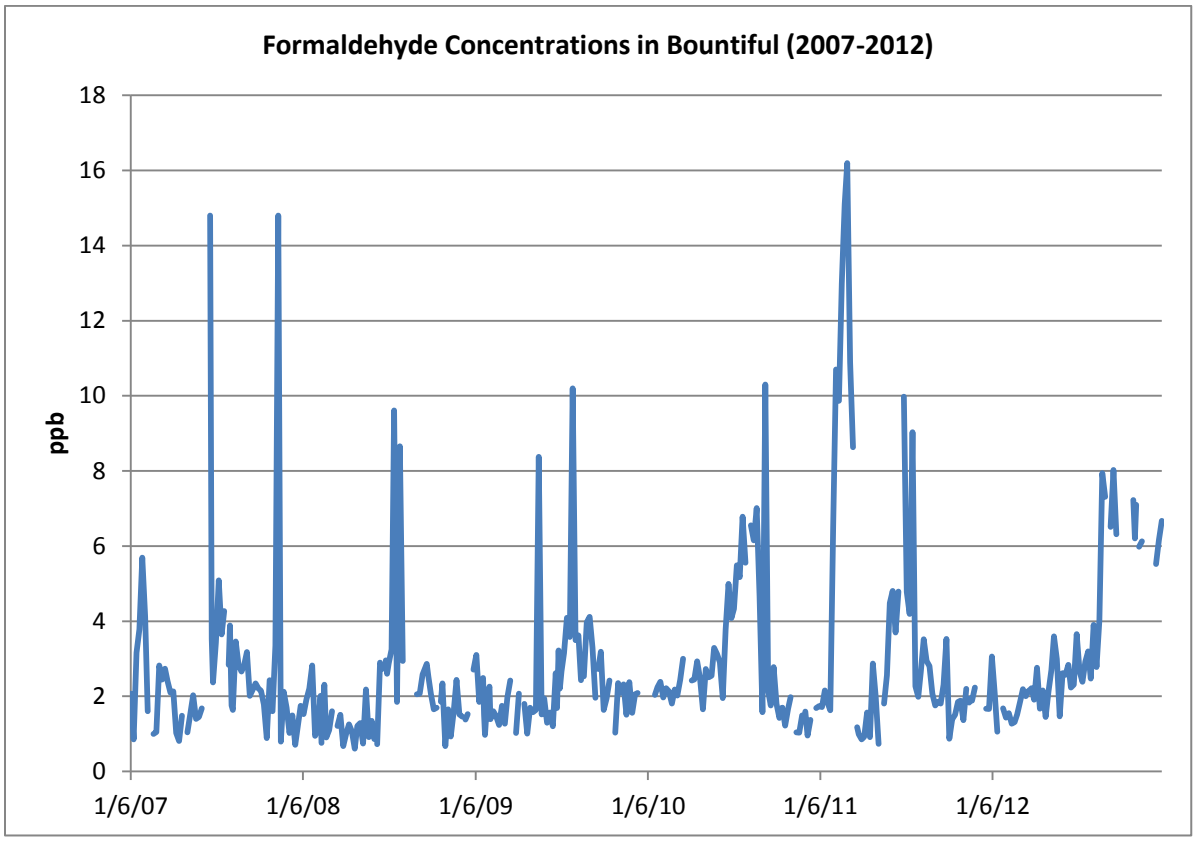


As with benzene and ethylbenzene, higher than expected levels of formaldehyde were observed at the West Valley site between 2000 and 2002. Phoenix recorded a greater range of formaldehyde measurements than Bountiful. Some of the outliers in the BV data tended to be in the low 10 ppb range. However, only a few of these data points coincided with recorded wildfire events in the area. This suggests the influence of other local emission sources.

The long-term trend graph in figure 8 shows that the highest concentrations of formaldehyde are generally observed during the hottest months of the year: July and August. This is consistent with the fact that formaldehyde is formed in the air at its highest rate during seasons of high photochemistry. During these periods, other ambient organic compounds undergo photochemically driven oxidation as well. Because large quantities of formaldehyde are produced as a result of the oxidation of other organics, potential control strategies for this pollutant are not

straightforward. Limiting the emissions of other organics, along with formaldehyde itself, may lower the current concentrations of this pollutant.

Figure 8. **A long-term trend graph of formaldehyde in Bountiful between 2007 and 2012.**

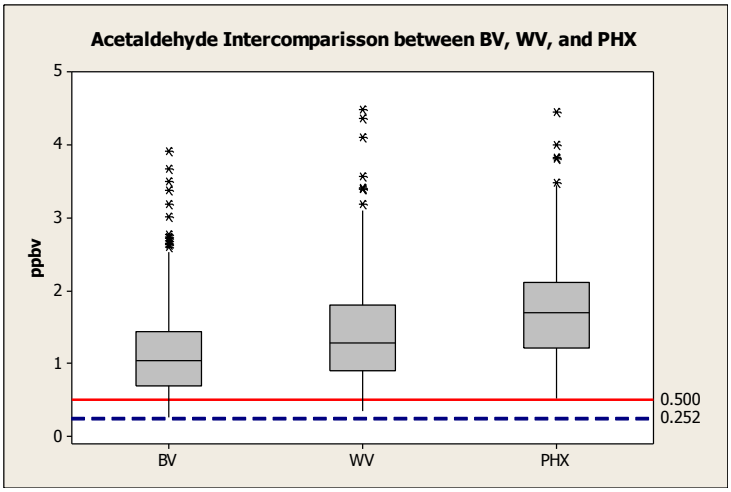


Acetaldehyde

Acetaldehyde is one of the major participants in atmospheric chemical processes. It is released into the environment through incomplete wood combustion, vehicle exhaust, and waste processing. It is also released during higher plant and vegetation respiration and is one of the intermediates in the photochemical oxidation of airborne organics.

Acute short-term exposure to acetaldehyde causes irritation of the eyes, skin, and respiratory tract. Long-term exposure to acetaldehyde causes olfactory degeneration in rats and hamsters. As of yet, studies haven't demonstrated conclusive results regarding the health effects of acetaldehyde on people. It is classified as a probable human carcinogen based on the insufficient number of human exposure studies.[10]

Figure 9. **The comparison of acetaldehyde data for Bountiful and Phoenix (2007-2012), and West Valley (2000-2002).**



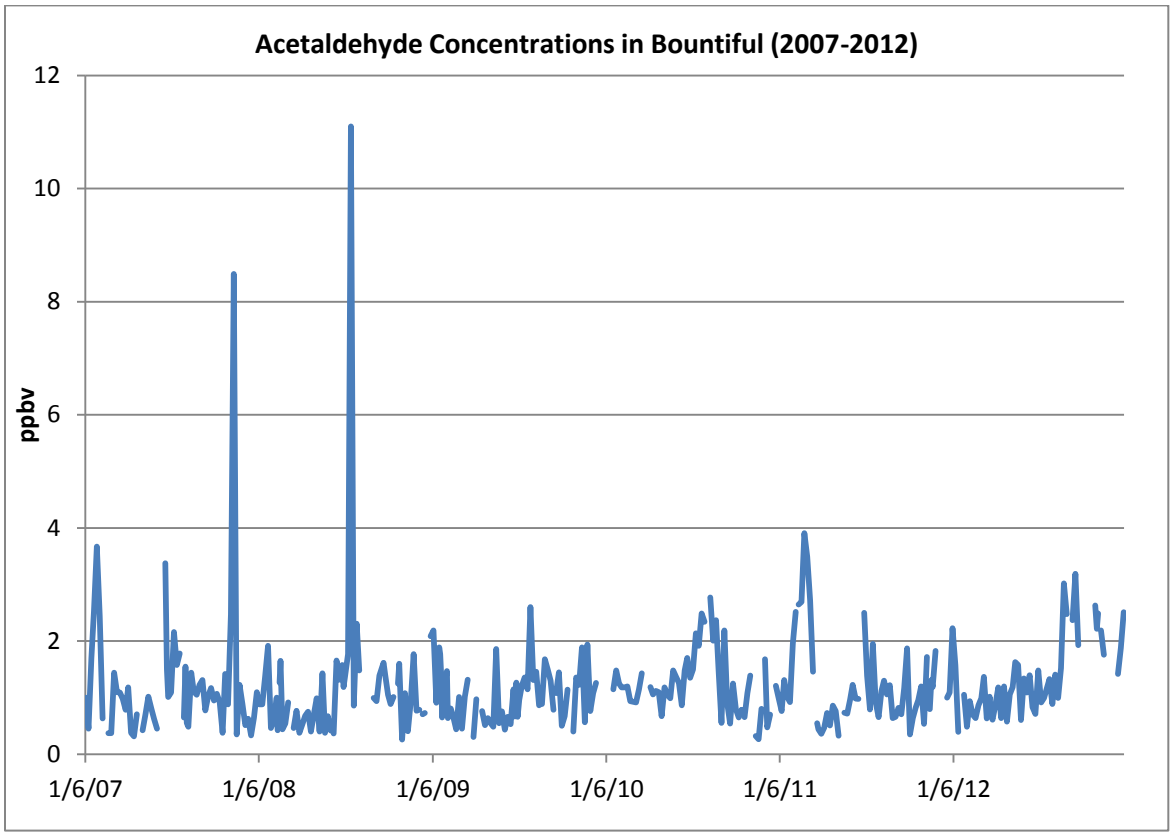
Phoenix acetaldehyde mean, median, and range values tended to be much higher than those observed in Bountiful. Nearly 89% of all acetaldehyde measurements at Bountiful, between 2007 and 2012, were found above the suggested chronic exposure limit of 0.5 ppb. During this same time, 100% of measurements at Phoenix were above the suggested chronic exposure limit. Since high acetaldehyde levels are correlated with urbanization, it is not surprising Phoenix generally exhibits higher acetaldehyde values.

The long-term trend of acetaldehyde, shown in figure 10, presents a picture similar to that of formaldehyde: maximum values are observed during warmer months. However, an increased production of acetaldehyde is also observed during winter months. This is likely due to increased

[10] U.S. Environmental Protection Agency. Health Assessment Document for Acetaldehyde. EPA/600/8-86-015A. Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Office of Research and Development, Research Triangle Park, NC. 1987.

wood burning during the colder season. Acetaldehyde tends to be at its lowest (approximately 1 ppb) during the spring and fall months. Two exceptionally high acetaldehyde values were observed on 11/6/07 and 7/6/08 posing an interesting question with respect to their origin. A closer investigation of the conditions on those days is needed to determine the probable causes of such high values.

Figure 10. **A long-term graph of acetaldehyde concentrations in Bountiful between 2007 and 2012.**

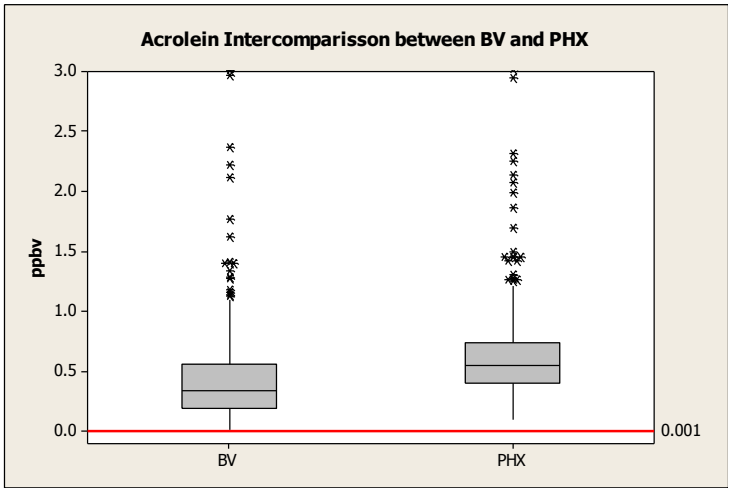


Acrolein

Acrolein is the simplest of the unsaturated aldehydes. It is primarily used as a biocide and in acrylic acid production. It is frequently used by the oil and gas industry as an additive to drilling waters and as a hydrogen sulfide scavenger. Acrolein has a strong acrid smell, similar to that of burning fat. It is a harsh skin irritant that may also cause respiratory tract irritation and congestion. Its carcinogenic and adverse effects on human reproduction have not been clearly determined. High concentrations of acrolein are observed near oil and gas facilities, smoking areas, gasoline vehicle exhaust, and the burning and frying of cooking oil and fats.[11,12]

Despite its proximity to local oil refineries and the I-15, the Bountiful monitor consistently recorded lower acrolein values than what was observed in Phoenix.

Figure 11. **The boxplot of two sets of acrolein data comprising the values collected between 2007 and 2012.**

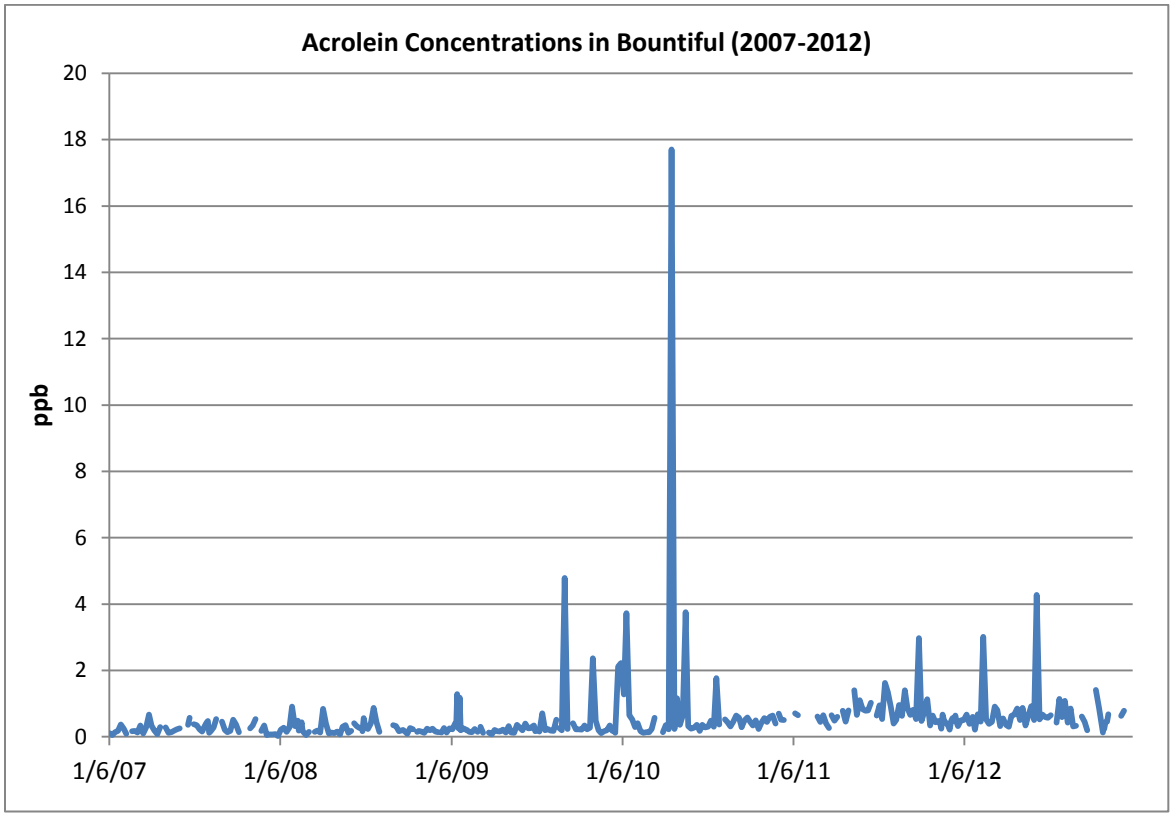


No seasonal trend was observed for acrolein. However, several unusually high readings heighten interest in finding possible acrolein emission sources. Additionally, mean annual values of acrolein increased from 2009 to 2012 suggesting a recent pollutant source.

[11] Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for Acrolein. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA. 2007.

[12] U.S. Environmental Protection Agency. Integrated Risk Information System (IRIS) on Acrolein. National Center for Environmental Assessment, Office of Research and Development, Washington, D.C. 2003.

Figure 12. **The long-term trend of acrolein at the Bountiful monitoring station between 2007 and 2012.**



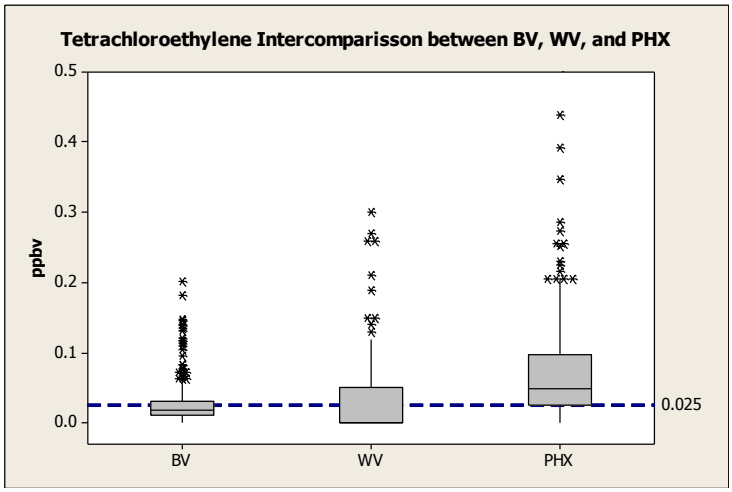
Tetrachloroethylene

Tetrachloroethylene is mainly used in dry cleaning because of its exceptional physical properties. It is also used as a degreasing agent in automobile and metalworking industries. Tetrachloroethylene's use has significantly decreased over the past few decades, but it is still regularly detected in ambient air and water.

