Minnesota Statewide Air Toxics Monitoring Study (1996-2001)

Final Report

Minnesota Pollution Control Agency
May 2005

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for the
Minnesota Pollution Control Agency
May 2005

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Executive Summary

In 1993, the Minnesota Legislature authorized the Minnesota Pollution Control Agency (MPCA) to establish a statewide air toxics monitoring network in order to collect baseline ambient air toxics concentration data for various locations throughout the state. The MPCA completed the Background Information and Project Plan for the Statewide Air Toxics Monitoring Study (1) in October 1996. The study proposed to conduct ambient air toxics monitoring in communities throughout Minnesota in order to meet four major objectives.

- Characterize ambient air concentrations and seasonal variation of VOCs, carbonyls and particulate metals in rural and urban/suburban locations in order to obtain baseline concentrations.

- Compare concentrations of specific VOCs, carbonyls and particulate metals at rural and urban/suburban sites to determine if people living in urban areas are exposed to more toxic air pollution than people living in rural and small town areas.

- Provide data for a preliminary screening assessment of potential health and environmental risks from exposure to selected VOCs, carbonyls and particulate metals.

- Provide a means for prioritizing and planning future work and sampling in a more in-depth and pollutant-specific and/or source-specific basis in local areas.

The MPCA divided the state into its six administrative regions and, using a random selection process, chose five cities or townships in each region to use as monitoring sites. One site from each region was monitored each year for five years. Five additional sites were added to give better geographical coverage to the northern one-third of the state. Monitoring began in September 1996 and continued until September 2001. Over the five years, a total of 35 cities and townships were monitored.

Of the 73 chemicals collected and analyzed in the Statewide Air Toxics Monitoring (SATM) study, at one site or more, four were above MPCA approved inhalation health benchmarks, 11 were near their respective health benchmark, 15 were at least 10 times lower than their health benchmarks, 22 lacked approved MPCA benchmarks and 21 were unable to be analyzed due to insufficient data above the detection limit.

The pollutants found above health benchmarks at one site or more were benzene, formaldehyde, carbon tetrachloride and ethylene dibromide. Each of these pollutants posed greater than a 1 in a 100,000 excess cancer risk at one or more monitoring sites. Of these four, carbon tetrachloride and ethylene dibromide are below levels of concern based on current data. Benzene is generally below health benchmarks at current monitors; however, since it is a known human carcinogen, it may still be of concern in areas with elevated concentrations such as near sources such as gas stations and busy roadways. Formaldehyde continues to be found at levels of concern across the state.

Four other air toxics had detection limits which were higher than the inhalation health benchmark. Of these, available data indicates that arsenic and cadmium may have exceeded a 1 in 100,000 cancer risk at one or more sites. 1,3-butadiene and chromium VI appear unlikely to exceed benchmarks.

The data was analyzed to see if there were differences by region, monitoring year or population of the city or township. Overall, regional differences were minimal. The Twin Cities area tended to be higher in concentration for many pollutants since that region is much more populated and contains many more

emission sources than the other regions of Minnesota. There were no statistical differences between the other regions.

Differences in monitoring years were also seen. It was difficult to distinguish trends because the monitoring sites rotated every year. Various factors made it nearly impossible to determine if differences between years were due to differences in monitoring locations, actual decreasing or increasing atmospheric concentration, changes in atmospheric conditions between years or changes in monitoring collection and analysis equipment.

Many of the pollutants, particularly the VOCs, had at least a partial correlation with population. In general, as population increased, concentration increased. For many VOCs, this was particularly true for the very sparsely populated areas and the very densely populated areas. Holloway, with 112 people, often had the lowest concentrations of air toxics, while the Twin City sites frequently were among the highest in concentration. While this holds true generally, population cannot explain all the differences between sites.

Many pollutants which were detected in most cities and townships and were well correlated with population are primarily emitted by motor vehicles. These compounds include acetaldehyde, benzene, ethylbenzene, formaldehyde, toluene and xylenes. Compounds which primarily came from point sources, such as arsenic, lead, manganese, nickel, and styrene were less likely to have increasing levels with increasing population.

Some sites were also influenced by relatively large emissions from point sources. These results were relatively rare since the monitoring locations were carefully chosen to avoid the influences of point sources. This is a reminder that concentrations within cities can vary depending on the vicinity of point sources and major roadways.

The inhalation risk for the various compounds monitored was added at each of the 35 monitoring sites to calculate a cumulative risk. Because of insufficient data above detection limits, only 26 pollutants were used to calculate the risk. As a result, the calculated risks may underestimate the risk from breathing ambient air. The cumulative 1 in 100,000 excess cancer risk for the monitoring sites ranged from 2.5 in Holloway in Swift County to 5.8 in Minneapolis. The MPCA considers a 1 additional chance in 100,000 of getting cancer in a lifetime due to air toxics emissions to be acceptable. Chronic, noncancer hazard indices ranged from 0.59 to 1.4. If a noncancer hazard quotient or index is less than one, the pollutant is not expected to cause an adverse effect to human health. If a quotient or index is greater than one, adverse effects are possible. Holloway again had the lowest risk while Winona had the highest. When the hazard index was broken down to take into account target endpoints, St. Paul, Minneapolis and Winona had upper respiratory endpoints slightly over one. Winona also had a lower respiratory hazard index over one.

As with many of the individual pollutants, the total cumulative risk tended to increase somewhat with population. The correlation was better for cancer risk than for noncancer risk. While population size is an important indicator of risk, other factors such as point sources and monitor location are also important. For example, Winona, Grand Rapids and Fort Ripley had higher risk levels than other cities with similar populations. The Twin Cities had slightly higher risk levels while there was no significant difference between risk levels in the other regions of Minnesota.

The 2000-2001 Minnesota SATM data was compared to the Environmental Protection Agency's National Pilot City data that was collected in 2001. Overall, Minnesota concentrations appear to be lower than or similar to air toxic concentrations found nationwide.

1. Introduction

In the mid- to late 1980s there was a movement by a number of states to assess non-criteria pollutants known as air toxics in ambient air. In Minnesota, the Pollution Control Agency (MPCA) upgraded its sampling and laboratory analysis capabilities and began analyzing selected volatile organic compounds (VOCs) and carbonyl compounds. By the early 1990s, MPCA was monitoring for air toxics in the Twin Cities metro area (Minneapolis, St. Paul, Pine Bend and St. Paul Park) as well as in Duluth.

Since it was commonly assumed that exposure to air toxics is lower in small towns and rural areas, the limited staff, equipment and funding for air monitoring were focused on select urban and industrial areas. However, the MPCA remained interested in collecting ambient air toxics concentration data for various locations throughout the state.

In 1993, the Minnesota Legislature authorized the MPCA to establish a statewide air toxics monitoring network. Funding for the network was made available for the 1995-1997 funding biennium. The funding set aside $400,000 for the Statewide Air Toxics Monitoring (SATM) Study. Subsequently, $200,000 per year was available to complete the study.

> ***Minnesota Statutes 116.454 Monitoring program.***
>
> By July 1, 1993, the agency shall establish a statewide monitoring program for, and inventory of probable sources of, releases into the air, ambient concentrations in the air, and deposition from the air of toxic substances.
>
> HIST: 1992 c 546 s 3

The MPCA completed the Background Information and Project Plan for the Statewide Air Toxics Monitoring Study (1) in October 1996. The study proposed to conduct ambient air toxics monitoring in communities throughout Minnesota in order to meet four major objectives.

- Characterize ambient air concentrations and seasonal variation of VOCs, carbonyls and particulate metals in rural and urban/suburban atmospheres in order to obtain baseline concentrations.

- Compare concentrations of specific VOCs, carbonyls and particulate metals at rural and urban/suburban sites to determine if people living in urban areas are exposed to more toxic air pollution than people living in rural and small town areas.

- Provide data for a preliminary screening assessment of potential health and environmental risks from exposure to selected VOCs, carbonyls and particulate metals.

- Provide a means for prioritizing and planning future work and sampling in a more in-depth and pollutant-specific and/or source-specific basis in local areas.

Ideally, the air toxics study would have included semivolatile organic compounds (SVOCs) as well as VOCs and metals since SVOCs are often persistent (slow to degrade in the environment) and/or bioaccumulative (a process where animals ingest and store chemicals more rapidly than their bodies can eliminate them). However, the Air Quality Laboratory did not have the capability to analyze SVOCs and contracting out to another lab was considered cost prohibitive. In addition, exposures to these chemicals are generally greater from ingestion exposure routes than from inhalation exposures. For this reason, the SATM study focused on the concentrations of air toxic chemicals that are of concern because of direct exposure through inhalation.

In order to achieve the maximum coverage of the state within funding parameters, the MPCA chose to use a statewide "screening" approach to meet the study objectives. The screening approach provides baseline information on the concentrations of VOCs and particulate metals in ambient air for most areas of the state.

The screening approach utilized "rotating" sites where monitoring was conducted for one year. After a one year period, the equipment was moved to another location, recalibrated, and then monitoring conducted for another year at the new location. This was done for five years from 1996-2001, with a total of 35 sites ultimately monitored.

Monitoring was completed for the SATM study in October 2001. This report summarizes the results of the study.

2. Study Design

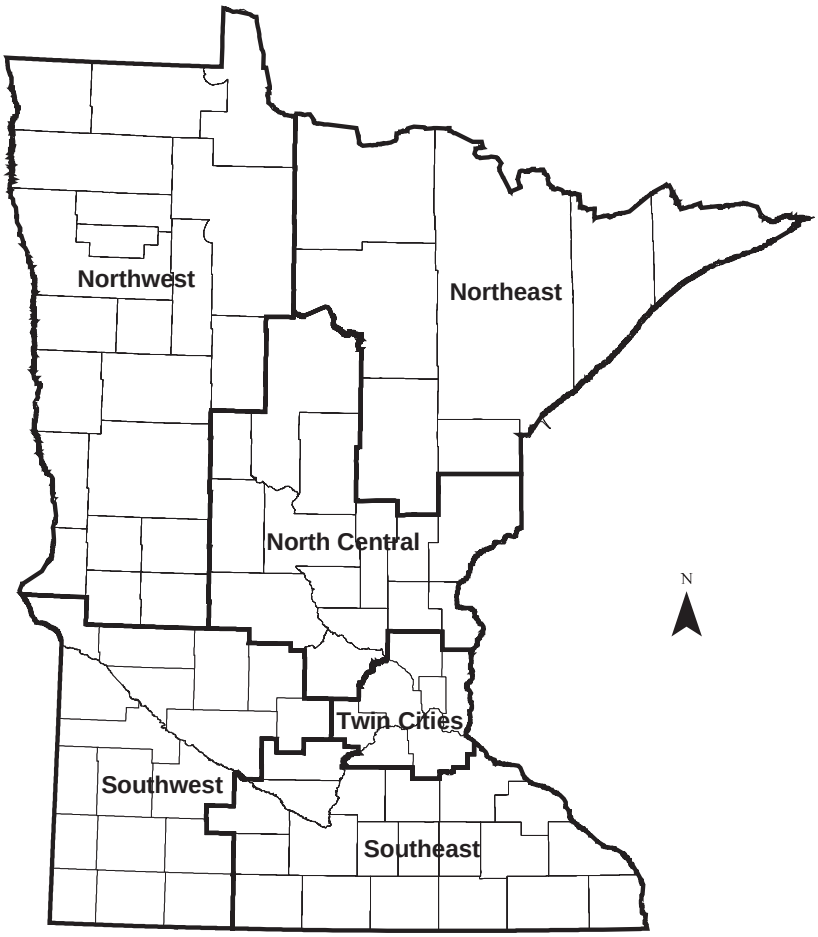
The SATM study was designed as a "screening" study because the data from a relatively small number of sites in the state would be used to draw general conclusions about pollutants in ambient air throughout the state. The study was designed to characterize typical ambient air toxic concentrations that Minnesota residents are potentially exposed to in residential areas of cities or townships. Special care was taken in picking sampling locations to avoid targeting specific industries.

2.1. Monitoring Locations

Funding allowed six to seven monitoring locations to be operated each year. The MPCA decided to use its six administrative regions as a convenient way to divide the state geographically. The regions include the Northeast (Region 1), the North Central (Region 2), the Northwest (Region 3), the Southwest (Region 4), the Southeast (Region 5), and the Twin Cities Metropolitan area (Region 6). Although these six regions were set up for administrative purposes, they also represent different ecoregions of Minnesota.

For example, the Northeast region encompasses the northern boreal forest (aspen-pine-spruce-balsam) and the rugged Boundary Waters Canoe Area Wilderness and the North Shore ridge area. This forested area and its mining and forest products industries contrasts sharply with the flat to rolling farmland of the Southwest region. In comparison, the Northwest, North Central, and Northeast regions all encompass the transition zone between agriculture and forest land uses. This transition zone cuts diagonally across the state from the northwest to the southeast where agricultural and forest areas are intermingled, but the forest areas tend to be in smaller blocks and are typically not continuous. Finally, the Twin Cities metropolitan area offers a unique contrast to the regions that are dominated by agriculture and forest land uses. Ambient air monitoring data for this large metropolitan area provides a benchmark for comparing and contrasting the ambient air data obtained from other urban/suburban areas and smaller towns in the state. A map of the regions is given in Figure 2.1.

Figure 2.1: MPCA Administrative Regions.



The MPCA randomly selected five sites from each administrative region. The sites were chosen from a potential list that included all cities and townships in the state. Population data (1994 estimated populations) were used to separate cities and townships within each region into five "tiers." Tier 1 contained the top 20 percent of the population in each region, Tier 2 contained the next 20 percent, Tier 3 the next 20 percent, Tier 4 the next 20 percent, and Tier 5 contained the lowest 20 percent of population in each region.

Typically, Tier 1, the top 20 percent of the scores, contained one or two cities. For example, in the Northeast region, only the city of Duluth was listed in Tier 1. In the Twin Cities region, only the city of Minneapolis was listed. In contrast, Tier 4 typically contained 10 to over 20 small towns and some townships. Tier 5 typically contained some small towns and most of the townships. In general, Tiers 1 through 3 contained most of the populated areas of each region, while Tiers 4 and 5 contain the less populated areas. To ensure that data were obtained from the full range of populated areas in each region, one sampling site from each of the five tiers in each region was included in the study. Random numbers were assigned to each city or township. Within each tier in each region, the city or township that had the highest random number was selected for inclusion in the study. In addition, the sites selected for monitoring in each region were again assigned random numbers and the site with the highest random number was selected for monitoring in Year 1. The site with the next highest random number was selected for monitoring in Year 2, etc., until all the selected sites were assigned to a sampling year.

The use of the random selection process resulted in some large geographic areas in the northern part of the state that did not have sampling sites. To address this, five additional sites were chosen to give better geographical coverage to the northern one-third of the state. The final schedule of sampling sites is provided in Table 2.1 and shown on the map in Figure 2.2. Site addresses and locations are given in Appendix A.

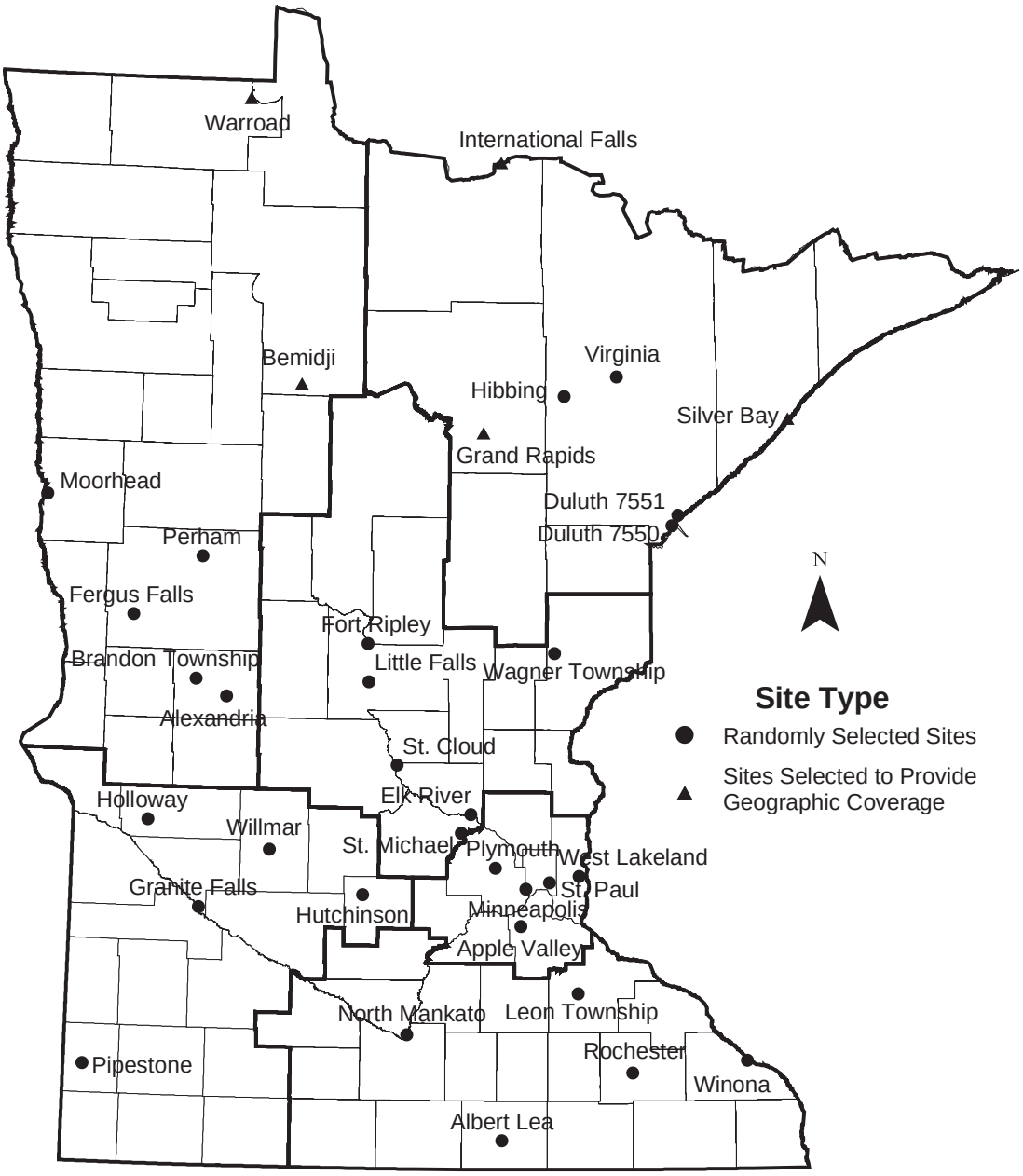
Table 2.1: List of Sites Monitored from 1996-2001 for the MPCA's Statewide Air Toxics Monitoring Study.