Chronic exposure to tetrachloroethylene in humans generally results in neurological effects, headaches, and impaired cognitive functioning. Liver and kidney damage, hematologic disorders, developmental and reproductive effects have also been reported. Tetrachloroethylene has been classified by the EPA as a likely carcinogenic agent to humans through all exposure routes.[13,14]

The measurements of tetrachloroethylene at Phoenix between 2007 and 2012 were substantially higher than those recorded at Bountiful. Whereas only 32.3% of the measurements observed at Bountiful were above the one-in-one-million risk level, 74.4% of the measurements recorded at Phoenix were above that level. 95% of the tetrachloroethylene levels observed in Bountiful between 2007 and 2012 were below 0.05 ppb.

Figure 13. **The tetrachloroethylene data for Bountiful (2007-2012), Phoenix (2007-2012), and West Valley (2000-2002).**



The long-term trend of tetrachloroethylene indicates a downward trend in the number of high emission episodes. There has only been one instance of ambient tetrachloroethylene levels exceeding 0.1 ppb between 2010 and 2012, whereas there were fourteen such exceedances in the two years prior. The wintertime range of the pollutant tends to be somewhat larger, ranging between 0.02 and 0.04 ppb. Summertime concentrations tend to fluctuate around 0.01 ppb. Figure 14 shows tetrachloroethylene levels between 2007 and 2012.

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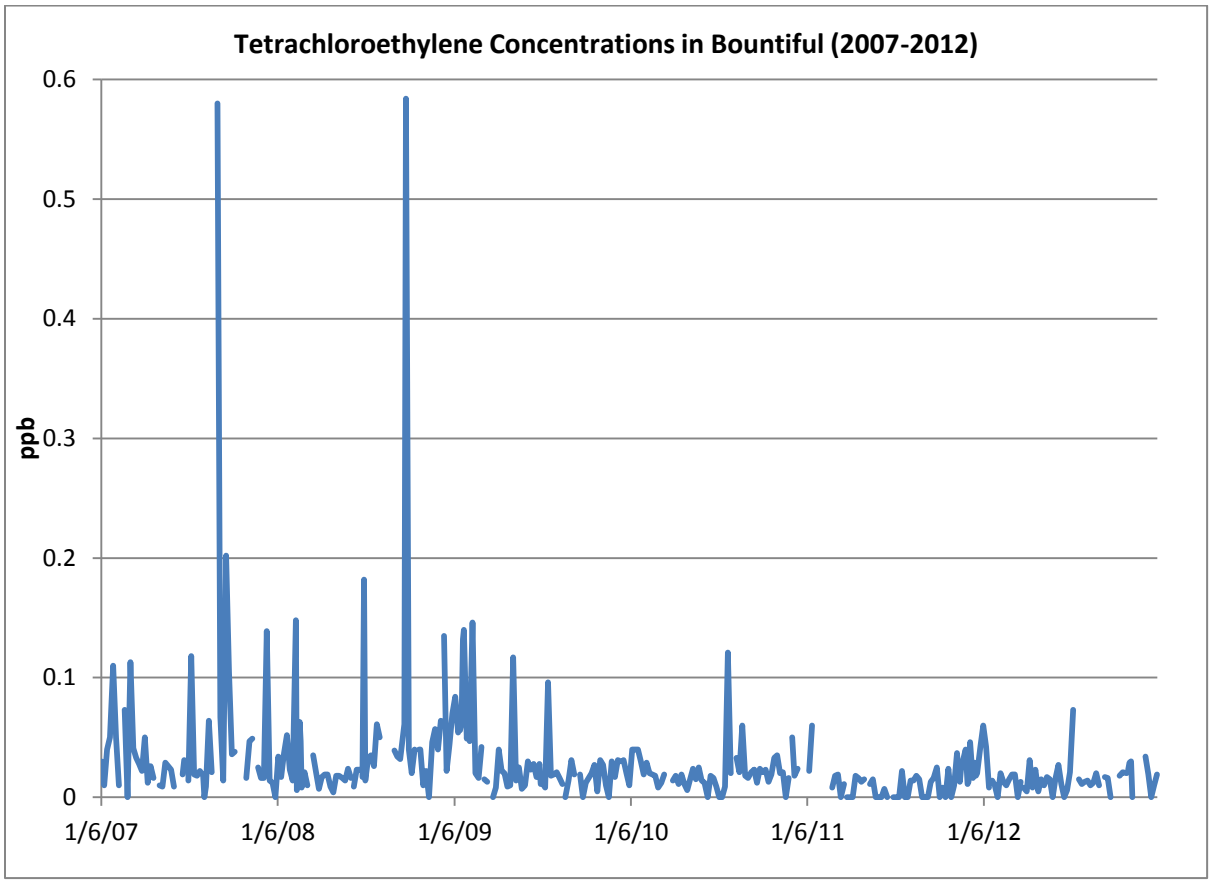
[13] Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for Tetrachloroethylene (Update). U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA. 1997.

[14] U.S. Environmental Protection Agency. *Integrated Risk Information System (IRIS) on Tetrachloroethylene*. National Center for Environmental Assessment, Office of Research and Development, Washington, DC. 2012.

Figure 14. **A long-term tetrachloroethylene trend graph for Bountiful (2007-2012).**



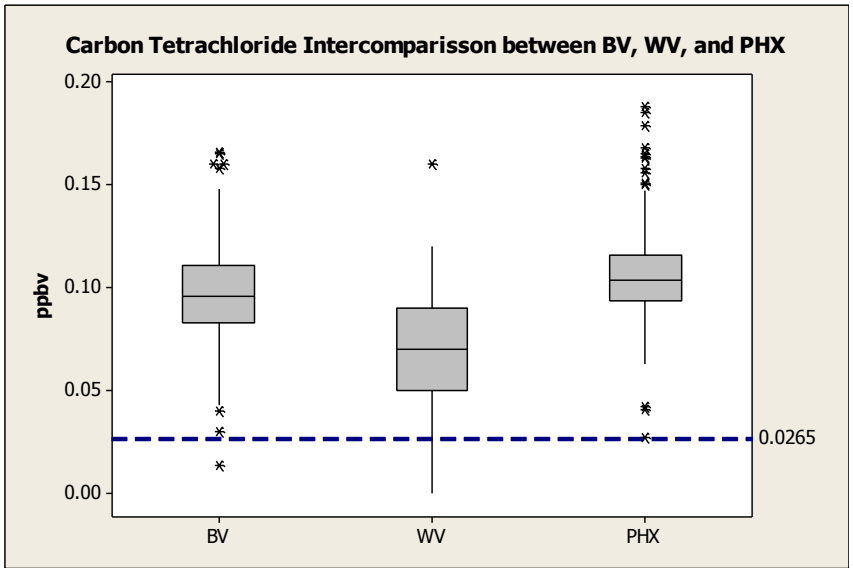
Carbon Tetrachloride

Carbon tetrachloride was widely used in the past as a propellant for aerosols and refrigerants. However, because of its carcinogenic effects and adverse influence on the ozone layer, all but industrial uses of carbon tetrachloride have been discontinued. At this time, the most common causes of carbon tetrachloride exposure are due to spills and releases from industrial processes or the evaporation of building materials and cleaning agents. Carbon tetrachloride exposure may also occur in close proximity to landfills.

Acute exposure to carbon tetrachloride causes headaches, nausea, weakness, and vomiting. As with most other chlorinated compounds, prolonged exposure results in kidney and liver damage as well as detrimental effects on the central nervous system.[15] EPA classifies carbon tetrachloride as a probable human carcinogen, but at this time the data on its carcinogenic effects is insufficient.[16]

Carbon tetrachloride concentrations were found to be comparable between the three monitoring sites. Figure 15 shows a boxplot for carbon tetrachloride data for all three sites. The Bountiful and Phoenix sites recorded the majority of their data above the one-in-one-million cancer risk threshold. However, both sites tended to have observations well below the chronic exposure level. The Phoenix data tended to occupy a slightly higher range of values when compared to Bountiful, but the difference was not significant. The median levels were 0.096 ppb and 0.104 ppb for Bountiful and Phoenix, respectively.

Figure 15. **Carbon tetrachloride data for the Bountiful, Phoenix (2007-2012), and West Valley (2000-2002) sites.**

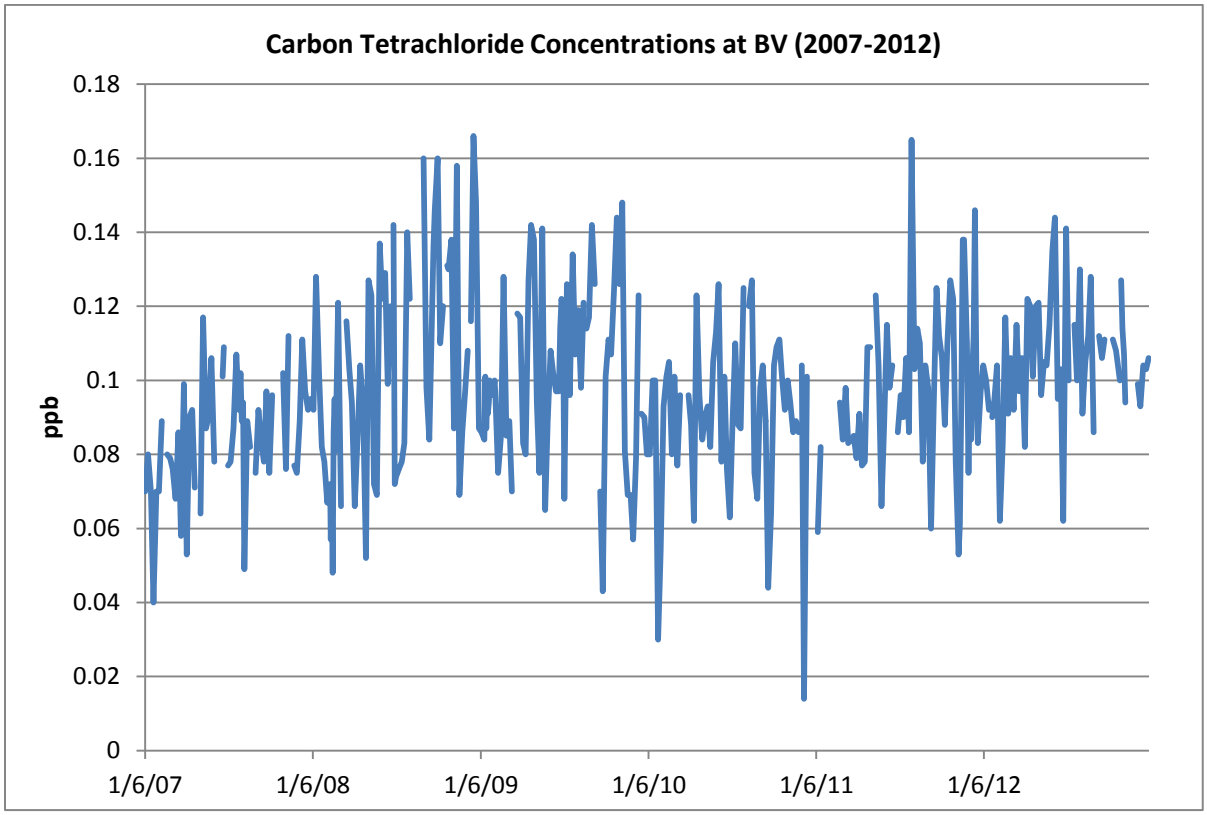


[15] Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for Carbon tetrachloride (Update). Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA. 1994.

[16] U.S. Environmental Protection Agency. Updated Health Effects Assessment for Carbon tetrachloride. EPA/600/8-89/088. Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Office of Research and Development, Cincinnati, OH. 1989.

The long-term trend indicated no obvious seasonal patterns (See Figure 16). The mean annual values of carbon tetrachloride varied between 0.11 ppb and 0.09 ppb.

Figure 16. **A long-term graph of carbon tetrachloride concentrations at the BV monitoring site (2007-2012).**



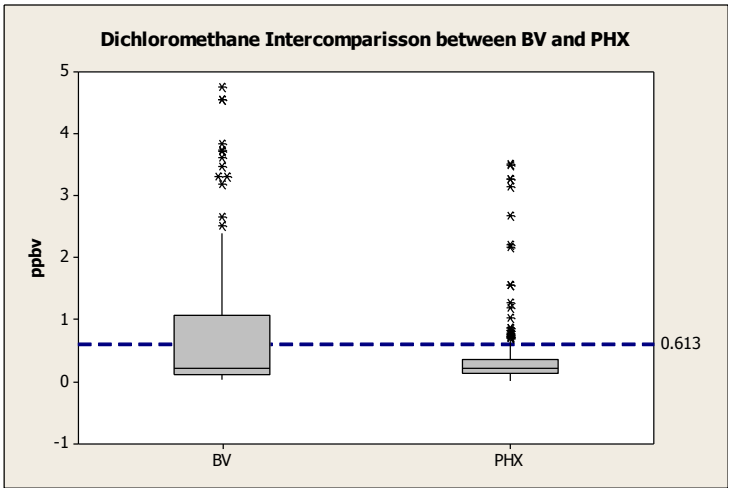
Dichloromethane

Dichloromethane, also known as methylene chloride, is predominantly used as a solvent in paint removers, pharmaceutical manufacturing, and film coatings. It is also produced from some biogenic sources generally associated with salty environments such as salt marshes. It is regarded as a probable carcinogenic agent in humans.

In acute exposures, dichloromethane causes a temporary suppression of visual, auditory, and motor function. However, long-term exposure may cause irreversible damage to the human central nervous system. Prolonged exposures in animal test subjects caused liver, lung, and mammary gland tumors.

Data collected between 2007 and 2012 showed higher mean values of dichloromethane at Bountiful compared to Phoenix. Nearly 32% of all of the dichloromethane measurements recorded at Bountiful were above the one-in-one-million risk exposure level. Only 10.6% of Phoenix data was above that level. These more frequent occurrences of dichloromethane above the one-in-one-million risk exposure level is likely associated with the natural dichloromethane emissions from salt marches surrounding the Great Salt Lake. However, emissions from local industries and businesses may also contribute.

Figure 17. **The dichloromethane data for Bountiful and Phoenix between 2007 and 2012.**



The long-term graphs of dichloromethane (Figures 18 and 19) show the occasional extremely high dichloromethane concentrations detected at Bountiful. Whereas typical concentrations of the pollutant tended to be in the vicinity of 0.25 ppb, dichloromethane levels reached as high as 700 ppb during the years between 2009 and 2011. The few unusually high dichloromethane values were well associated with acrylonitrile detected in similarly high concentrations on most of the same days. The correlation of these occurrences was a clear indication that some industrial or other anthropogenic sources were emitting those two pollutants. A closer investigation of these emissions was conducted in 2013 and is referred to later in this report.