	SAMPLE YEAR				
MPCA REGION	**1**	**2**	**3**	**4**	**5**
REGION 1 NORTHEAST	Wagner Township; Aitkin County Tier 5	Hibbing; St. Louis County Tier 3	Duluth; St. Louis County Tier 1	Virginia; St. Louis County Tier 4	Duluth; St. Louis County Tier 1
REGION 2 NORTH CENTRAL	Little Falls; Morrison County Tier 3	Elk River; Sherburne County Tier 2	St. Cloud; Stearns County Tier 1	St. Michael; Wright County Tier 4	Fort Ripley; Crow Wing County Tier 5
REGION 3 NORTHWEST	Alexandria; Douglas County Tier 3	Fergus Falls; Otter Tail County Tier 2	Moorhead; Clay County Tier 1	Perham; Otter Tail County Tier 4	Brandon Township; Douglas County Tier 5
REGION 4 SOUTHWEST	Pipestone; Pipestone County Tier 3	Granite Falls; Yellow Medicine Tier 4	Holloway; Swift County Tier 5	Hutchinson; McLeod County Tier 2	Willmar; Kandiyohi County Tier 1
REGION 5 SOUTHEAST	Leon Township; Goodhue County Tier 5	Rochester; Olmsted County Tier 1	Winona; Winona County Tier 2	Albert Lea; Freeborn County Tier 3	North Mankato; Nicollet County Tier 4
REGION 6 TWIN CITIES	Plymouth; Hennepin County Tier 3	Minneapolis; Hennepin County Tier 1	St. Paul; Ramsey County Tier 2	West Lakeland Township; Washington County Tier 5	Apple Valley; Dakota County Tier 4
ADDED SITES	International Falls; Koochiching County	Warroad; Roseau County	Bemidji; Beltrami County	Silver Bay; Lake County	Grand Rapids; Itasca County

*Shaded areas indicate monitoring year swap changes made within the region.

Sample Year 1 = September 1996 Through September 1997
Sample Year 2 = October 1997 Through September 1998
Sample Year 3 = October 1998 Through September 1999
Sample Year 4 = October 1999 Through September 2000
Sample Year 5 = October 2000 Through September 2001

Figure 2.2: Sampling Sites Included in the MPCA Statewide Air Toxics Monitoring Study.



All of the monitoring equipment was located according to the following criteria:

- Was typical of air that most community residents would breathe.
- Located in a secure location on a rooftop or on the ground, free of obstructions such as trees, towers, and mechanical systems such as air conditioners.
- Had access to electrical power.
- Had all-day access during the entire year.

2.2. Pollutants Monitored

Each of the seven monitoring sites was equipped with samplers to collect VOCs, carbonyl compounds and particulate matter less than 10 micrometers in diameter (PM_{10}). The metals were analyzed from the PM_{10} filters. Every six days, each of the sites collected a 24-hour sample. This allowed samples to be collected every day of the week during the one-year time period and prevented day of the week biases. Approximately 60 samples were collected at each site for VOCs, carbonyl compounds and metals on the PM_{10} filters. The VOCs included the compounds listed in the United States Environmental Protection Agency's (EPA) Toxic Organic Method 14 (TO-14). Carbonyls included those found in EPA's Toxic Organic Method 11 (TO-11). The metals included those available by the X-Ray Florescence method (See the Methods section for more details). Tables 2.2-2.4 list the VOCs, carbonyls and metals included in the Statewide Air Toxics Monitoring Study.

Table 2.2: Volatile Organic Compounds (VOCs) Included in the SATM Study.

	Chemical	CAS #	Formula		Chemical	CAS #	Formula
1.	Benzene	71-43-2	C_6H_6	20.	Ethylene dibromide	106-93-4	$C_2H_4Br_2$
2.	1,3-Butadiene*	106-99-0	C_4H_6	21.	4-Ethyltoluene*	622-96-8	C_9H_{12}
3.	Carbon tetrachloride	56-23-5	CCl_4	22.	Hexachlorobutadiene	87-68-3	C_4Cl_6
4.	Chlorobenzene	108-90-7	C_6H_5Cl	23.	Methyl bromide	74-83-9	CH_3Br
5.	Chloroform	67-66-3	$CHCl_3$	24.	Styrene	100-42-5	C_8H_8
6.	1,2-Dichlorobenzene	95-50-1	$C_6H_4Cl_2$	25.	1,1,2,2-Tetrachloroethane	79-34-5	$C_2H_2Cl_4$
7.	1,3-Dichlorobenzene	541-73-1	$C_6H_4Cl_2$	26.	Tetrachloroethylene	127-18-4	C_2Cl_4
8.	1,4-Dichlorobenzene	106-46-7	$C_6H_4Cl_2$	27.	Toluene	108-88-3	C_7H_8
9.	Dichlorodifluoromethane (Freon 12)	75-71-8	CCl_2F_2	28.	1,1,1-Trichloroethane	71-55-6	$C_2H_3Cl_3$
10.	1,1-Dichloroethane	75-34-3	$C_2H_4Cl_2$	29.	1,1,2-Trichloroethane	79-00-5	$C_2H_3Cl_3$
11.	1,2-Dichloroethane	107-06-2	$C_2H_4Cl_2$	30.	Trichloroethylene	79-01-6	C_2HCl_3
12.	1,1-Dichloroethene	75-35-4	$C_2H_2Cl_2$	31.	Trichlorofluoromethane (Freon 11)	75-69-4	CCl_3F
13.	cis-1,2-Dichloroethene	156-59-2	$C_2H_2Cl_2$	32.	Trichlorotrifluoroethane (Freon 113)	76-13-1	$C_2Cl_3F_3$
14.	Dichloromethane (Methylene chloride)	75-09-2	CH_2Cl_2	33.	1,2,4-Trimethylbenzene	95-63-6	C_9H_{12}
15.	1,2-Dichloropropane	78-87-5	$C_3H_6Cl_2$	34.	1,3,5-Trimethylbenzene	108-67-8	C_9H_{12}
16.	cis-1,3-Dichloropropene	10061-01-5	$C_3H_4Cl_2$	35.	Vinyl chloride	75-01-4	C_2H_3Cl
17.	trans-1,3-Dichloropropene	10061-02-6	$C_3H_4Cl_2$	36.	o-Xylene**	95-47-6	C_8H_{10}
18.	Dichlorotetrafluoroethane (Freon 114)	76-14-2	$C_2Cl_2F_4$	37.	m&p-Xylene**	108-38-3	C_8H_{10}
19.	Ethylbenzene	100-41-4	C_8H_{10}				

*Monitoring for 1,3-butadiene and 4-ethyl toluene began in 1999.
**Xylenes were combined for data analysis in this report.

Table 2.3: Carbonyls Included in the SATM study.

	Chemical	CAS #	Formula		Chemical	CAS #	Formula
1.	Acetaldehyde	75-07-0	C_2H_4O	5.	Crotonaldehyde	123-73-9	C_4H_6O
2.	Acetone	67-64-1	C_3H_6O	6.	Formaldehyde	50-00-0	CH_2O
3.	Benzaldehyde	100-52-7	C_7H_6O	7.	Propionaldehyde	123-38-6	C_3H_6O
4.	Butyraldehyde	123-72-8	C_4H_8O				

Table 2.4: Particulate Metals Included in the SATM study.

Metals					
1.	Antimony (Sb)	6.	Lead (Pb)	11.	Tin (Sn)
2.	Arsenic (As)	7.	Manganese (Mn)	12.	Titanium (Ti)
3.	Cadmium (Cd)	8.	Molybdenum (Mo)	13.	Vanadium (V)
4.	Chromium (Cr)	9.	Nickel (Ni)	14.	Zinc (Zn)
5.	Cobalt (Co)	10.	Silver (Ag)		
Rare Earth Metals					
15.	Gallium (Ga)	18.	Palladium (Pd)	21.	Yttrium (Y)
16.	Indium (In)	19.	Rubidium (Rb)	22.	Zirconium (Zr)
17.	Lanthanum (La)	20.	Strontium (Sr)		
Crustal Elements					
23.	Calcium (Ca)	24.	Iron (Fe)	25.	Potassium (K)
Other*					
26.	Barium (Ba)	28.	Chlorine (Cl)	30.	Selenium (Se)
27.	Bromine (Br)	29.	Phosphorus (P)		

*Sulfur was dropped due to contamination issues.

3. Methods

Starting in September 1996, the MPCA collected ambient air toxic samples every six days from midnight to midnight over a 24-hour period. The standard operating procedure was to retrieve the samples from the sites within 24 hours of collection and return them to the MPCA Air Monitoring Lab in St. Paul. Three types of samples were collected at each site: VOCs, carbonyl compounds, and metals on PM10 filters.

VOCs were collected following the U.S. federal reference method TO-14A (2) in evacuated, summa-polished, stainless steel canisters, two-valve model (Scientific Instrumentation Specialists, Moscow, ID, USA). The canisters were deployed using a Xon Tech model 910A canister sampler housed in an enclosure that allowed heating during the cold season (Xon Tech, Inc., Van Nuys, CA, USA). After 1999, sample analysis was done using a Varian Saturn model 2000 gas chromatograph/mass spectrometer (Varian, Inc., Palo Alto, CA, USA). Prior to 1999, a Varian Saturn model 1 gas chromatograph/mass spectrometer (Varian, Inc., Palo Alto, CA, USA) was used.

Carbonyl sampling followed U.S. federal reference method TO-11A (3). Carbonyl samples were chemically trapped on a silica gel cartridge that contains 2,4-dinitrophenylhydrazine (DNPH). The cartridges were deployed along with the VOC canisters and inserted into the Xon Tech instrument. Ozone scrubbing to reduce loss of formaldehyde was done by adding a section of Teflon tubing containing granulated potassium iodide to the carbonyl sampling trains. The cartridges were extracted with acetonitrile and sample analysis was done using Dionex high performance liquid chromatography (HPLC).

PM_{10} samples were collected in accordance with U.S. federal reference method 40 C.F.R. Part 53 (4). After gravimetric analysis, a 47-mm disk was cut from each filter at a random location. The disks were analyzed for metals using energy dispersive X-ray fluorescence (XRF) (Spectrace Quan-X model 8000; Spectrace Instruments, Fort Collins, CO, USA).

3.1. Detection Limits

Method detection limits are not reported because some of the analytes are not detected in a large fraction of the samples, making it difficult to calculate the method detection limit. Instrument detection limits are available, but are not reported here. Lower detection limits (LDLs) were determined as described below. The lower detection limits used in the SATM study are given in Appendix B.

VOCs and carbonyls: The LDLs were determined using the following procedure. A standard was prepared to five times the estimated LDL. Seven replicate measurements were made of the standard, and the LDL was taken as the standard deviation (SD) of the replicate analyses divided by the square root of *n*, and this quantity was multiplied by the Student's *t*-value appropriate for a 99% confidence level with *n*-1 degrees of freedom.

$$LDL = t \times (SD/\sqrt{n}), \text{ where}$$

t = the student's t-value appropriate for a 99% confidence level for the standard deviation with *n*-1 degrees of freedom, and
SD = the standard deviation of replicate analyses.

Metals (XRF): Using the XRF instrument, we determined the LDL using guidance provided by Spectrace Instruments, according to which an element's peak is detected above background with 99% confidence if

the peak counts are greater than three times the square root of the background counts: Thus, the LDL can be calculated from analysis of a standard filter using the following equation:

$$LDL = [3 \times (I_b)^{1/2}] / I_p \times 1/(T^{1/2}) \times \text{concentration, where:}$$

I_b = background [counts per second (cps),
I_p = peak (cps), and
T = lifetime under specified excitation condition.

The detection limits for metals were calculated once. The same detection limit was used for all sites and for all five years of the SATM study.

3.2. Protocol for Treating Values below Detection

Although some measurements are below the level of reliable quantification, the information contained in the reading is valuable and should not be discarded. Likewise, it would represent a loss in information to assign some arbitrary value, such as one-half the detection limit. Therefore, all valid data above zero are retained in the database used for statistical analysis. Negative values or zero values are replaced with one-half the detection limit. Chemicals that were found above detection limits less than 25 percent of the time were generally not considered for analysis.

The detection limits for the carbonyls were calculated annually. Collected data was matched to the detection limit calculated closest to the collection date unless the LDL was calculated due to a method or instrumentation change. For example, lower detection limits for carbonyls were calculated in February, 1998, July 1999 and June 2000. Therefore, the July 1999 LDL was compared to data collected between November 1999 and November 2000. However, the 1998 LDLs were calculated because the column on the HPLC had been replaced. Since there was an instrumentation change, all of the 1997 and January 1998 data was compared to the 1997 LDL calculated with the old column.

LDL results were matched to collected data concentrations in a similar way for VOCs. However, more substantial changes were made to the VOC instrumentation. The electron multiplier was replaced on December 12, 1997. The older multiplier had to be run at a higher voltage than the new one. At higher voltages, there is more background noise. For some compounds which are near their detection limits, higher values in the 1996-1997 monitoring year may be due to background noise. In January 1999, the gas chromatograph/mass spectrometer was replaced. The LDLs were generally higher with the new instrumentation. In addition, in 2001, operators were having problems with excess water entering the instrumentation. To help ameliorate the water problem, less sample volume was injected into the system. As a result, most of the LDLs again increased substantially.

Many of the VOC concentrations are at low levels near the LDLs in ambient air. The health benchmarks for many of these compounds are also near their LDL. In some cases, such as for ethylene dibromide, the change in LDL through the years was enough to result in sufficient data over detection limits for early years, and insufficient data in later years. When negative and zero values are replaced with one half the detection limit, the LDL can begin to drive the risk, making it appear that higher risks occur in later years, although the risk is probably the result of the method change and not an actual increase in ambient concentration. If compounds with less than 25 percent of data above detection limits are removed from analysis, risks appear higher in earlier years, although this is also likely due to the change in LDLs rather than ambient air concentration decreases.

Ultimately, only compounds where all sites had sufficient data above detection limits, or where it could be determined that the differences were due to true concentration differences and not varying LDLs could be compared between years.

3.3. Statistical Analysis

Statistical analyses were done using SPSS version 12.0.1 (SPSS, Inc., Chicago, IL, USA). Site comparisons were done on log normalized data (when appropriate) using one-way Anova. Outliers were included in the analysis unless an instrumental or analytical reason was determined to remove a data point.

3.4. Health Benchmarks

The concentrations calculated from the monitored data were compared to acute noncancer and chronic cancer and noncancer inhalation health benchmarks.

An inhalation health benchmark (IHB) is the concentration of a chemical in ambient air, at or below which the chemical is unlikely to cause an adverse health effect to the general public. Noncancer IHBs are used for effects other than cancer. Acute noncancer IHBs are typically compared to one-hour averaged concentrations of chemicals. However, the SATM study did not have one hour values available, so the acute IHBs were compared to 24 hour averages. Chronic noncancer IHBs were compared to the annual mean concentration of a chemical.

Cancer IHBs are based on unit risk values and the judgment that 1 additional chance in 100,000 of getting cancer in a lifetime is an acceptable risk. A unit risk value is the upper-bound additional lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 $\mu g/m^3$ in air. The cancer IHBs are calculated by dividing 1×10^{-5} by the unit risk. The cancer IHBs were compared to the annual mean concentrations of the chemicals.

The health benchmarks used in this study were derived from several sources. The primary source of benchmarks was the Minnesota Department of Health (MDH) inhalation Health Risk Values (HRVs) (5). In some cases, the HRVs have been reevaluated by MDH or they have reviewed additional chemicals and issued a Health Based Value (HBV) which supersedes the HRV.

If an HRV or HBV was not available, other sources of health benchmarks were used. The second source of benchmarks was EPA's reference concentrations and inhalation unit risks from the Integrated Risk Information System (IRIS) (6). If values from IRIS were not available, Inhalation unit risks and reference exposure levels from the California Office of Environmental Health Hazard Assessment (OEHHA) were used (7). The final source of inhalation health benchmarks was from EPA's Health Effects Assessment Summary Tables (HEAST) (8).

Pollutants that did not have an inhalation health benchmark from one of these sources were not evaluated for potential public health concerns. The health benchmark values presented here are the values from the various data sources as of August 2004. Appendix C lists the health benchmarks used in this report.

Although the absolute magnitude of the risks represented by benchmark values are uncertain and it is unknown at what exposure concentration above the inhalation health benchmark health effects will occur, the use of these values provides a standard approach to evaluate the risk of exposure to air toxic concentrations.

4. Results

The 24 hour maximum and the annual mean concentration were calculated for each chemical monitored at each location. The maximum was then compared to the acute health benchmark for each chemical. The mean was compared to the appropriate cancer and noncancer chronic health benchmarks. Concentration results for air toxics at each monitoring location are provided in Appendix D.