Figure 18. **A long-term dichloromethane trend graph for Bountiful between 2007 and 2012. The graph's scale allows the viewing of unusually high dichoromethane concentrations during those years.**

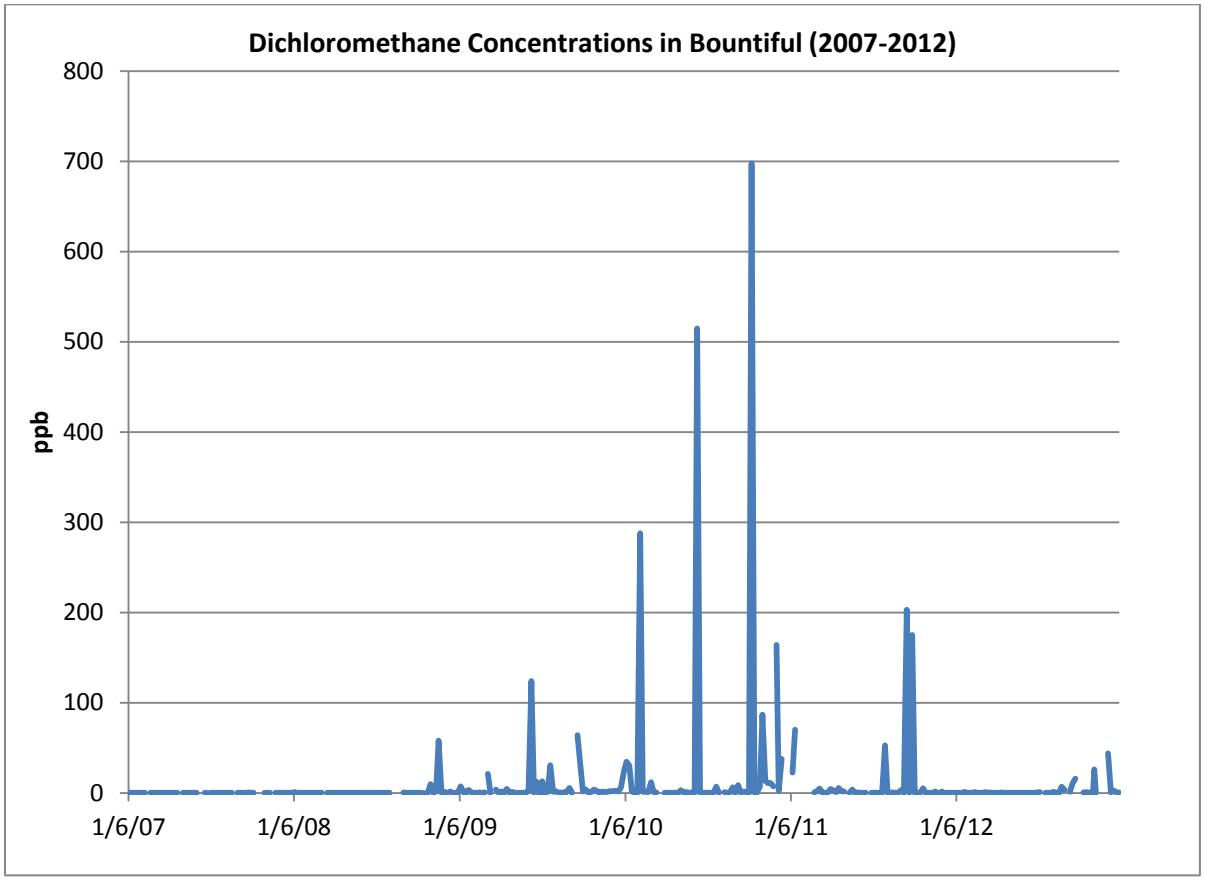
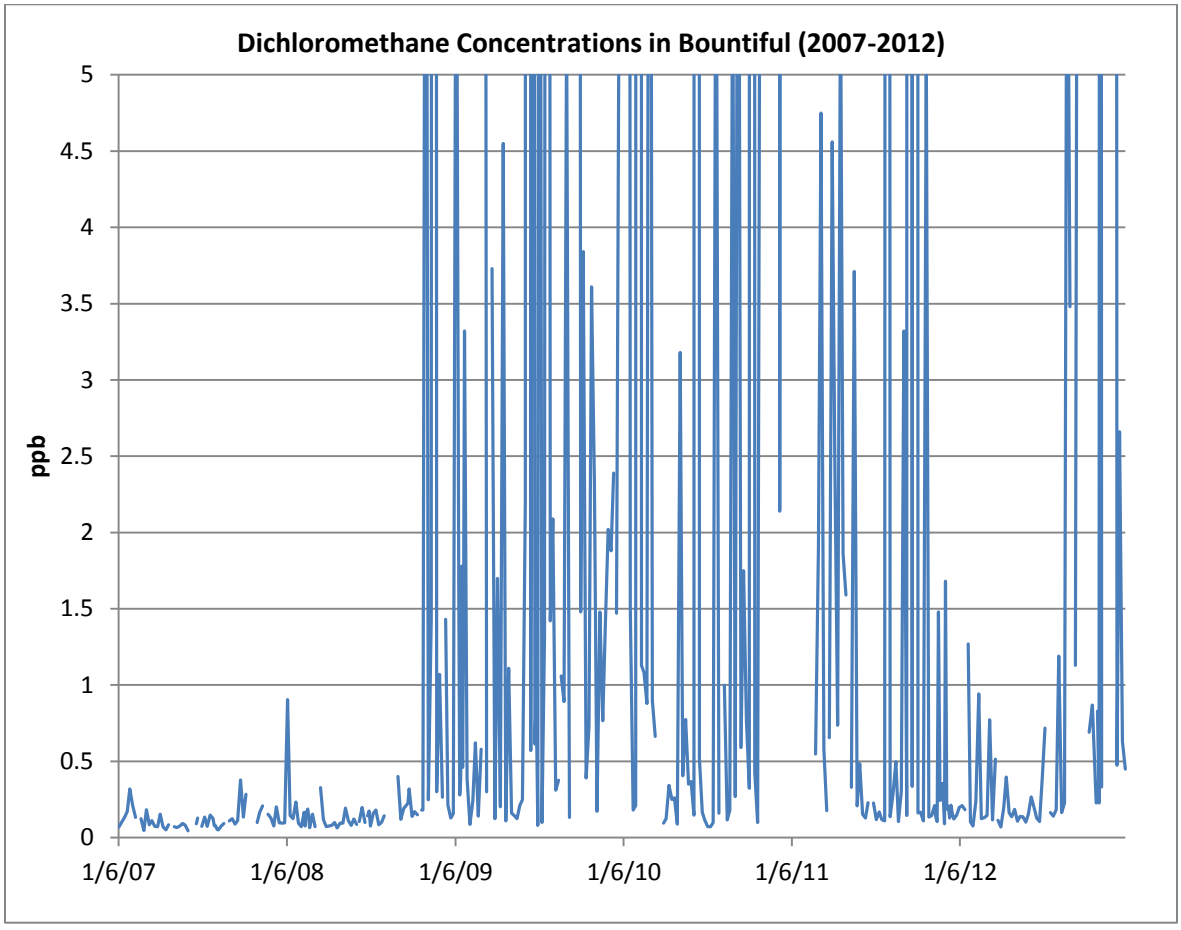


Figure 19. **A long-term trend graph for dichloromethane in Bountiful between 2007 and 2012. The smaller scale allows the examination of low-concentrations.**



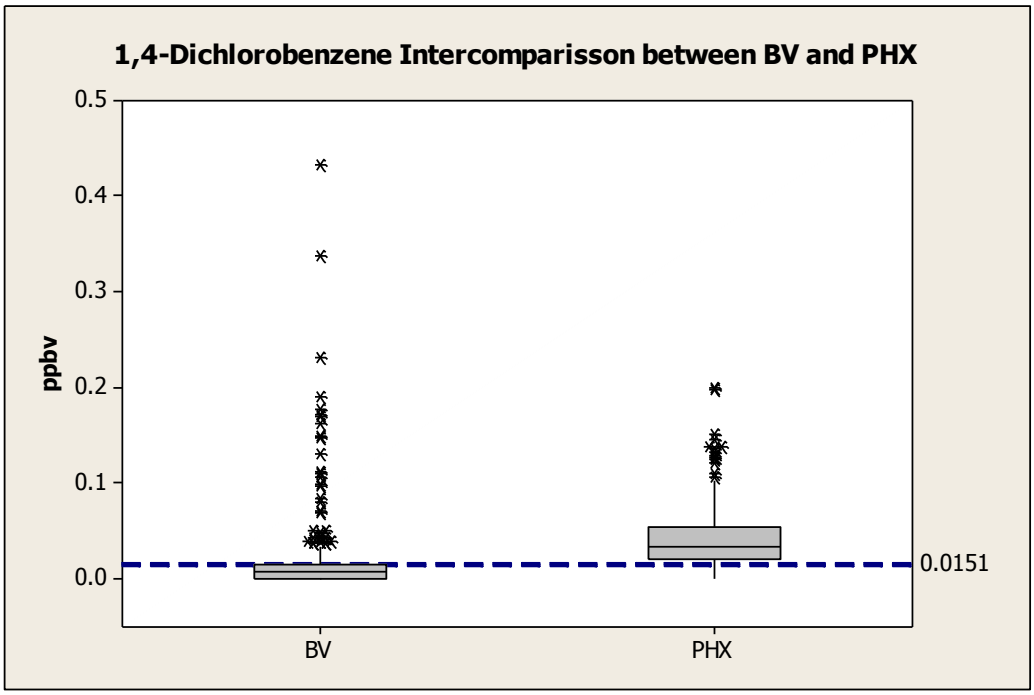
1,4-Dichlorobenzene (para-Dichlorobenzene)

1,4-Dicholorobenzene is primarily an indoor pollutant. It is mainly used as a fumigant against molds, mildews, and moths, as well as a deodorant for toilets. Sometimes, 1,4-dichlorobenzene is produced as an intermediate during the manufacturing of other chemicals.

As with most chlorinated organics, 1,4-dichlorobenzene attacks the kidneys, liver, and the central nervous system. Although there is data lacking in human carcinogenic studies, 1,4-dichlorobenzene is classified as a possible human carcinogen. Prolonged exposure of rats through inhalation caused changes in kidney and liver function, as well as blood. Direct exposure to the chemical in the animals' stomachs caused the formation of malignant tumors.[17]

1,4-Dichloromethane was not monitored at the West Valley station between 2000 and 2002, so the data for this pollutant is only available for the Bountiful and Phoenix monitors.

Figure 20. **The 1,4-dichlorobenzene data between 2007 and 2012 for Bountiful and Phoenix.**

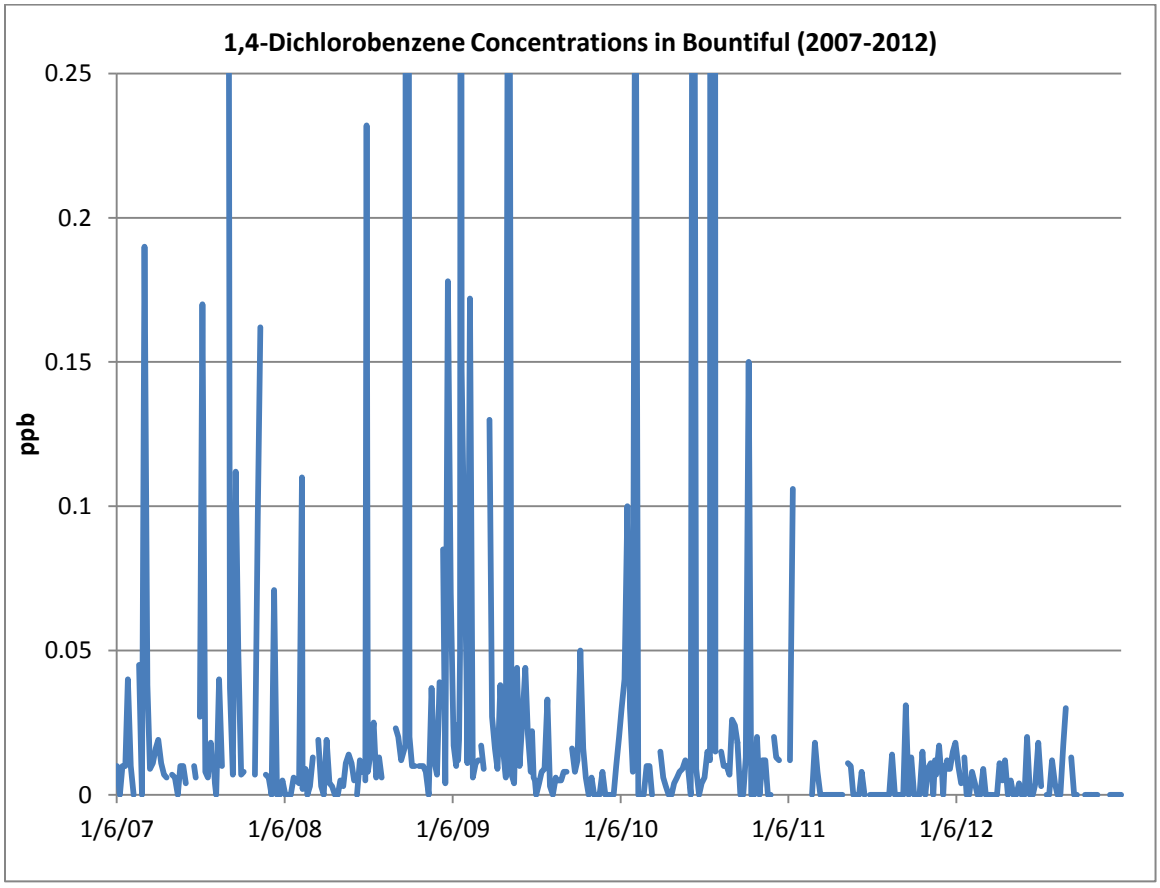


The concentrations of 1,4-dichlorobenzene at the Bountiful site between 2007 and 2012 were significantly below those observed at Phoenix. While 83.6% of all Phoenix measurements were above the one-in-one-million exposure risk level, only 22.8% of Bountiful measurements were above that level.

[17] Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for 1,4-Dichlorobenzene (Update). Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA. 1998.

The long-term graph (Figure 22) of the 1,4-dichloromethane data shows there were a considerable number of unusually high concentration spikes between 2007 and 2011. There were no such spikes post-2011, indicating an emissions source (likely a single source) was removed from the area. As the data presented in Figure 20 indicates, most measurements fall within the 0.01 to 0.015 ppb range; just below the one-in-one-million exposure risk level. Thus, it is unlikely this pollutant is associated with refining activity near Bountiful.

Figure 22. **A long-term trend graph of 1,4-dichrolorbenzene in Bountiful between 2007 and 2012.**



M/P Xylene and Ethylene Dichloride

M/P xylene and ethylene dichloride were the last two HAPs of interest that had a number of detections above one-in-one-million exposure risk limits. M/P xylene was only detected in noticeable amounts at the West Valley site. It was not observed at concentrations above the one-in-one-million exposure risk level at Bountiful or Phoenix.

However, ethylene dichloride measurements rose significantly at Bountiful beginning in 2011. This is likely due to the operation of a new industrial source. In order to locate possible sources, a closer investigation into the emission patterns of this pollutant is necessary.

Metals

There are ten metals that are listed as HAPs. With the exception of Chromium (VI) at the West Valley site, all metals were monitored using comparable equipment. Samples were also analyzed using the same methods.

Unlike the gaseous portion of HAPs, metal content in ambient air is represented in units of micrograms per cubic meter. It is important to remember that metals are rarely found among ambient primary matter (PM) in their elemental states. Thus, it is better to treat these metals as their corresponding compounds (e.g., not "elemental arsenic", but "arsenic compounds"). The screening levels for each metal specie were based on the corresponding aggregate toxicities of that element's most common compounds.

Table 2. **The percentage of sample days for which concentrations of monitored toxic metals were above one of the risk screening thresholds.**

	BV		WV		PHX	
	1/1mil	Chronic	1/1mil	Chronic	1/1 mil	Chronic
Antimony		0.00%		14.55%		
Arsenic	81.25%	9.38%	100.00%	52.73%	86.50%	7.67%
Beryllium	0.00%	0.00%	0.00%	0.00%		
Cadmium	5.40%	1.99%	38.18%	32.73%	1.23%	0.00%
Chromium (VI)	4.64%	0.00%	100.00%	0.00%	31.65%	0.00%
Cobalt		0.00%		0.00%		
Lead		1.42%		9.09%		0.31%
Manganese		63.92%		92.7%		94.48%
Nickel		0.85%		0.00%		
Selenium		0.00%		0.00%		

Contrary to the pattern observed with the organic portion of HAPs, the West Valley data shows a universally higher incidence of metal concentrations at both one-in-one-million and chronic exposure levels. Additionally, the mean concentration and range of typical metal samples were much higher at the West Valley site. One possible reason for this is that two different sample methods were used to collect the data. A PM_{10} sampler was used at Bountiful, while a total suspended matter (TSP) sampler was used in West Valley. This implies that on most days, the PM_{10} fraction could be substantially smaller than the TSP fraction. A second reason for higher metal counts could be the near-proximity of the West Valley station to the Kennecott mine, smelter, and tailing ponds. This means the difference in sampling methods would only enlarge the disparity between Bountiful and West Valley observations.

Lead did not appear in relevant concentrations in $PM_{2.5}$. Only about 1% of lead samples collected by speciation monitors had concentrations above the chronic exposure limit.

Manganese

Manganese is ubiquitous in the environment. In small doses, it is essential for health. However, prolonged exposure to elevated concentrations of this metal can result in adverse effects on the central nervous system. Manganese exposure can weaken hand-to-eye coordination, reduce reaction times, cause tremors, and lead to impotence and a decreased libido in males.[18]

Large concentrations of manganese are generally observed around smelters, where the greatest exposure to manganese often occurs. A typical ambient air concentration of manganese is approximately 0.02 µg/m^3.[19]

The manganese data collected indicated that manganese is present in the ambient air in both Utah and Arizona. Its concentration was above the chronic screening exposure level at all three locations. It is noteworthy, however, that manganese concentrations observed at both, Bountiful and West Valley, were lower than those observed in Phoenix. Figure 23 shows the boxplot of manganese data for all three monitoring sites.

The long-term trend for manganese in Utah shows a moderate decrease in maximum annual concentrations between 2007 and 2012 (graph not shown). However, a strong seasonal pattern was not detected.