Acute health benchmarks were not exceeded at any of the monitoring locations. However, the SATM study was not designed to investigate areas near pollution sources where the highest concentrations are expected. Also, each monitoring sample was a 24 hour average, while the health benchmarks used by the MPCA are designed for one hour exposures. Comparing a 24 hour average to a one hour benchmark would tend to underestimate risk. In addition, the MPCA monitored only every sixth day. If the highest concentration did not occur on a day that MPCA was monitoring, it would be missed altogether. Overall, the MPCA's sample collection methods tend to underestimate short-term health risks.

Cancer risk for each air toxic was calculated by dividing the mean concentration by the cancer IHB. The result is the upper-bound estimated number of people likely to get cancer due to their exposure to that air toxic in ambient air out of 100,000 people. Cancer risks were also added together to determine the total risk of cancer at every monitoring location. Generally a risk less than 1 in 100,000 is considered acceptable.

Chronic noncancer hazard quotients were calculated by dividing the mean concentration by the noncancer IHB. If the hazard quotient is less than one, the pollutant is not expected to cause an adverse effect to human health. If the hazard quotient is greater than one, an adverse effect is possible. Noncancer hazard quotients for chemicals that effect the same organ or system can be added together to calculate a hazard index for a monitoring location. As with a hazard quotient, a hazard index below one indicates that, cumulatively, the air toxics at that location are not expected to cause an adverse effect. If a hazard index is greater than one, adverse effects due to the inhalation of ambient air toxics is possible at that location. Summaries of the risk results for each site are given in Appendix E.

No compound individually exceeded a noncancer chronic benchmark. Four compounds exceeded a cancer benchmark at one or more monitoring sites. The chemicals that exceeded cancer health benchmarks in the SATM study are listed in Table 4.1

Table 4.1: Air Toxics Exceeding a 1 in a 100,000 Cancer Risk.

Compound	Type	# of Sites Above IHB
Benzene	VOC	5
Carbon tetrachloride	VOC	23
Ethylene dibromide	VOC	7
Formaldehyde	VOC	35

Several pollutants did not exceed health benchmarks, but had a chronic noncancer hazard index greater than 0.1 or a cancer risk greater than 1 in a million at one or more monitoring sites. While these risks are below benchmarks for individual pollutants, they may contribute significantly to cumulative risk. These air toxics are listed in Tables 4.2 and 4.3.

Table 4.2: Air Toxics Exceeding a 1 in a Million Cancer Risk.

Compound	Type	# of Sites Near Health Benchmark
Benzene	VOC	30
Carbon tetrachloride	VOC	12
1,4-Dichlorobenzene	VOC	28
Ethylene dibromide	VOC	1
1,2-Dichloroethane	VOC	14
Hexachlorobutadiene	VOC	16
1,1,2,2-Tetrachloroethane	VOC	11
Tetrachloroethylene	VOC	18
1,1,2-Trichloroethane	VOC	6
Trichloroethylene	VOC	9
Acetaldehyde	Carbonyl	35

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Table 4.3: Air Toxics Exceeding a Hazard Quotient of 0.1.

Compound	Type	# of Sites Near Health Benchmark
Acetaldehyde	Carbonyl	25
Formaldehyde	Carbonyl	35
Barium	Metal	17
Chlorine	Metal	7
Manganese	Metal	1

Some pollutants were routinely detected in ambient air, but were below chronic benchmarks at all locations. These compounds are listed in Table 4.4.

Table 4.4: Air Toxics below Health Benchmarks.

Compound	Type
Methyl bromide	VOC
Chlorobenzene	VOC
Chloroform	VOC
1,2-Dichlorobenzene	VOC
Dichlorodifluoromethane	VOC
1,1-Dichloroethene	VOC
Dichloromethane	VOC
Ethylbenzene	VOC
Styrene	VOC
Toluene	VOC
1,1,1-Trichloroethane	VOC
Trichlorofluoromethane	VOC
Trichlorotrifluoroethane	VOC
Xylenes	VOC
Lead	Metal

Several compounds were routinely detected in ambient air, but do not have available approved health benchmarks. These compounds are listed in Table 4.5.

Table 4.5: Air Toxics Lacking Approved Health Benchmarks.

Compound	Type
1,3-Dichlorobenzene	VOC
Dichlorotetrafluoroethane	VOC
4-Ethyltoluene	VOC
1,2,4-Trimethylbenzene	VOC
1,3,5-Trimethylbenzene	VOC
Acetone	Carbonyl
Benzaldehyde	Carbonyl
Butyraldehyde	Carbonyl
Crotonaldehyde	Carbonyl
Propionaldehyde	Carbonyl
Bromine	Metal
Calcium	Metal
Cobalt	Metal
Iron	Metal
Molybdenum	Metal
Potassium	Metal
Rubidium	Metal
Strontium	Metal
Tin	Metal
Titanium	Metal
Yttrium	Metal
Zinc	Metal

If a pollutant was not detected at a monitoring site in at least 25% of the valid samples, the chemical was deemed to have insufficient valid data for further analysis. In a few cases, due to instrumental or other concerns, too few valid samples of a pollutant were available for statistical analysis. Table 4.6 lists the chemicals that were removed from analysis due to insufficient data.

Table 4.6: Pollutants Removed from Analysis at all Sites due to Insufficient Data above Detection Limits.

Compound	Type	Percent Above Detection Limit
1,3-Butadiene	VOC	0-2%
1,1-Dichloroethane	VOC	0-17%
1,2-Dichloropropane	VOC	0-19%
trans-1,3-Dichloropropene	VOC	0-8%
cis-1,3-Dichloropropene	VOC	0-25%
cis-1,2-Dichloroethene	VOC	0-17%
Vinyl chloride	VOC	0-4%
Antimony	Metal	9-63%*
Arsenic	Metal	0-15%
Cadmium	Metal	0-6%
Chromium	Metal	0-22%
Gallium	Metal	0-10%
Indium	Metal	0-43%*
Lanthanum	Metal	0-71%*
Nickel	Metal	0-20%
Palladium	Metal	0-4%
Phosphorous	Metal	0%
Selenium	Metal	0%
Silver	Metal	0-33%*
Vanadium	Metal	0-100%*
Zirconium	Metal	0-8%

* Antimony, indium, lanthanum, phosphorous and vanadium had too few valid samples to allow for analysis of the data.

Of these compounds, four of them have detection limits that are higher than their health benchmarks. Therefore, we can not determine definitively if the concentrations of 1,3-butadiene, arsenic, cadmium and chromium are above or below health benchmarks.

The modeling and monitoring data we have available indicates that arsenic and cadmium might have been above health benchmarks at one or more sites if lower detection rates were achievable. Concentrations of 1,3-butadiene do not appear likely to be over health benchmarks.

The health benchmark used for chromium was actually derived for chromium VI, while the MPCA monitors for total chromium. This tends to overestimate risk since chromium VI is the most toxic form for inhalation and it is unlikely that the majority of chromium is in that form. The EPA assumed that 34 percent of chromium was in the form of chromium VI in the National Air Toxics Assessment (9). California, which monitors for both total chromium and chromium VI, shows statewide averages of total chromium to be 30-50 times higher than chromium VI (10). In addition, the EPA has funded 10 Pilot Cities to monitor a handful of air toxics. Preliminary chromium results from those sites also show total chromium concentrations to be 30-50 times higher than chromium VI (11). If similar ratios are found in Minnesota, it would be unlikely that chromium VI would exceed the inhalation health benchmark at the locations monitored in the SATM study.

4.1. Air Toxics above Health Benchmarks

The following pages provide summaries of the pollutants found to be of particular concern in the SATM study.

4.1.1. Benzene

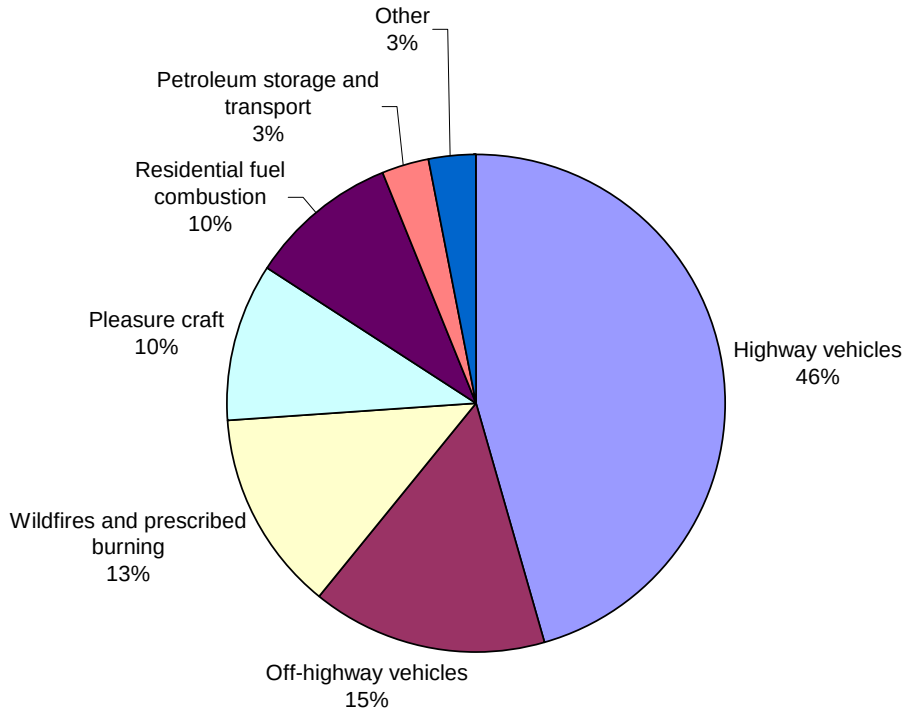
The chemical formula for benzene is C_6H_6 with a molecular weight of 78.11. It is a volatile, colorless, highly flammable liquid that dissolves easily in water.

Sources

Benzene in Minnesota comes primarily from gasoline burning highway and off-highway vehicles. Benzene occurs naturally in crude oil and is a byproduct in gasoline. In addition, aromatics such as benzene have anti-knock characteristics and are added to gasoline to increase performance. Benzene is also a combustion byproduct from wildfires, prescribed burning and woodstoves and fireplaces used in residential fuel combustion. Benzene emissions also occur from evaporation from gasoline service stations. Air around heavy traffic, gas stations or hazardous waste sites may contain higher levels of benzene. Benzene concentrations in ambient air are due primarily to the direct emissions given in Figure 4.1.1. Secondary formation of benzene is considered to be of little importance (12).

Benzene remains in the air for a few hours to a few days. It is volatile and found primarily in the air rather than soil or water. Other than workplace exposures or well contamination, people are generally exposed to benzene through breathing tobacco smoke or contaminated ambient air (13). In Minnesota, benzene is found in both rural and urban air, although concentrations tend to be higher in larger towns and cities due to increased traffic and gas station density. In 1999, 7035 short tons of benzene were directly emitted into Minnesota's air (14).

Figure 4.1.1: 1999 Direct Emissions of Benzene.



*1999 Minnesota Air Toxics Emissions Inventory

Inhalation Health Benchmarks

Acute (short-term) inhalation exposure of humans to benzene may cause drowsiness, dizziness and headaches, as well as eye, skin, and respiratory tract irritation, and, at high levels, unconsciousness. Chronic (long-term) inhalation exposure has caused various disorders in the blood, including reduced numbers of red blood cells and aplastic anemia, in occupational settings. Reproductive effects have been reported for women exposed by inhalation to high levels, and adverse effects on the developing fetus 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. EPA has classified benzene as a known human carcinogen (15).

The cancer health benchmark for benzene is a range of concentrations from 1.3-4.5 $\mu g/m^3$. The cancer benchmark addresses the potential risk of benzene causing leukemia. A range of health benchmarks exists for benzene because the health study the benchmarks were based on had two sets of exposure estimates. The higher exposure estimate resulted in the 1.3 $\mu g/m^3$ benchmark while the lower estimate resulted in the 4.5 $\mu g/m^3$ benchmark. According to EPA "The set of risk estimates falling within this interval reflects both the inherent uncertainties in the risk assessment of benzene and the limitations of the epidemiologic studies in determining dose-response and exposure data (6)." The MDH set the benzene cancer health benchmark as an HRV.

The noncancer chronic benchmark for benzene is 30 $\mu g/m^3$. The noncancer benchmark is based on a decreased lymphocyte count in the blood. The noncancer health benchmark is a reference concentration from the EPA's IRIS database.

The acute benchmark for benzene is 1000 µg/m^3 based on developmental effects. The acute benchmark is also an HRV set by the MDH.

Concentrations in Minnesota

Benzene was found at all monitoring locations in the state. The mean concentration ranged from 0.47 µg/m^3 in Holloway to 1.7 µg/m^3 in St. Paul. See Appendix D for a complete list of concentration results. The annual mean concentrations of benzene are given in Figure 4.1.2. Figure 4.1.3 shows a map of median benzene concentrations in the state. The mean concentration at five locations in Minnesota exceeded the lower range of the 1 in 100,000 cancer risk for benzene in Minnesota. The sites were Plymouth (1.3 µg/m^3), Minneapolis (1.4 µg/m^3), St. Paul (1.7 µg/m^3), International Falls (1.4 µg/m^3) and Winona (1.4 µg/m^3). All of the remaining sites exceeded a 1 in a million cancer risk.

The differences in concentrations are driven by several factors. These include the location of the monitor in the state, the size of the city being monitored, the year monitoring took place, and local sources of emissions.

Figure 4.1.2: Mean Benzene Concentrations in Minnesota (1996-2001).

This chart shows the mean concentration of benzene for the monitoring year at each site. The dot shows the mean concentration. The bars show the range where it is 95% certain that the true mean of the data falls. The sites are arranged by monitoring year: Starting with the 1996-97 monitoring year and ending with the 2000-01 monitoring year. Within each monitoring year the sites are arranged by region, starting with the Northeast Region and ending with the Twin Cities. The sites added for geographic coverage are last.