Figure 23. **Manganese data from West Valley (2000-2002), Bountiful (2007-2012), and Phoenix (2007-2012) sites.**

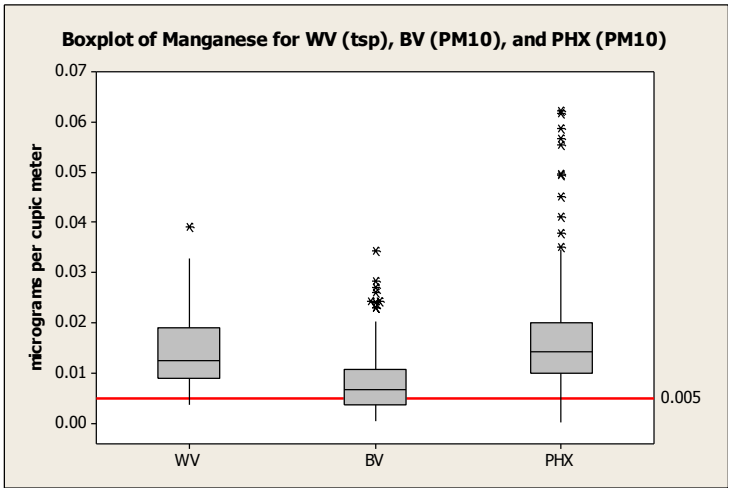


Figure 24. **A long-term graph of manganese concentrations observed at the Bountiful monitor between 2007 and 2012.**

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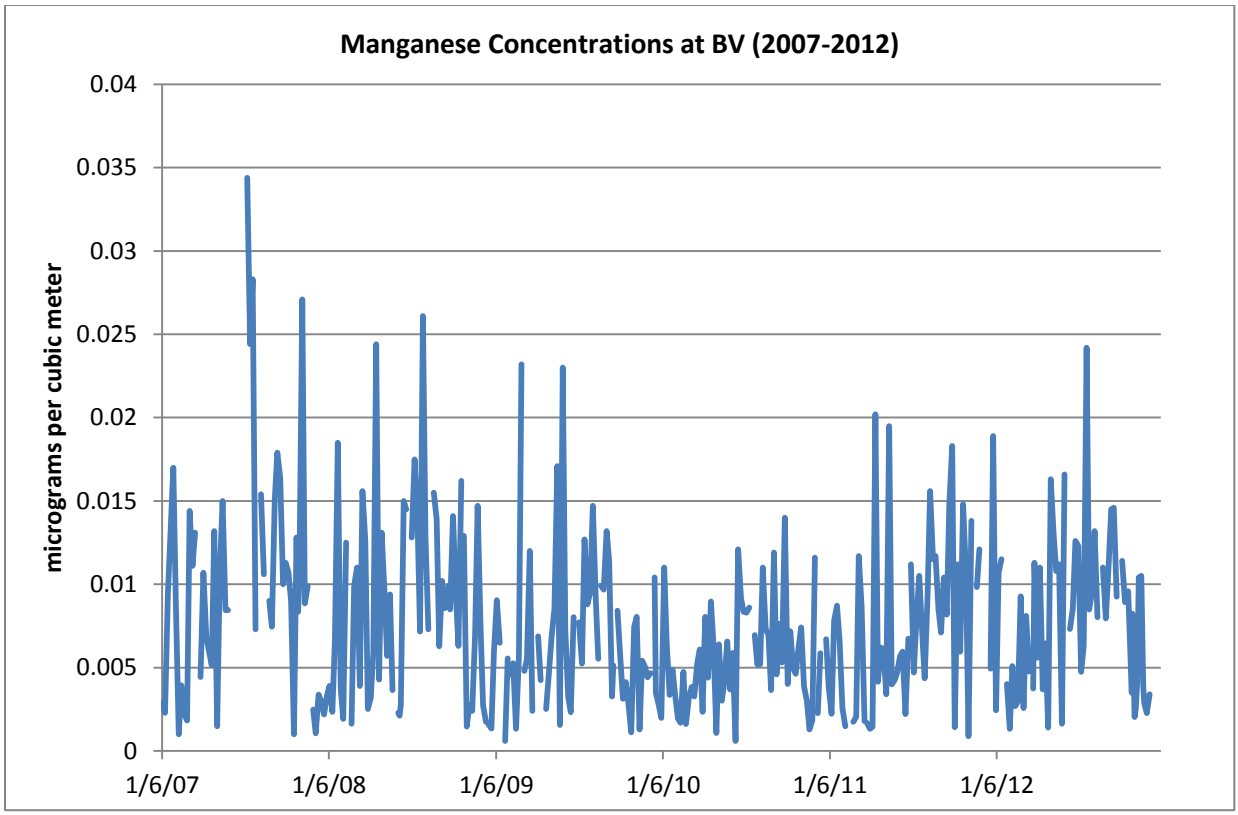
[18] Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for Manganese (Update). Draft for Public Comment. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA. 1997.

[19] U.S. Environmental Protection Agency. Integrated Risk Information System (IRIS) on Manganese. National Center for Environmental Assessment, Office of Research and Development, Washington, DC. 1999.


Manganese Concentrations at BV (2007-2012)
micrograms per cubic meter
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
1/6/07
1/6/08
1/6/09
1/6/10
1/6/11
1/6/12

Arsenic

Arsenic is a naturally occurring element found throughout the environment. Although the primary exposure route for humans is through ingestion, some arsenic can be inhaled as it attaches to ambient primary matter. Long-term inhalation exposure to inorganic arsenic has been linked to lung cancer, while ingested arsenic has been shown to cause skin, bladder, and liver tumors. Arsenic is primarily used as wood products preservative. However, its use in residential construction has been phased out. Arsenic is also used in electronics and semiconductor manufacturing. Inorganic arsenic has been classified as a human carcinogen by the EPA.[20,21,22]

A boxplot of arsenic concentrations is shown in figure 25. Arsenic concentrations observed at the West Valley site were significantly higher than those recorded at either, Bountiful or Phoenix. However, this is likely due to the difference in sampling methodology between the monitors. TSP monitors were used at West Valley, while PM_{10} samplers were used at Phoenix and Bountiful. The mean arsenic concentration at Phoenix was slightly higher than at Bountiful, but still well below the chronic exposure level. Neither, Phoenix nor Bountiful saw a significant number of measurements below the one-in-one-million exposure risk level.

Figure 25. **Arsenic data for the West Valley (2000-2002), Bountiful (2007-2012), and Phoenix (2007-2012) sites.**

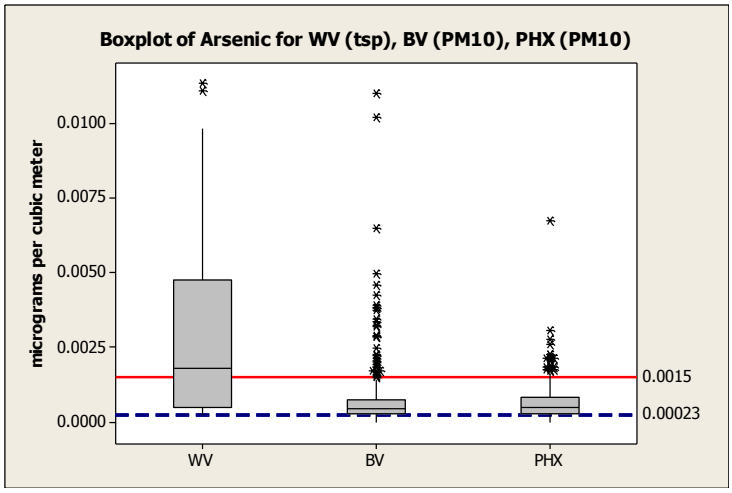


Figure 26 indicates a seasonal trend in arsenic concentrations. The largest concentrations of arsenic generally occur during colder months of the year. The period between October and March is the only time during the year when arsenic concentrations exceed the chronic exposure level of 0.0015

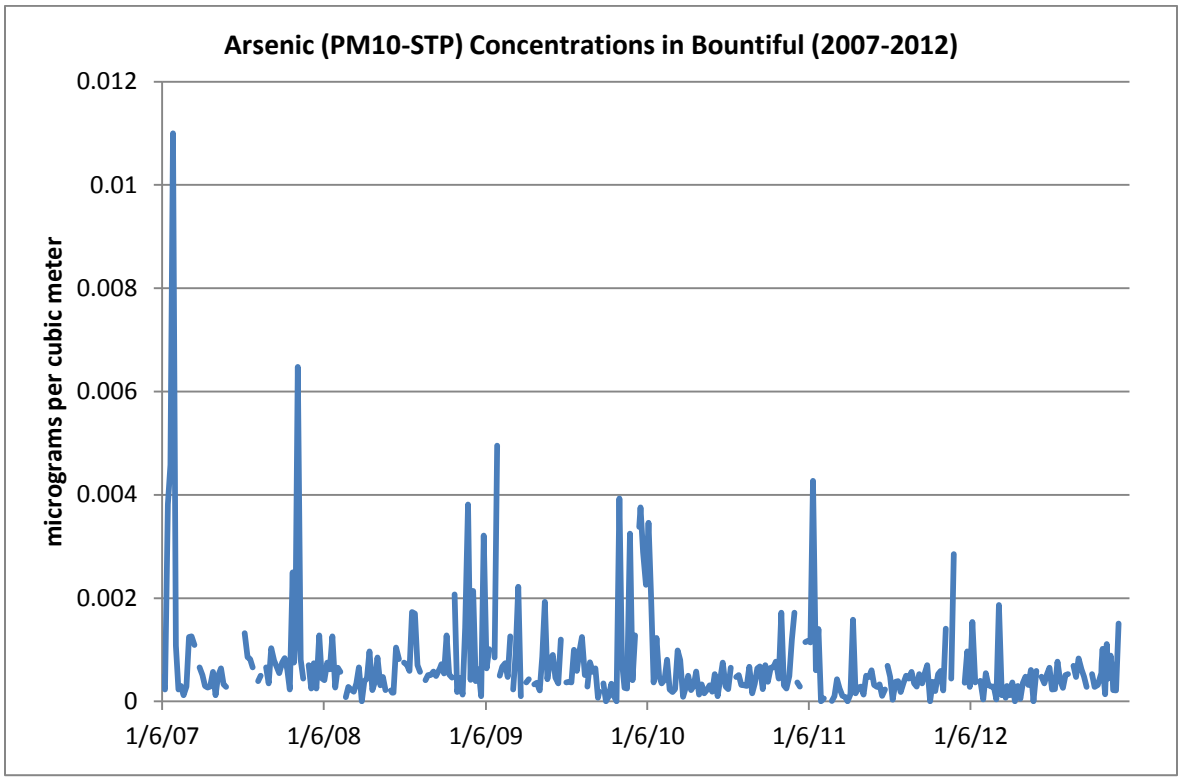
[20] Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for Arsenic (Update). U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA. 2007.

[21] U.S. Environmental Protection Agency. Health Assessment Document for Inorganic Arsenic. EPA/540/1-86/020. Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Office of Research and Development, Washington, DC. 1984.

[22] U.S. Environmental Protection Agency. Integrated Risk Information System (IRIS) on Arsine. National Center for Environmental Assessment, Office of Research and Development, Washington, DC. 1994.

µg/m^3. However, the data also indicates a strong negative trend in maximum arsenic concentrations over time.

Figure 26. **A long-term trend graph for arsenic at Bountiful (2007-2012).**



Chromium

Chromium is a metal naturally found in the environment. Chromium is generally present in two valence states: chromium(III) and chromium(VI). Although toxic in large amounts, chromium(III) (a.k.a. trivalent chromium) is essential to human health. Even though a portion of chromium (VI) is converted to its trivalent counterpart in the human body, it was found to be a strong human carcinogen, especially when inhaled.

Both, chromium(III) and chromium(VI) are generally found in rocks, soil, and volcanic dust and gas. However, chromium in ambient PM is mainly released from anthropogenic activities such as mining, smelting, electroplating, leather/wood processing, pigment production, the application of automobile brakes and catalytic converters, and from the treatment of cooling tower water.

The boxplot of chromium(VI), in Figure 26, summarizes observations collected at Bountiful and Phoenix using TSP sampling methodology. Between 2007 and 2012, the majority of chromium(VI) measurements taken at Bountiful were well below the one-in-one-million exposure risk level.

Figure 26. **Chromium(VI) data at Bountiful and Phoenix (2007-2012).**

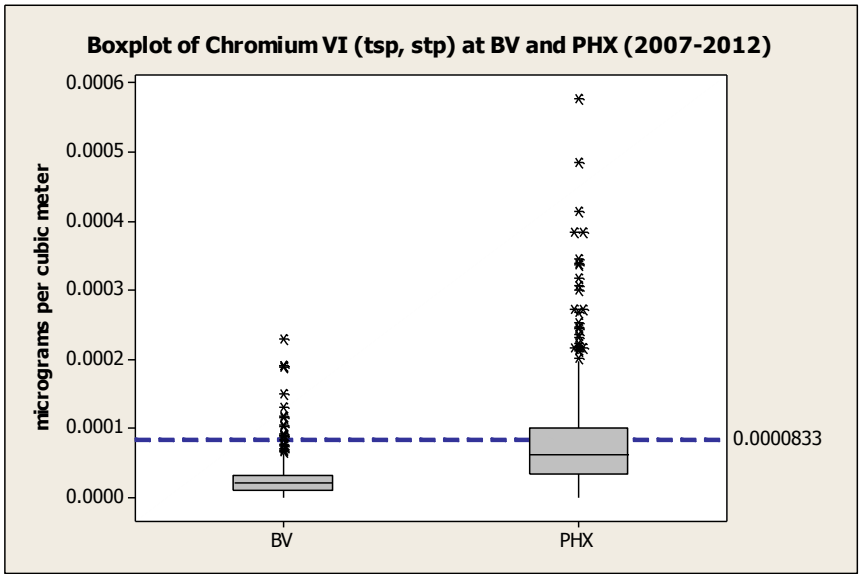
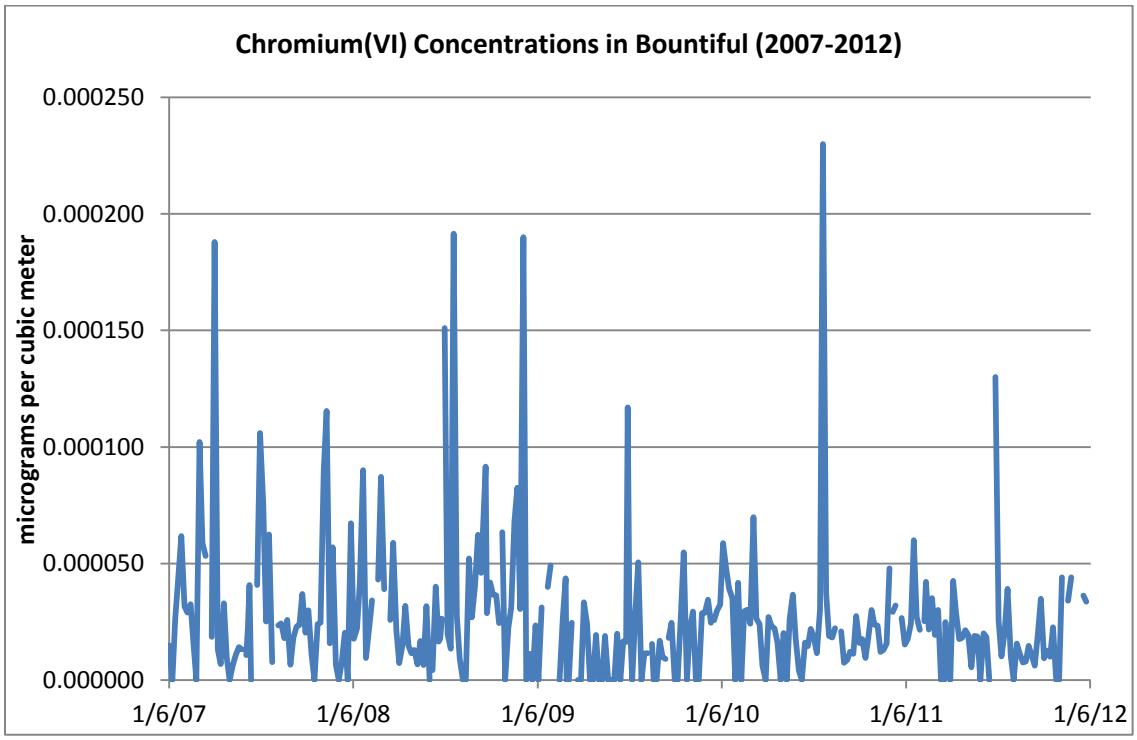


Figure 27, below, shows a clear seasonal pattern with mean chromium(VI) concentrations rising during colder months and decreasing during warmer months. Several outliers in the data were observed on days surrounding national holidays, specifically New Years and the Independence Day. Two large peaks were also detected in near Pioneer Day, July 24th. It seems likely that these spikes in chromium are associated fireworks. However, the few high chromium(VI) readings seen during March, April, and September are puzzling with respect to their origin.

Figure 27. **A long-term trend of chromium (VI) in Bountiful (2007-2012).**



Lead and Cadmium

Lead and cadmium often appear in the environment as the result of industrial activities. Cadmium is generally emitted into the atmosphere from the incineration of garbage, fossil fuels combustion, and metal smelting. Lead is commonly emitted during mining operations and smelting activities. Lead is also an additive to some aircraft fuels, but its use in automobiles has been phased out and banned.[23,24]

Long-term exposure to cadmium may cause kidney dysfunction. Cadmium has also been shown to cause fetal damage and lung cancer in animals, though adequate human exposure data does not currently exist. Lead exposure is characterized by harmful effects on the kidney, immune, nervous, and cardiovascular systems. Lead is also linked to diminished cognitive abilities, low IQ, and altered memory and behavior.[25,26]

Although the mean lead concentration at Phoenix was slightly higher than at Bountiful (0.0042 vs 0.0034 µg/m^3, respectively), Bountiful saw more outliers that were above the risk screening level (0.015 µg/m^3). The long-term trend of lead and cadmium observed in Bountiful (Figure 28, below) suggest a strong seasonal pattern similar to arsenic and chromium. High concentrations of both, arsenic and chromium, were likely the result of sustained temperature inversions that often trap and accumulate PM within the Salt Lake Valley. High cadmium and lead levels during spring and fall months are likely due to dust storms that are common in Utah during those months.