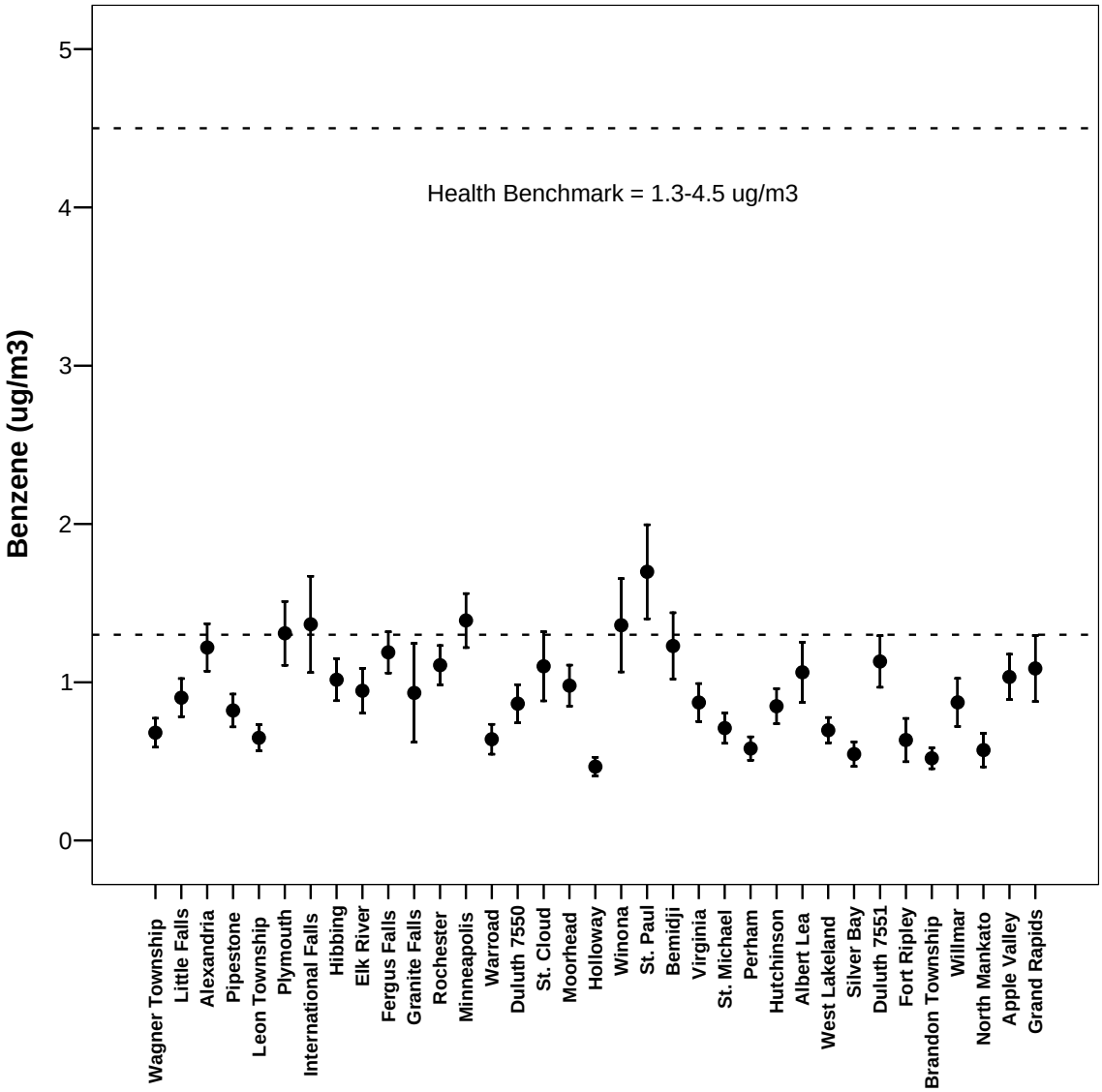
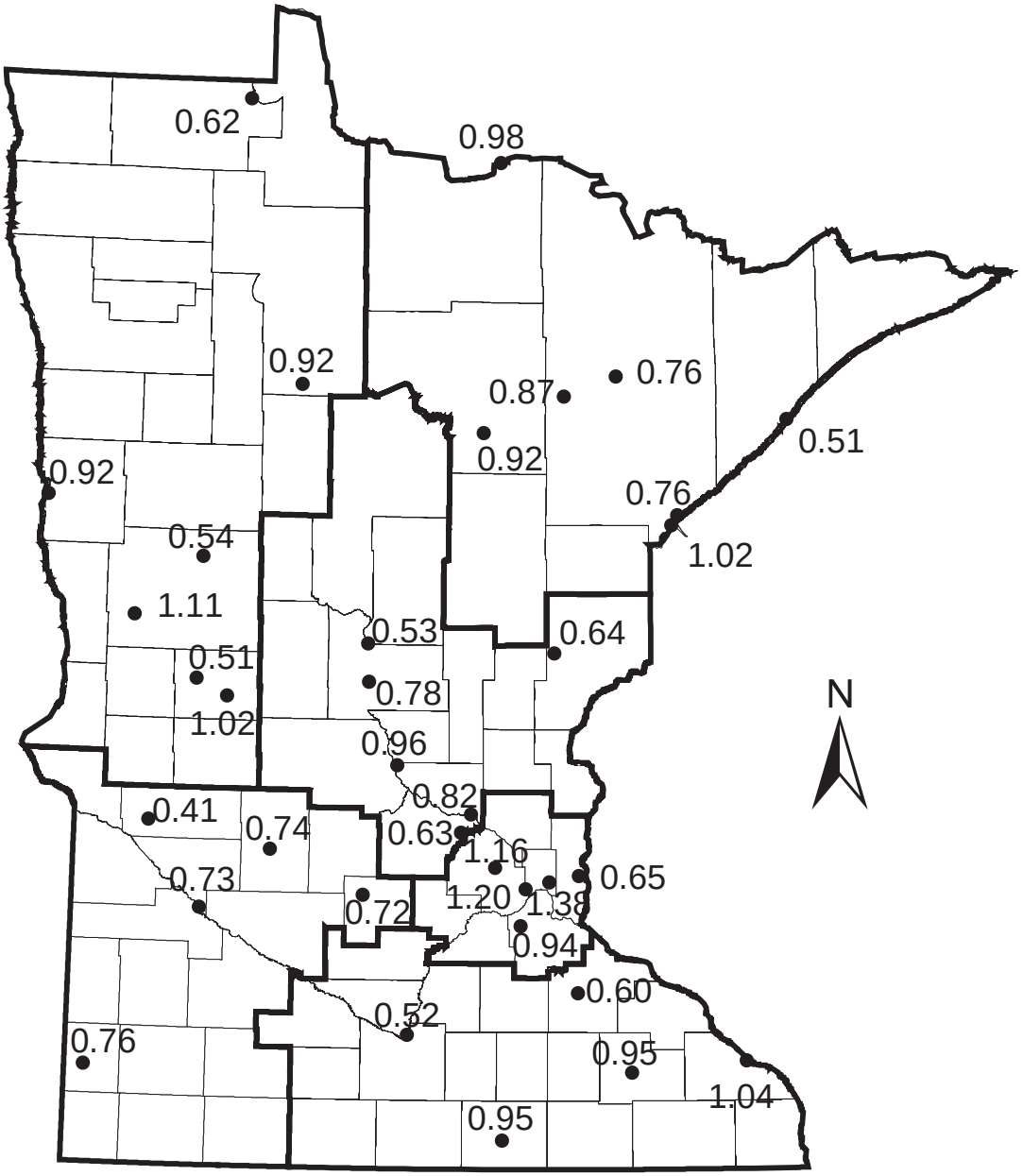
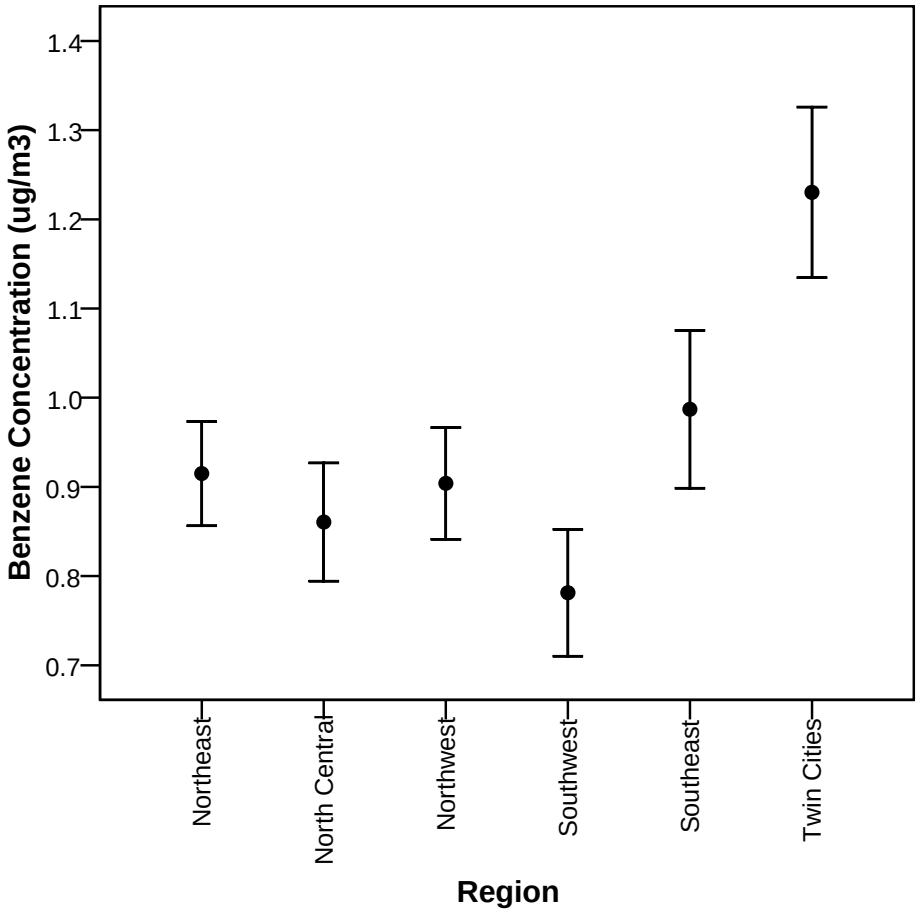


Figure 4.1.3: Median Benzene Concentrations across Minnesota (1996-2001).



The data were explored to see if there were differences between regions. The Southwest region had a lower concentration of benzene than the other locations and the Twin Cities had a higher concentration of benzene. The remaining regions were not significantly different. The regional differences are shown in Figure 4.1.4.

Figure 4.1.4: Mean Benzene Concentrations by Region (1996-2001).
The point in the middle is the mean concentration. The bars show the range where it is 95% certain that the true mean of the data falls.

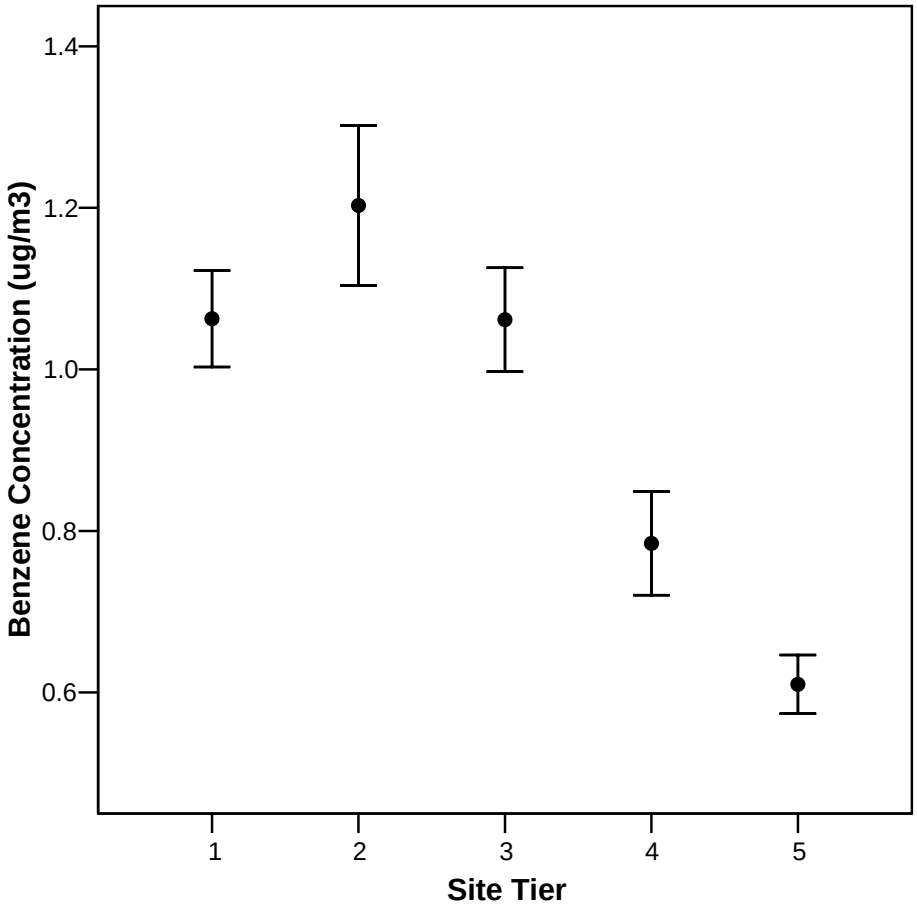


The difference in benzene concentration between regions is likely a result of population differences between regions. In general, regions with higher average populations had higher concentrations of benzene. For example, the southwest region had the lowest average population and a significantly lower benzene concentration than the other regions. In contrast, the Twin Cities region had the highest average population and the highest mean benzene concentration.