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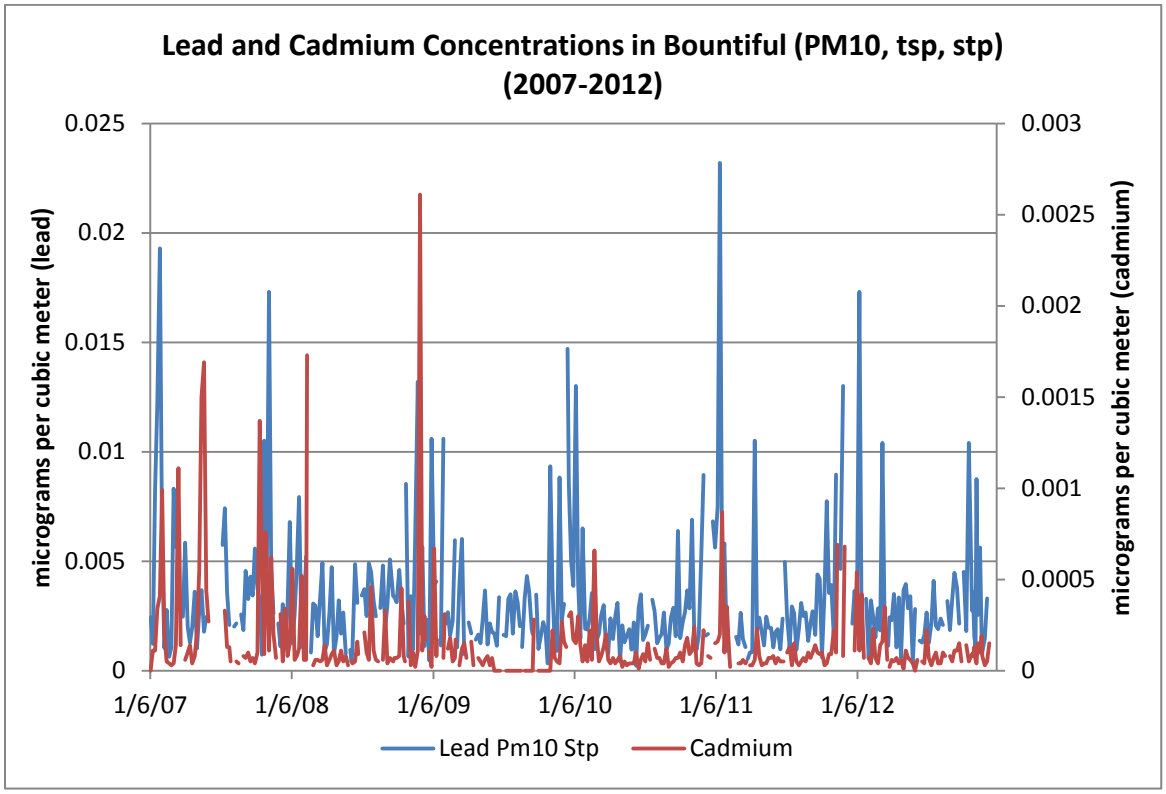
[23] Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for Cadmium. Draft for Public Comment. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA. 1997.

U.S. Environmental Protection Agency. Air Quality Criteria for Lead (2006) Final Report. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-05/144aF-bF, 2006.

[25] E.J. Calabrese and E.M. Kenyon. Air Toxics and Risk Assessment. Lewis Publishers, Chelsea, MI. 1991.

[26] Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for Lead (Update). Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA. 2007.

Figure 28. **A long-term trend graph of cadmium in Bountiful (2007-2012).**



Discussion

West Valley Data Organics (2000-2002)

At least 50% of 1,3-butadiene, benzene, acetaldehyde, and formaldehyde measurements are above both the chronic and one-in-one-million risk threshold levels. Most observations of carbon tetrachloride, ethylbenzene, and tetrachloroethylene were above the one-in-one-million levels but well below chronic exposure values.

Peculiar behavior was seen in the acrylonitrile dataset. All non-zero acrylonitrile measurements were classified as outliers with a p-value below 5%. In other words, the overwhelming majority of observations are below the detection limit. The pollutant is only detected on rare occasions. This hints at the likelihood of a single source of emissions. Since acrylonitrile is primarily used in plastics manufacturing, these acrylonitrile detections were probably linked to accidental emission events at a local facility.

Bountiful Organics (2007-2012)

HAPs monitoring at Bountiful involved the same number of compounds as West Valley, with the addition of acrolein and ethylenedichloride. Acrolein could be connected to oil refining processes. However, since it was not monitored at West Valley, it is impossible to determine if Bountiful acrolein levels are related to the nearby refineries. Fossil fuel combustion, wood burning, and tobacco use have also been implicated in the production of acrolein. Therefore, a distinct source for that pollutant is currently difficult to identify.

The frequency of carbon tetrachloride exceedances, of the one-in-one-million risk threshold, was approximately 10% higher at Bountiful than West Valley. The most common use for carbon tetrachloride is as an industrial solvent. Further investigation into determining possible emitters of carbon tetrachloride is necessary.

Both, dichloromethane and acetonitrile show significant outlier activity indicative of a single process or emission source near the Bountiful station. The investigation into this possible emission source was recently conducted in 2013. Results of the investigation identified several possible local emission sources.

Although more incidences of 1,3-butadiene above the chronic cancer risk level appeared at Bountiful, values were generally lower than what was observed at West Valley. This is in spite of the close proximity of the Bountiful monitor to the I-15 freeway. The parity between the two sites is likely explained by ongoing improvements in automobile emissions.

Speciation Metals

Table 3, below, shows a number of statistics for toxic metals observed by Utah Speciation Trends Network (STN) monitors located in the cities of Lindon, Hawthorne, and Bountiful.

Table 3. **Percentage of risk level exceedances by metal specie at three Utah STN sites.**

		Antimony	Arsenic	Cadmium	Chromium	Cobalt	Lead	Manganese	Nickel
LN	Chronic	9.45%	0.00%	0.50%	0.50%	0.00%	1.00%	1.49%	0.00%
	1/1mil		36.57%	19.40%	57.71%				
HW	Chronic	6.18%	0.13%	0.79%	1.32%	0.00%	1.32%	0.13%	0.26%
	1/1mil		40.92%	22.50%	64.47%				
BV	Chronic	9.52%	0.00%	1.00%	0.75%	0.00%	0.25%	0.25%	0.00%
	1/1mil		39.85%	23.81%	54.89%				

As a percentage of $PM_{2.5}$, metal observations appear distributed similarly across all three STN sites, suggesting relatively uniform behavior across Davis, Salt Lake, and Utah County. It is important to note that STN stations only capture the metals that partially comprise $PM_{2.5}$. Therefore, STN observations are unlikely to represent an individual's day-to-day exposure to airborne metals. Though none of the monitors detect concentrations above the chronic exposure level with any exceptional frequency, most metal species regularly breach the one-in-one-million risk threshold.

Boxplots for STN data are found in Appendix 3.

Phoenix, Arizona Comparison

Phoenix was selected for a side-by-side comparison with Salt Lake City because of its similar topography. The lack of oil refineries and mining in contrast with the Salt Lake Valley was also appealing. Comparing Phoenix and Salt Lake City could reveal the contribution from these particular industries to Salt Lake Valley HAPs concentrations.

The Phoenix metropolitan area population is roughly four times larger than that of Salt Lake City's. This asymmetry in population will likely result in less HAPs in Salt Lake City than Phoenix. However, the complexity of chemical mechanisms and differences in meteorology and emission patterns prohibit drawing a linear relationship between population and pollutant levels.

In terms of mean ambient values and risk-assessment threshold exceedances, HAPs observations at Phoenix almost always exceeded values at Bountiful and West Valley. There were some notable exceptions. First, ethylbenzene was seen in high concentrations only at West Valley. Benzene was also more frequently observed in West Valley, but in higher concentrations than elsewhere. Dichloromethane was observed more often and measured greatest at Bountiful. Finally, formaldehyde data showed higher concentrations and more frequent exceedances at West Valley than Phoenix.

Expected differences between Bountiful and Phoenix did not materialize with respect to the refineries. The slightly increased incidences of lead and cadmium are likely associated with the mining and smelting activity in Salt Lake Valley. The breakdown of individual HAPs in Phoenix and the Salt Lake Valley was nearly identical; a result from the degree of urbanization common to both areas. The generally larger and more frequent HAPs concentrations observed in Phoenix is indeed likely due to its bigger population.

Summary

An overview of the HAPs data in the Salt Lake Valley shows that some HAPs frequently and significantly exceed the one-to-one-million cancer risk and chronic exposure thresholds. These pollutants are: 1,3-butadiene, 1-4-dichlorobenzene, acetonitrile, acetaldehyde, acrolein, acrylonitrile, benzene, carbon tetrachloride, dichloromethane, ethylbenzene, ethylenedichloride, formaldehyde, and tetrachloroethylene.

Some toxics, such as 1,3-butadiene, acrolein, benzene, acetonitrile, carbon tetrachloride, and acrylonitrile are connected with urban/industrial activity. Others species like formaldehyde, acetaldehyde, and dichloromethane may be heavily influenced by natural sources in the area such as salt marches and atmospheric oxidation.

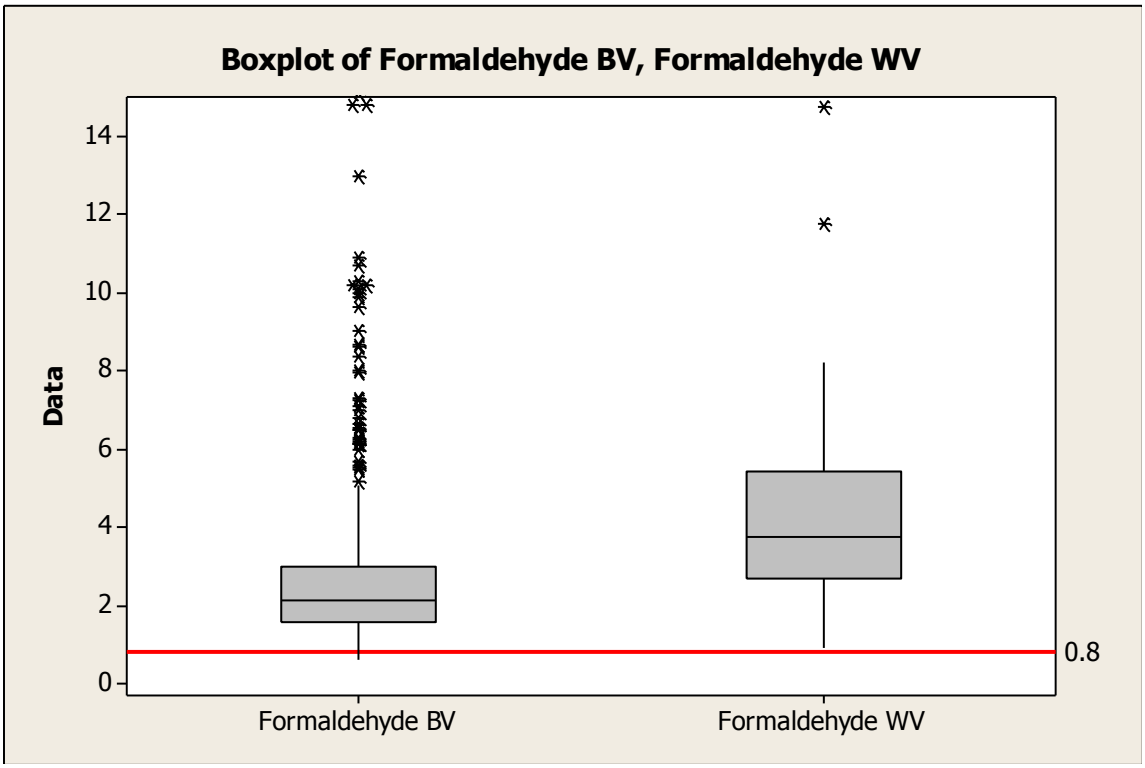
The frequency of detection and amount of metal toxics was found to be higher at the West Valley monitoring site. However, it cannot be conclusively determined whether this is due to nearby Oquirrh Mountains mining and smelting operations or because of differences in sampling methodology.

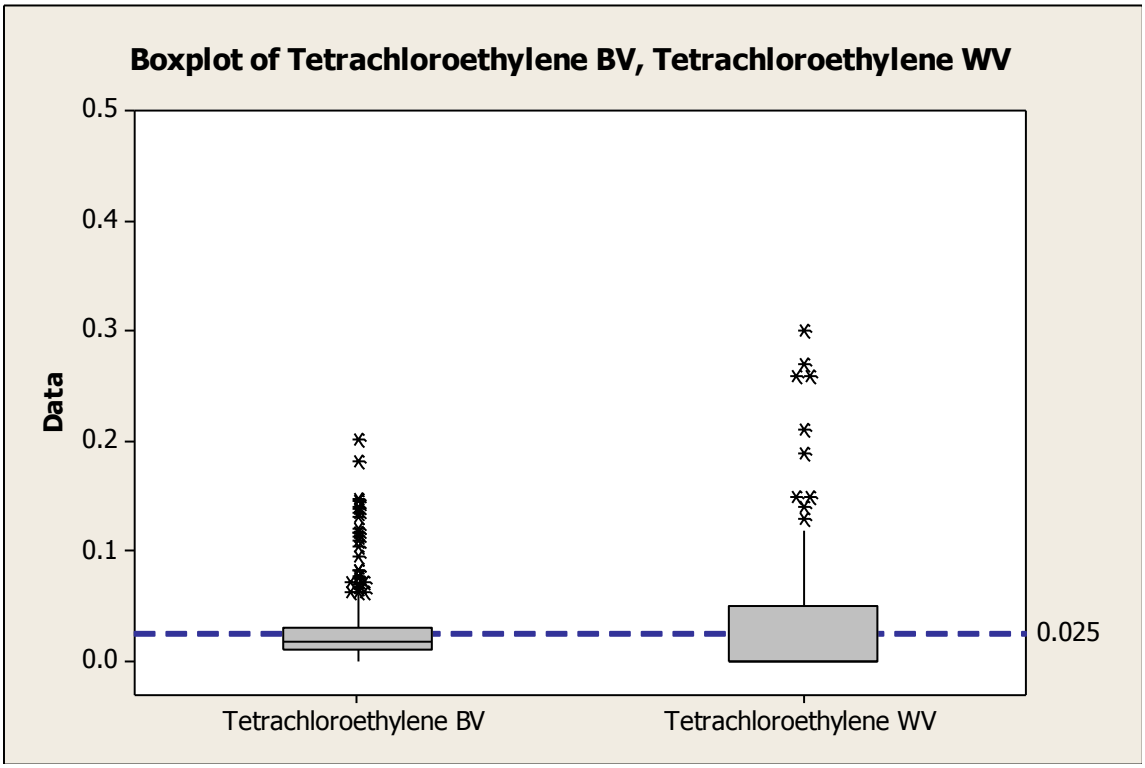
Unusually high occurrences of arsenic, cadmium, and chromium exceeding their respective one-in-one-million risk exposure levels was confirmed by Utah's STN network. However, these pollutants were detected in lower concentrations than what was observed at Bountiful or West Valley. Chromium(VI) data obtained from PM_{10} monitors showed significantly lower levels of chromium in ambient PM. This discrepancy results from the inability of x-ray fluorescence technology, used in STN filter analysis, to differentiate chromium(VI) from chromium(III).

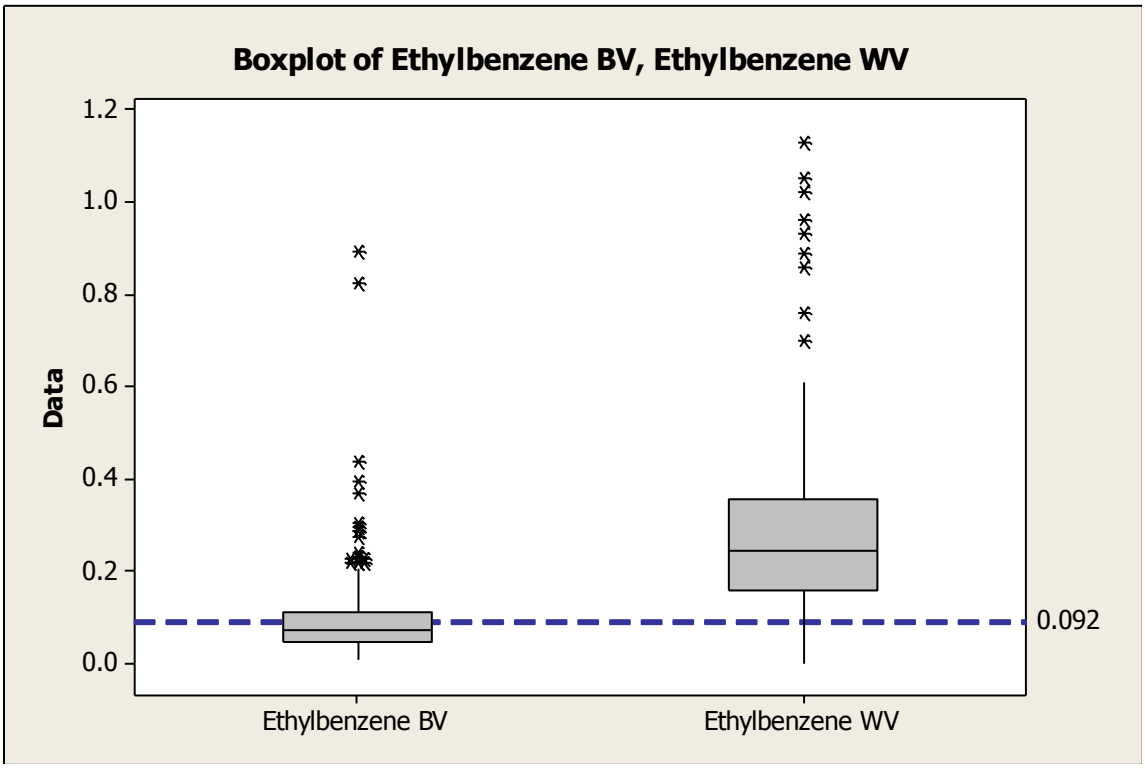
Unexpectedly, the close proximity of local refineries to the Bountiful site did not increase the frequency or range of organic toxic material when compared with West Valley data. However, more HAPs at Bountiful exceeded the one-in-one-million cancer risk threshold; Thirteen species at Bountiful showed exceedances, as opposed to only eight species at West Valley.

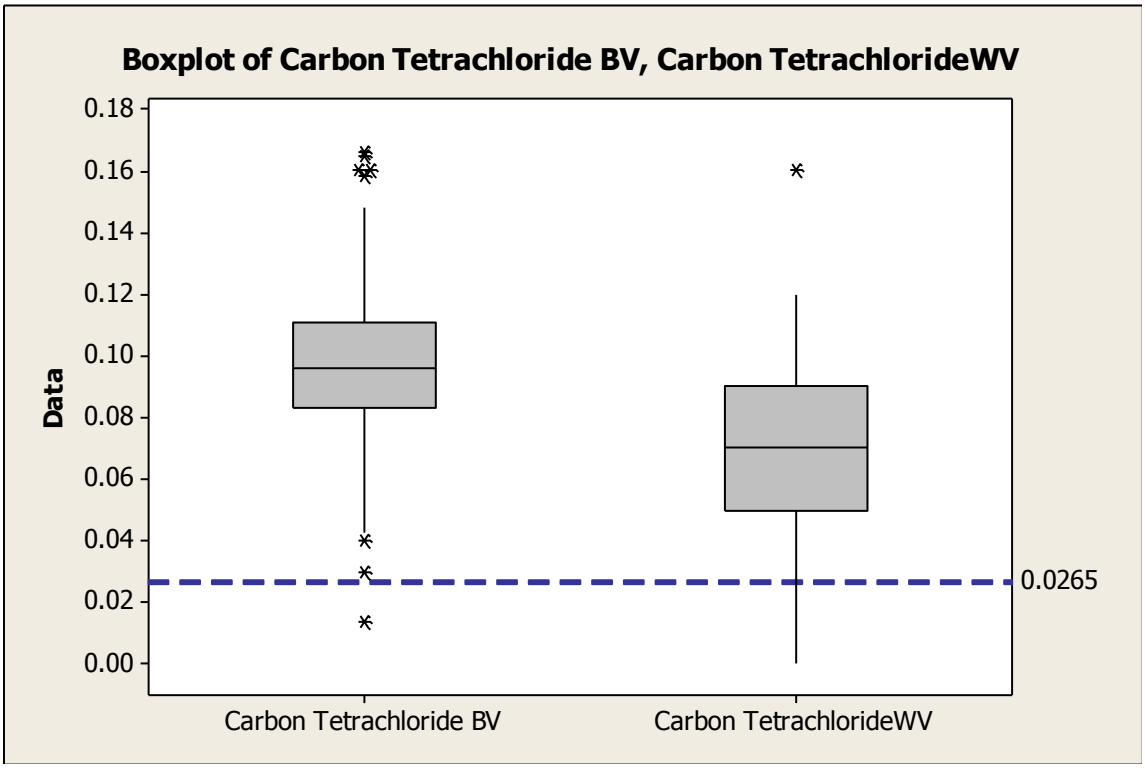
1,3-butadiene and benzene exhibited a trend common to reactive organics in the atmosphere: high concentrations during the winter, low concentrations in the summer. But, Acrolein and carbon tetrachloride displayed no such pattern; their concentrations remained moderately flat over the last seven years. A further study of these particular species is needed in order to determine their sources of emission.

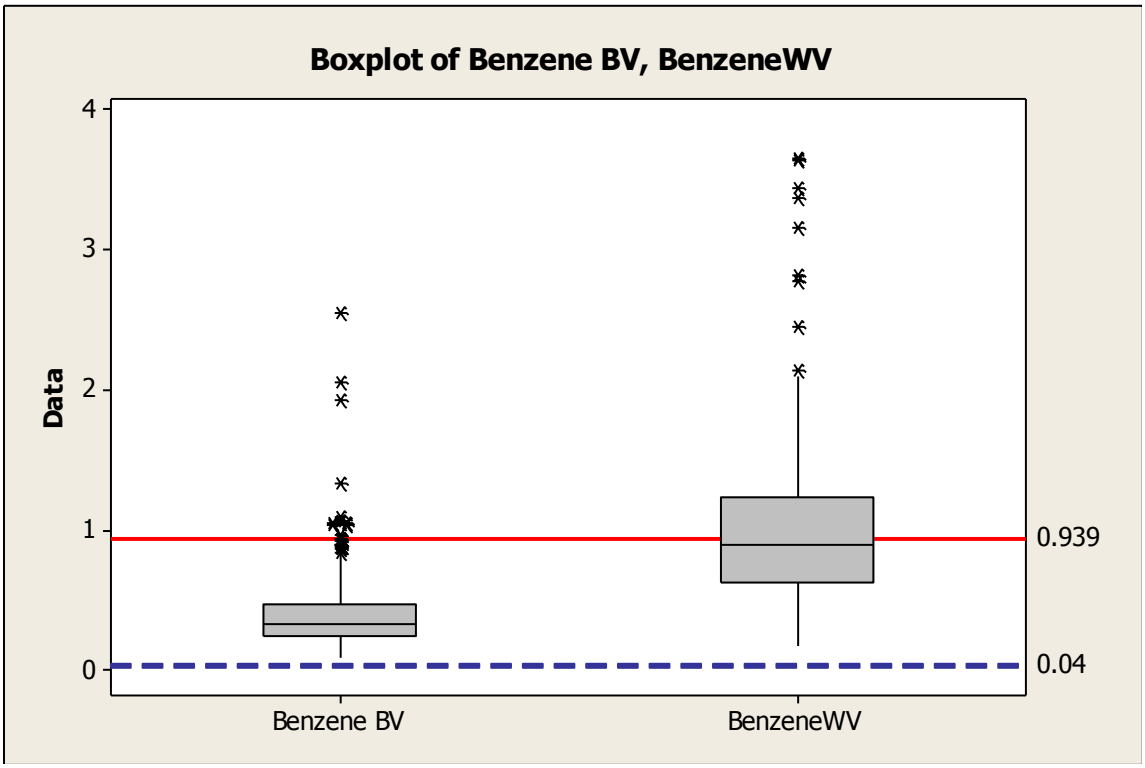
Appendix 1, Organic HAPs measured at West Valley and Bountiful

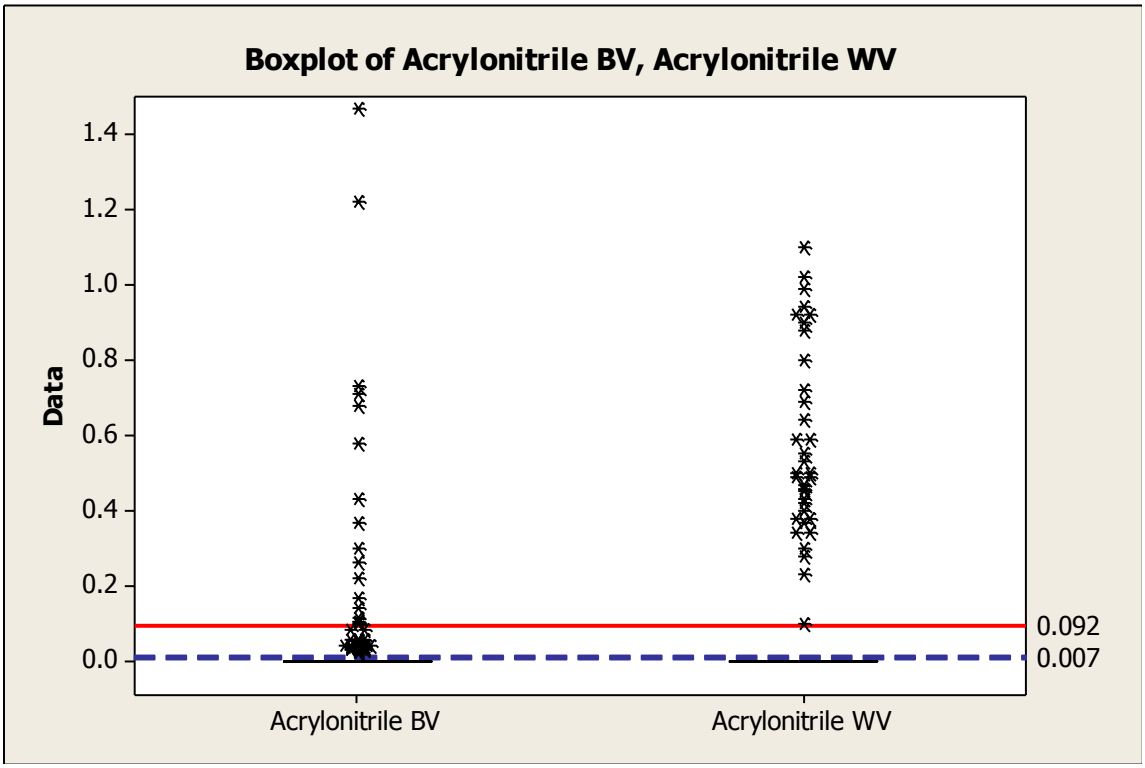

Boxplot of Formaldehyde BV, Formaldehyde WV
Data
14
12
10
8
6
4
2
0
0.8
Formaldehyde BV
Formaldehyde WV

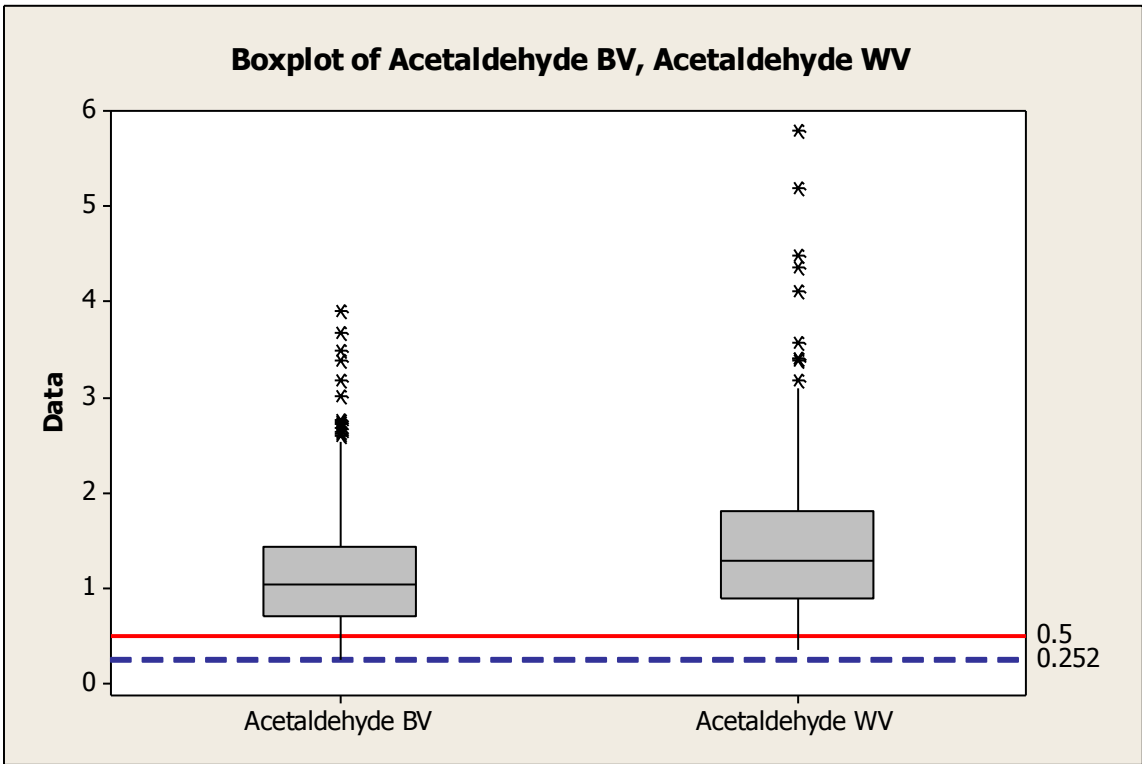

Boxplot of Tetrachloroethylene BV, Tetrachloroethylene WV
Data
0.5
0.4
0.3
0.2
0.1
0.0
0.025
Tetrachloroethylene BV
Tetrachloroethylene WV

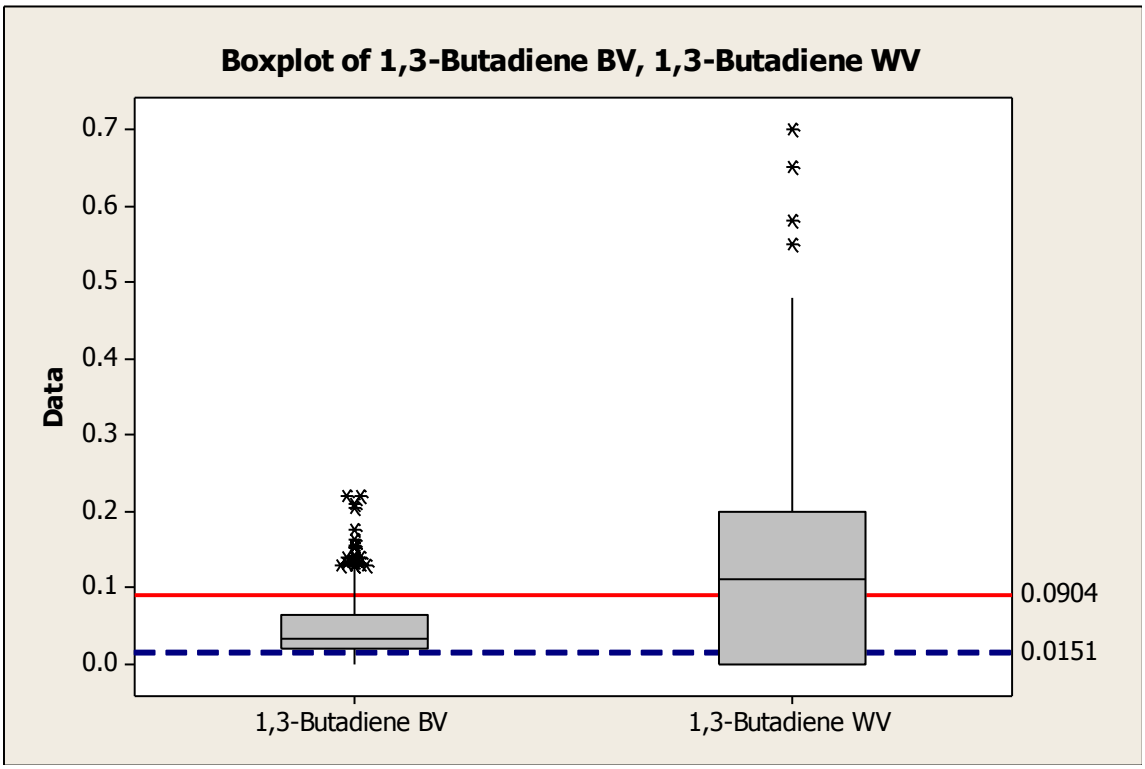

Boxplot of Ethylbenzene BV, Ethylbenzene WV
Data
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.092
Ethylbenzene BV
Ethylbenzene WV

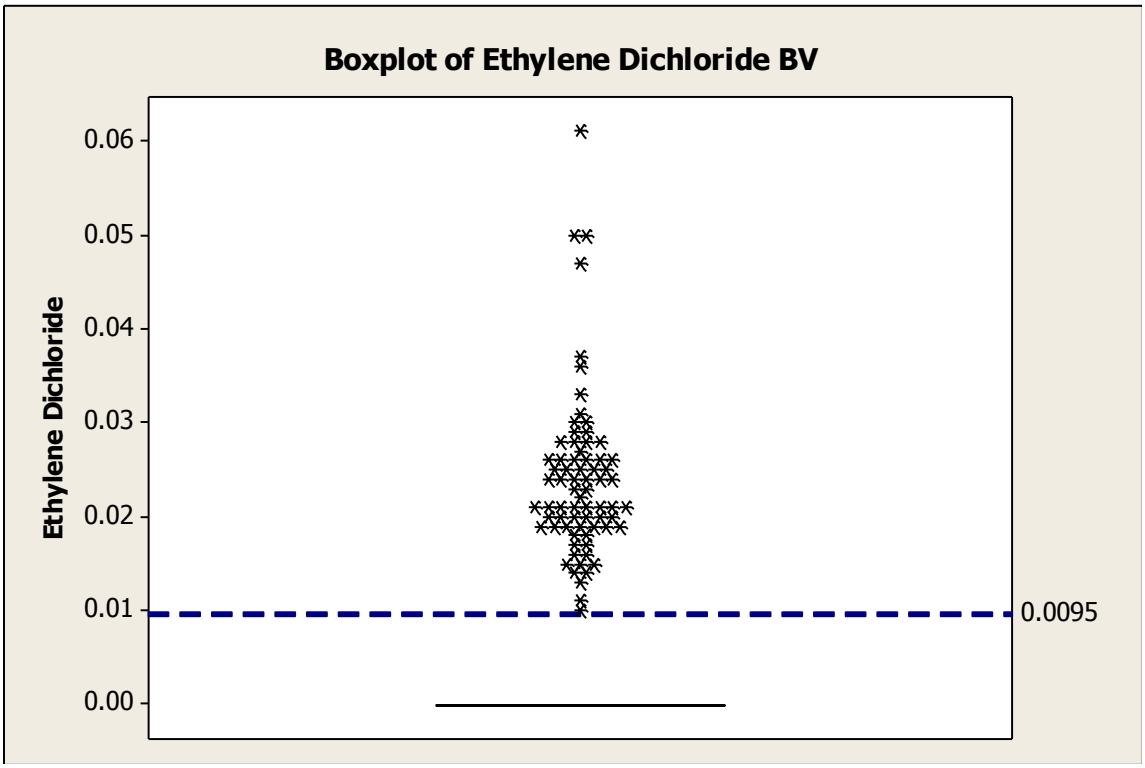

Boxplot of Carbon Tetrachloride BV, Carbon TetrachlorideWV
Data
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0.0265
Carbon Tetrachloride BV
Carbon TetrachlorideWV

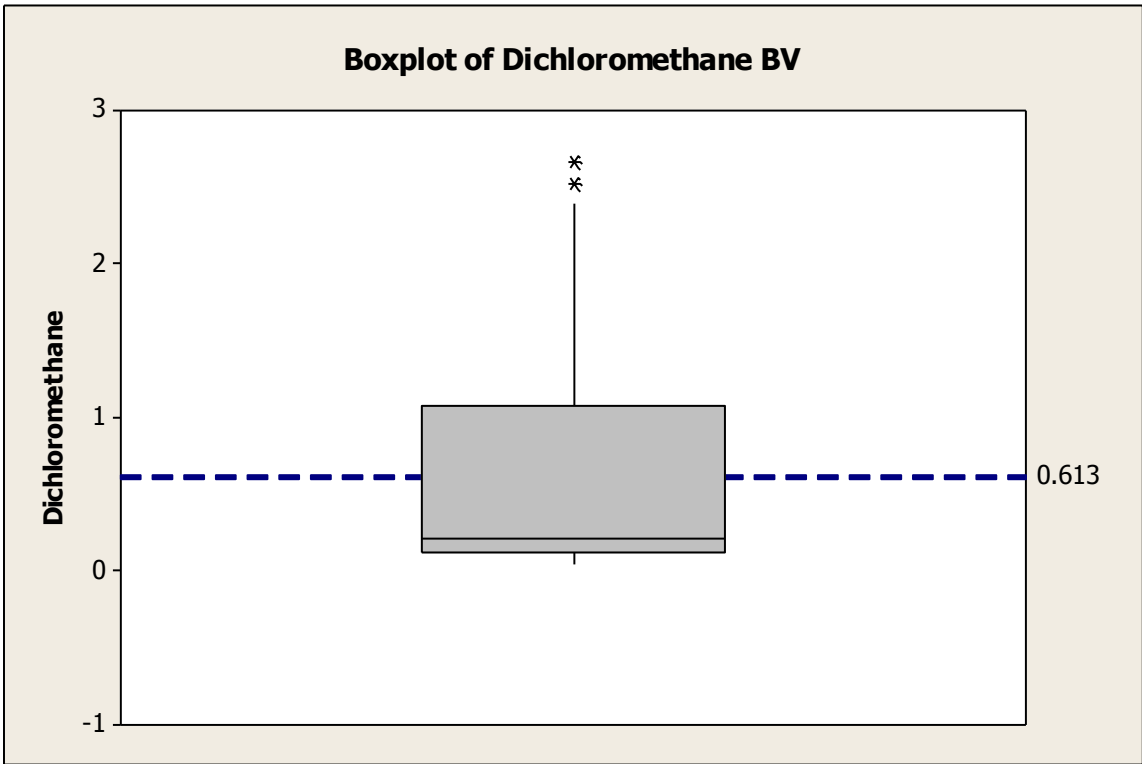

Boxplot of Benzene BV, BenzeneWV
Data
4
3
2
1
0
0.939
0.04
Benzene BV
BenzeneWV

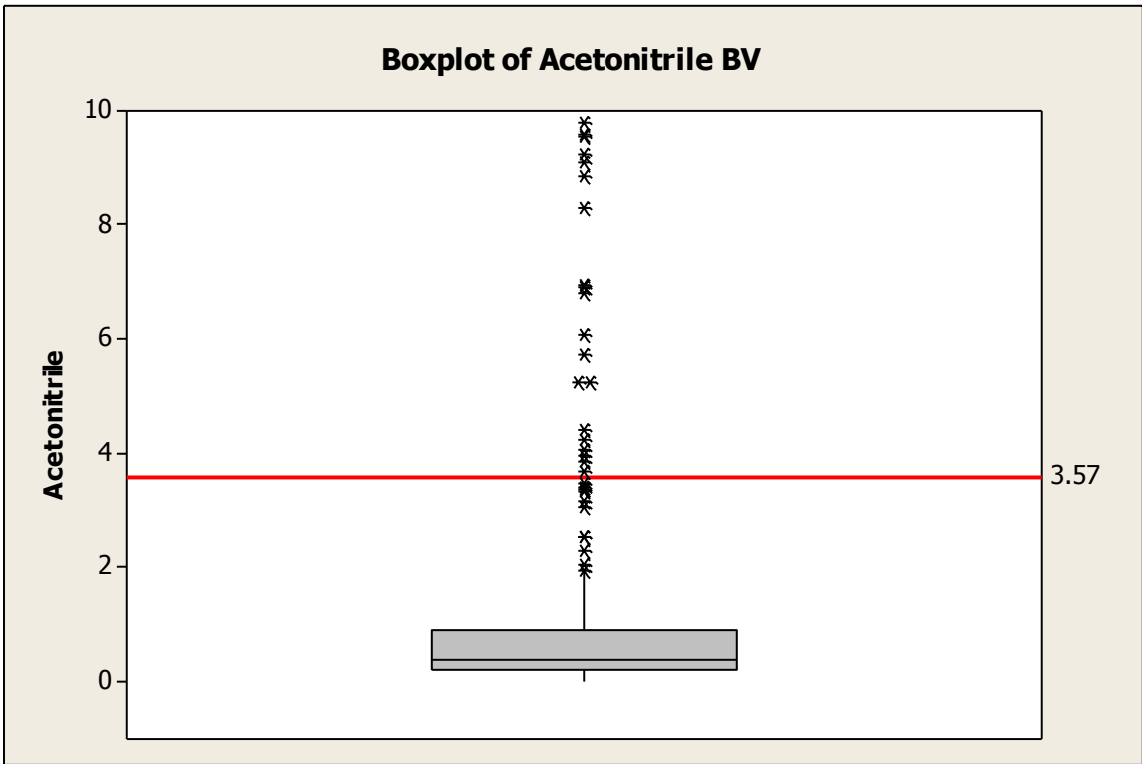

Boxplot of Acrylonitrile BV, Acrylonitrile WV
Data
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.092
0.007
Acrylonitrile BV
Acrylonitrile WV

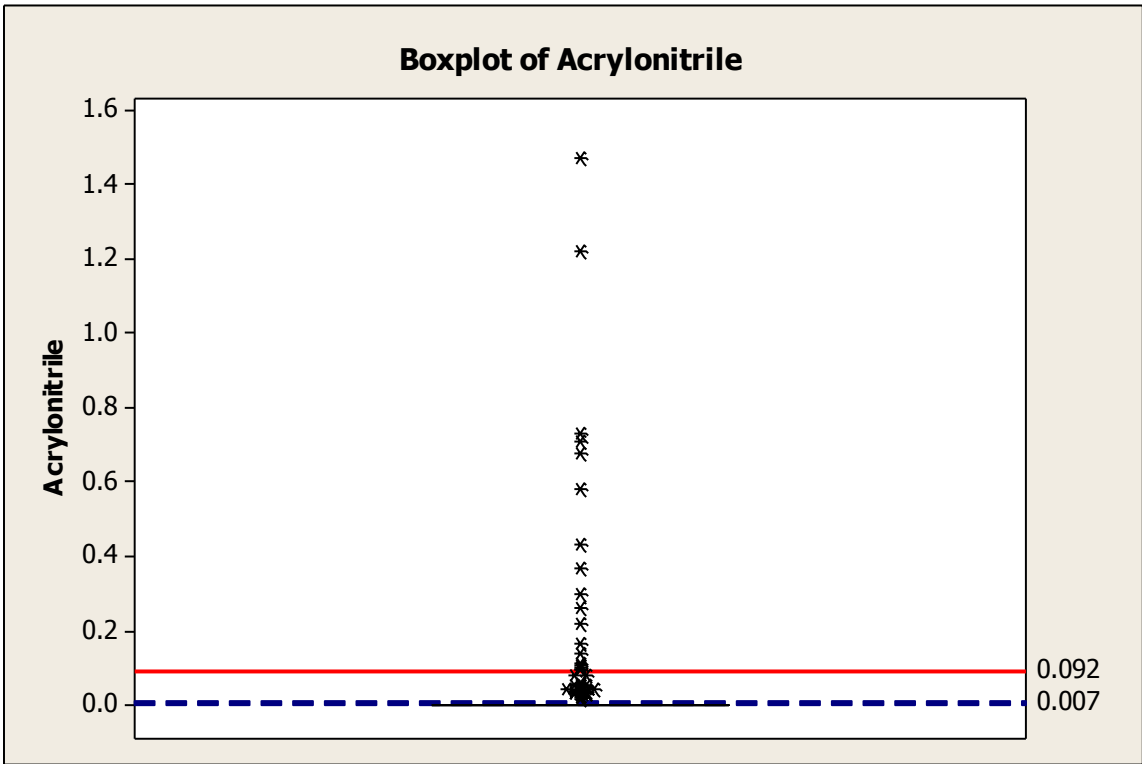

Boxplot of Acetaldehyde BV, Acetaldehyde WV
Data
6
5
4
3
2
1
0
0.5
0.252
Acetaldehyde BV
Acetaldehyde WV


Boxplot of 1,3-Butadiene BV, 1,3-Butadiene WV
Data
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0904
0.0151
1,3-Butadiene BV
1,3-Butadiene WV

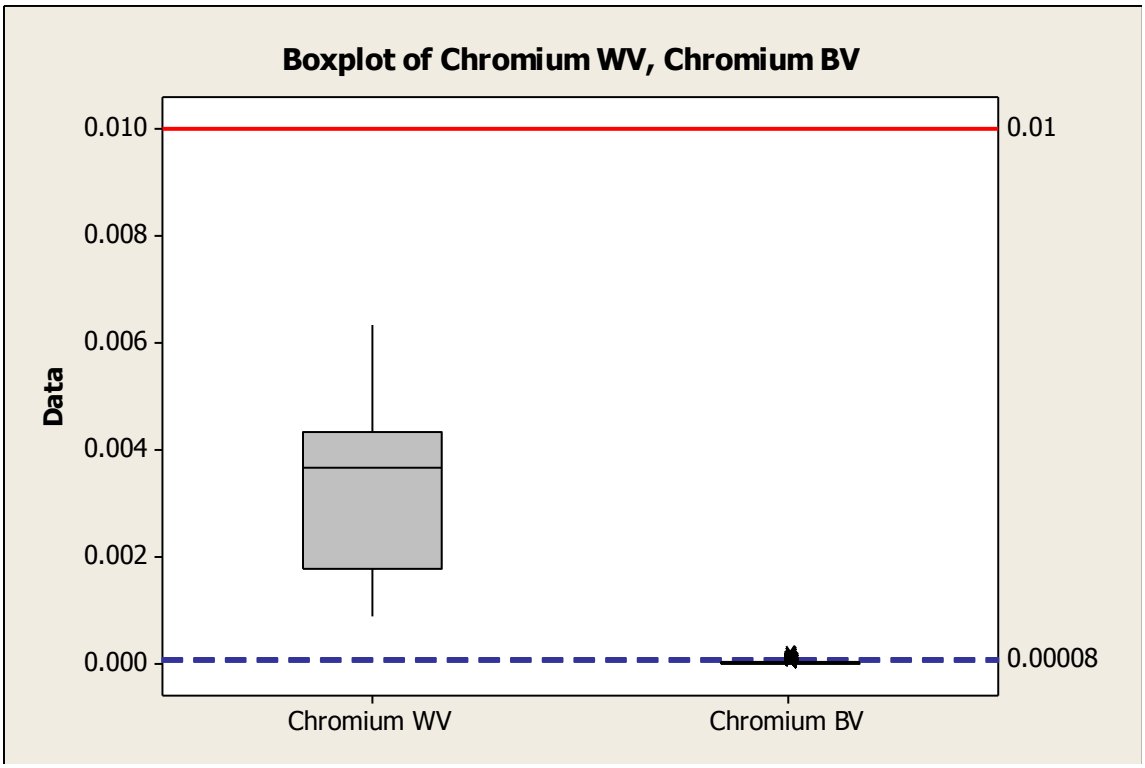

Boxplot of Ethylene Dichloride BV
Ethylene Dichloride
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0.0095

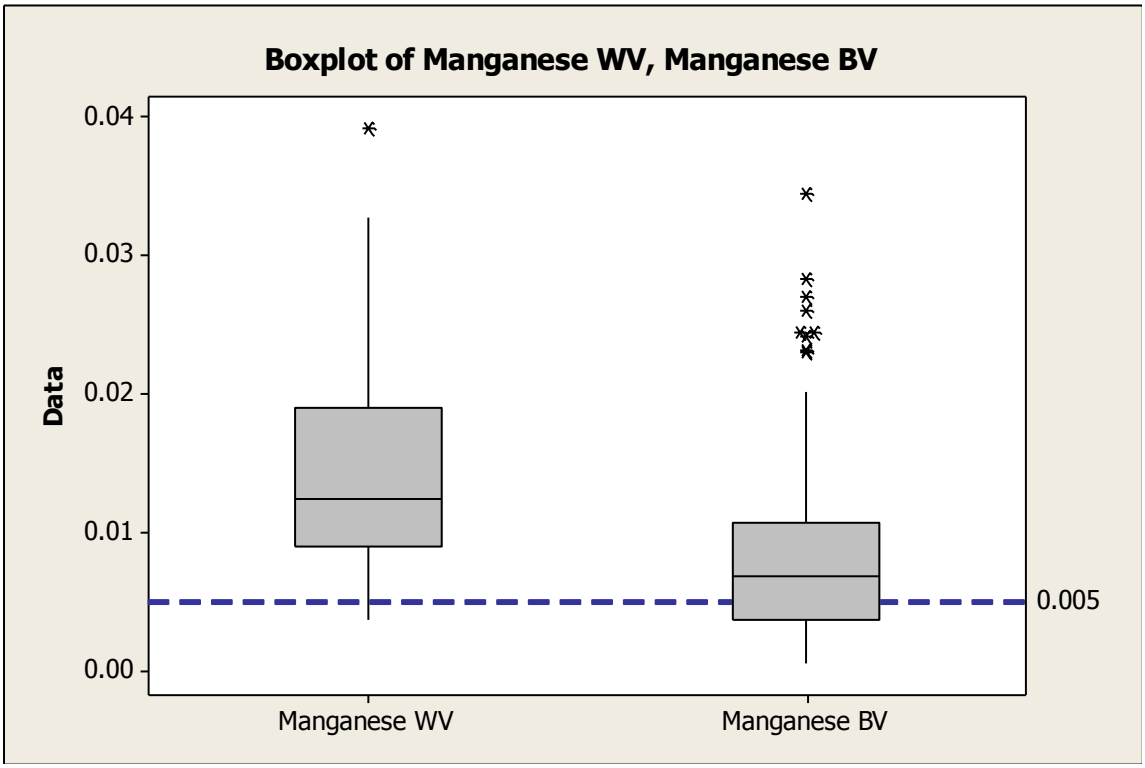

Boxplot of Dichloromethane BV
Dichloromethane
3
2
1
0
-1
0.613

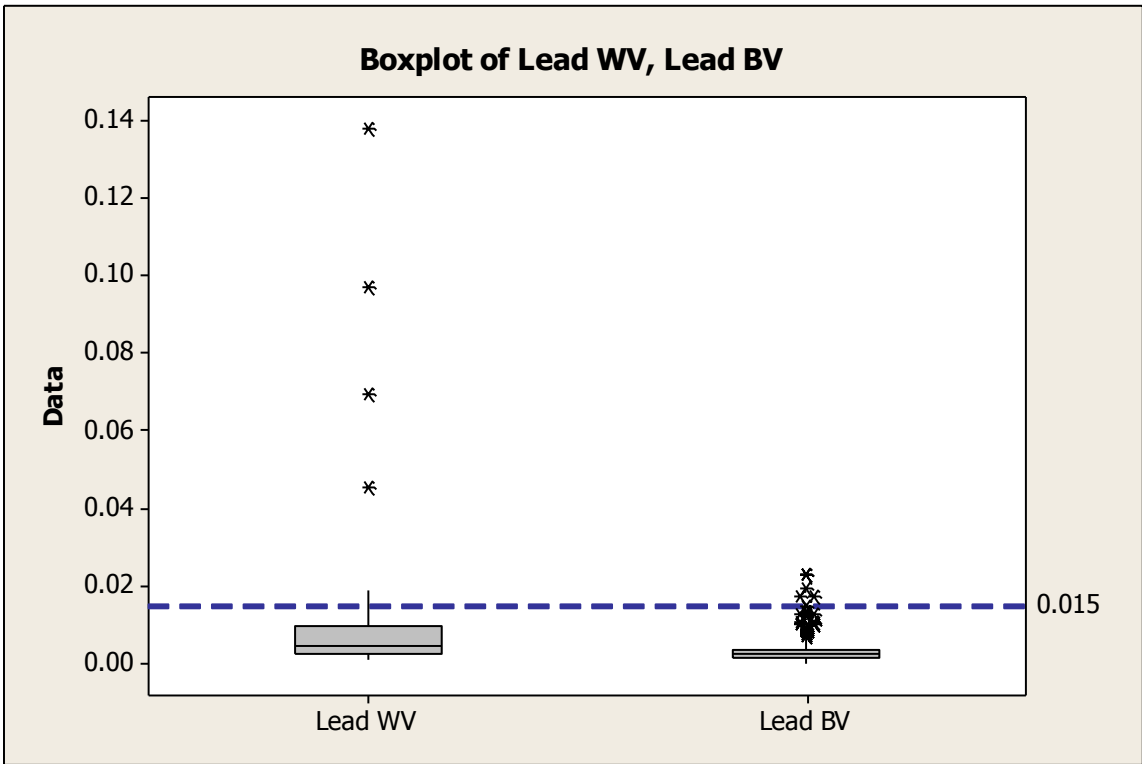

Boxplot of Acetonitrile BV
Acetonitrile
10
8
6
4
2
0
3.57

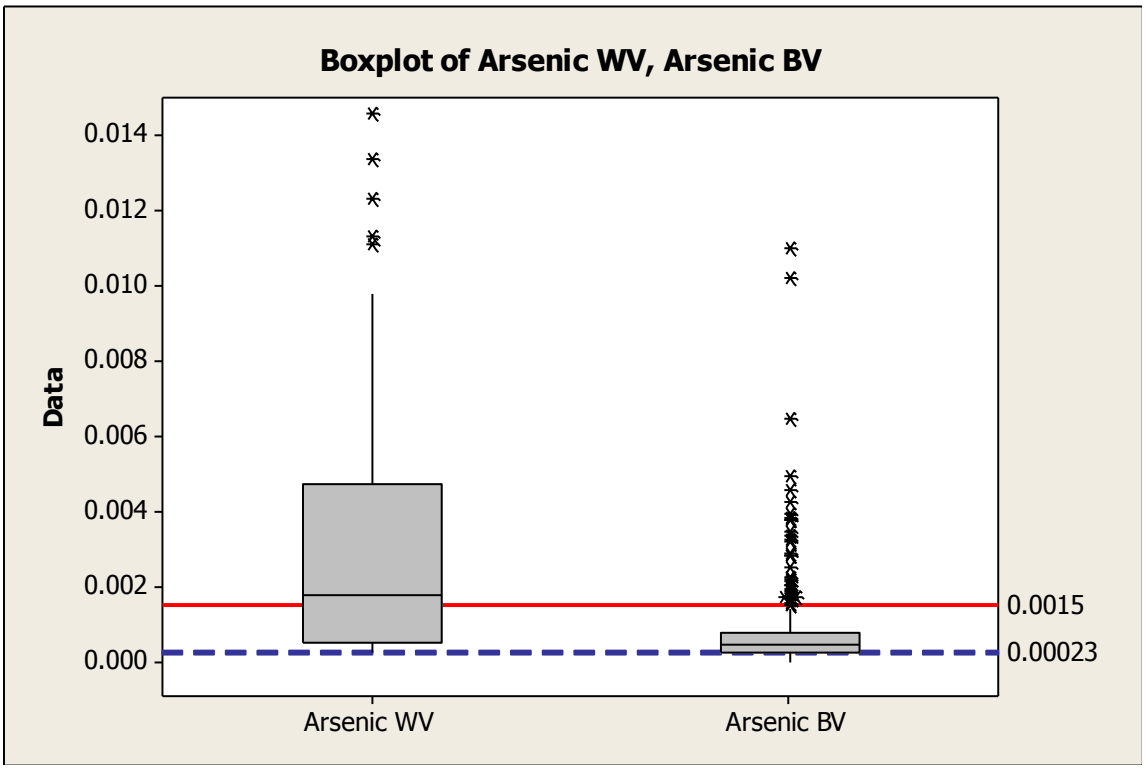

Boxplot of Acrylonitrile
Acrylonitrile
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.092
0.007

Appendix 2, Metal HAPs Measured at West Valley and Bountiful

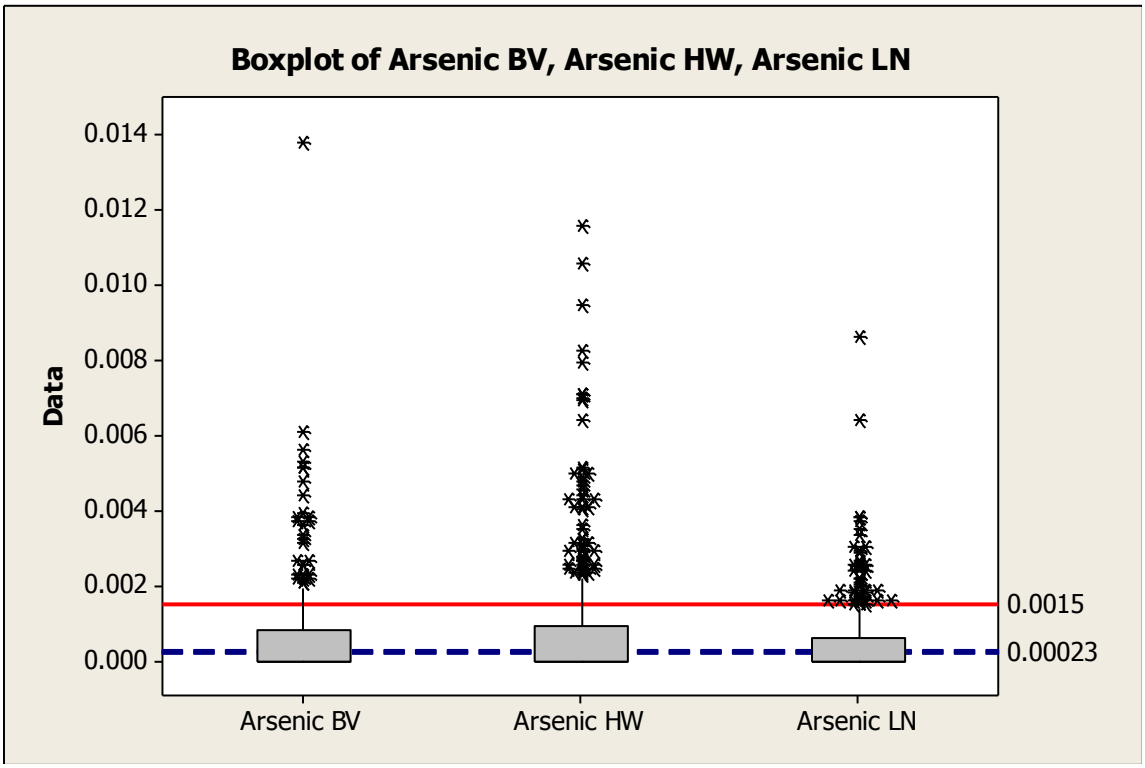

Boxplot of Chromium WV, Chromium BV
Data
0.010
0.008
0.006
0.004
0.002
0.000
0.01
0.00008
Chromium WV
Chromium BV

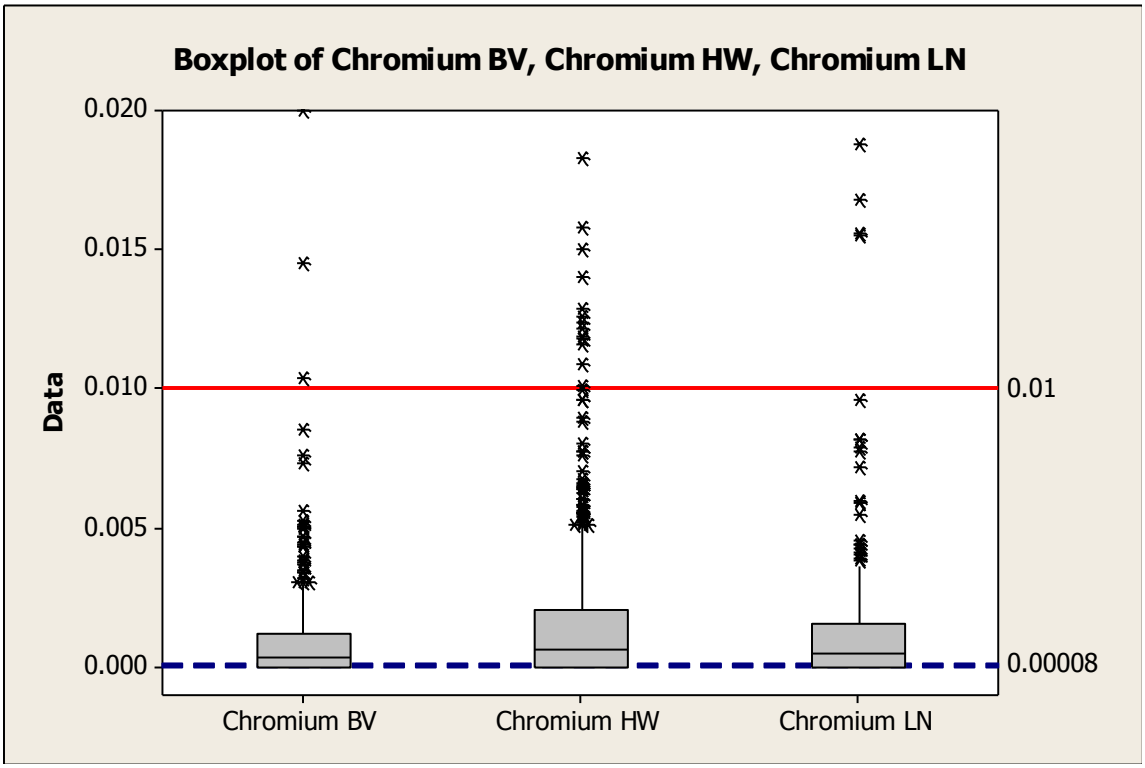

Boxplot of Manganese WV, Manganese BV
Data
0.04
0.03
0.02
0.01
0.00
0.005
Manganese WV
Manganese BV

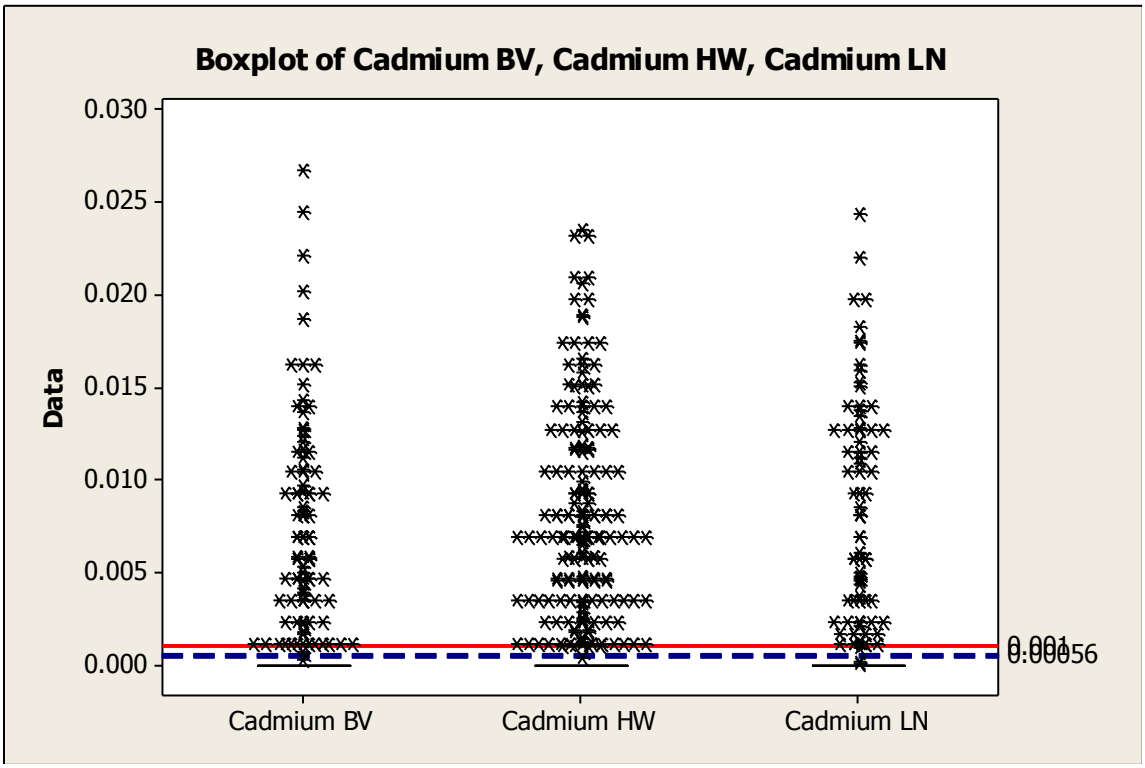

Boxplot of Lead WV, Lead BV
Data
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0.015
Lead WV
Lead BV

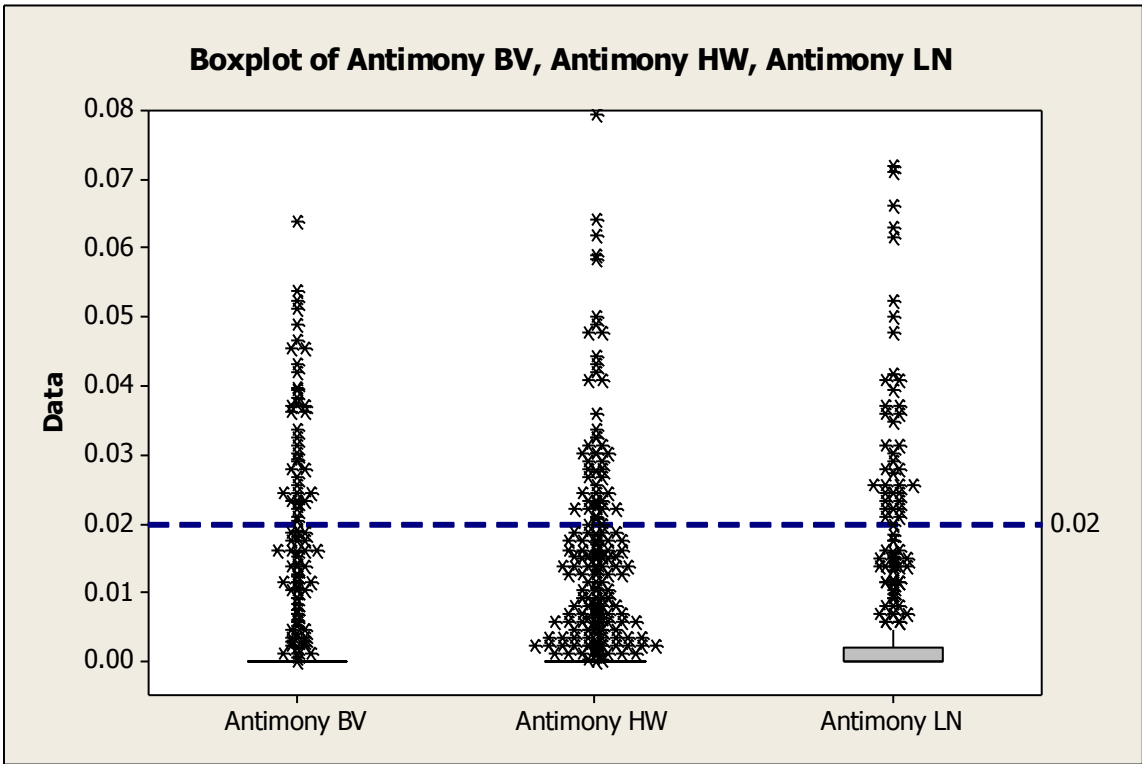

Boxplot of Arsenic WV, Arsenic BV
Data
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
0.0015
0.00023
Arsenic WV
Arsenic BV

Appendix 3, STN Observations of HAPs


Boxplot of Arsenic BV, Arsenic HW, Arsenic LN
Data
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
0.0015
0.00023
Arsenic BV
Arsenic HW
Arsenic LN


Boxplot of Chromium BV, Chromium HW, Chromium LN
Data
0.020
0.015
0.010
0.005
0.000
0.01
0.00008
Chromium BV
Chromium HW
Chromium LN


Boxplot of Cadmium BV, Cadmium HW, Cadmium LN
Data
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0.001
0.00056
Cadmium BV
Cadmium HW
Cadmium LN


Boxplot of Antimony BV, Antimony HW, Antimony LN
Data
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0.02
Antimony BV
Antimony HW
Antimony LN