To further understand the relationship between benzene concentration and population, the benzene concentration was analyzed by tier. The lower tiers (1-3) generally include cities and townships with higher populations. Higher tiers (4-5), generally encompass very small towns and rural areas. Figure 4.1.5 illustrates that concentrations of benzene were similar in larger cities and suburban areas and significantly lower in smaller cities and rural areas.

Figure 4.1.5: Mean Benzene Concentrations by Tier (1996-2001).

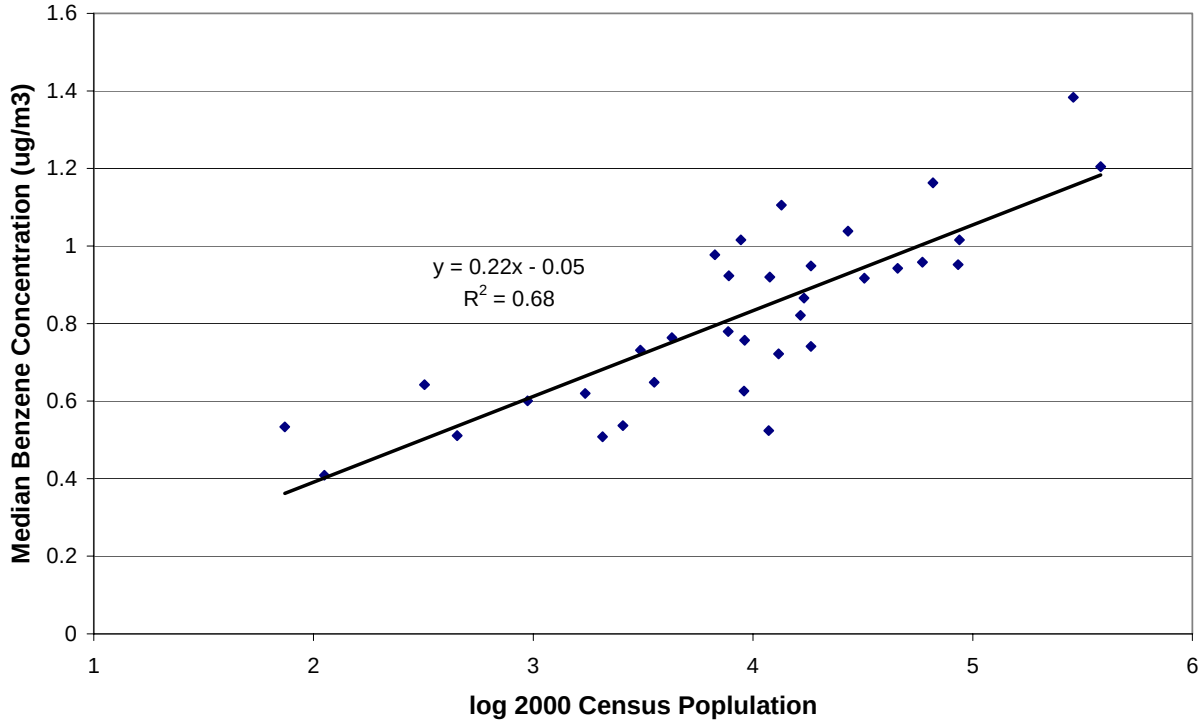
The point in the middle is the mean concentration. The bars show the range where it is 95% certain that the true mean of the data falls.



A similar concept was explored by analyzing the effect of population on benzene concentration. Benzene concentrations appeared to have a logarithmic association with population. As shown in Figure 4.1.6, the log of the population shows a good correlation with benzene concentration. There is a rapid increase in benzene concentration in cities with a population up to around 20,000. Towns above 20,000 show a much smaller rate of benzene concentration increase.

This leveling of benzene concentrations at higher populations may be due to benzene's sources. Benzene tends to primarily come from transportation sources and area sources such as gas stations. Once a monitoring site is fully surrounded by traffic and area sources of benzene, it is not as important how many other sources are in neighborhoods further from the monitoring site. This may also be an indication that the sources in the immediate vicinity of a monitor are more important than sources several miles away.

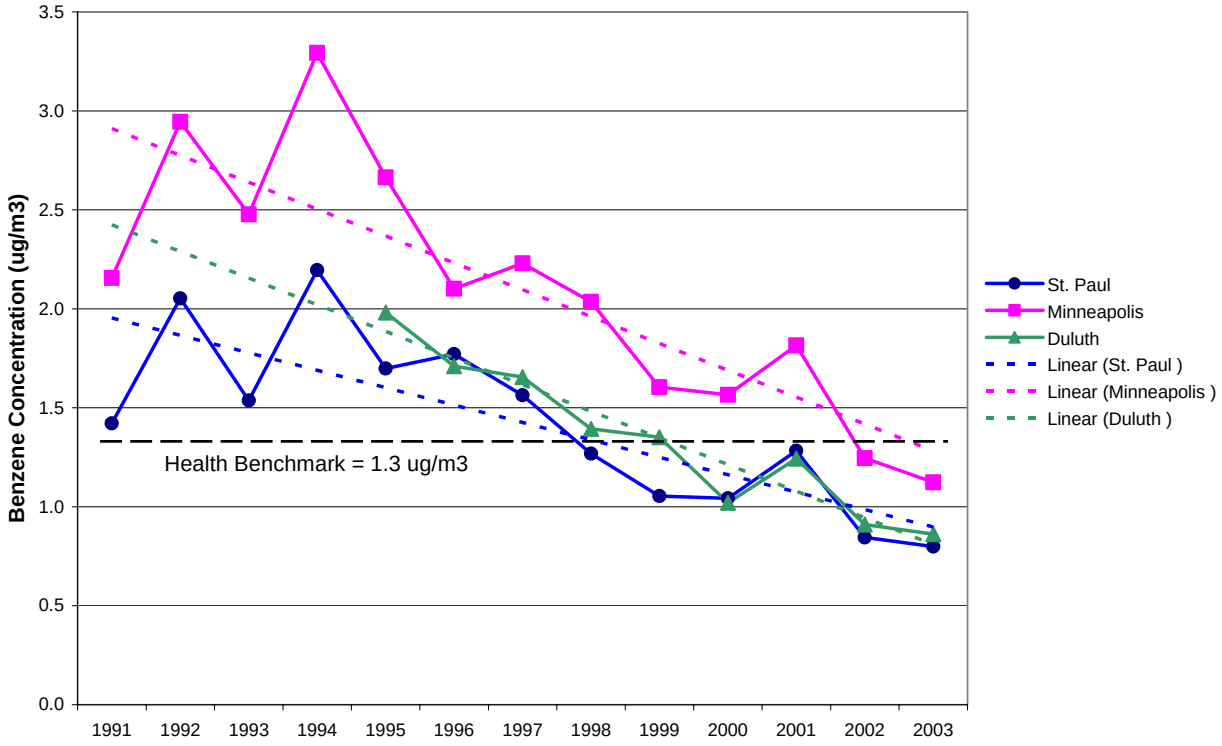
Figure 4.1.6: Median Benzene Concentrations Compared to log Population (1996-2001).



Temporal Trends

The SATM study was not set up to follow temporal trends since the sites rotated each year. However, several other monitors which were not part of the SATM study began monitoring for benzene as early as 1991. These sites are located in downtown Minneapolis, St. Paul and Duluth. All of the monitoring sites showed a downward trend in benzene concentration from 1996-2001. Benzene concentrations decreased by 0.1 µg/m^3 per year between 1996 and 2003. These trends are shown in Figure 4.1.7. By 2002, mean benzene concentrations at all of these sites were below the health benchmark.

Figure 4.1.7: Trends in Minnesota Benzene Concentrations (1991-2003).



Summary

Benzene is a known human carcinogen which is ubiquitous in the environment. It is emitted from transportation and energy sources which are found in all modern communities. Detectable benzene concentrations were found at all monitoring sites in the state. Five locations were above a one in 100,000 additional cancer risk level while the remaining sites were above a one in a million additional cancer risk level. Two of the higher sites, Minneapolis and St. Paul, were located in the most populated cities in Minnesota and the elevated concentrations were likely due to increased density of traffic and other sources. Plymouth and International Falls were both monitored in 1996 before ambient benzene levels began to decrease. Winona was high for several monitored compounds and the monitoring site may have been located near local sources. Benzene concentrations tend to be higher in larger towns and cities due to increased traffic and density of sources. Benzene concentrations have been decreasing in Minnesota since 1996 due to cleaner burning vehicle engines and decreased industrial usage.

4.1.2. Formaldehyde

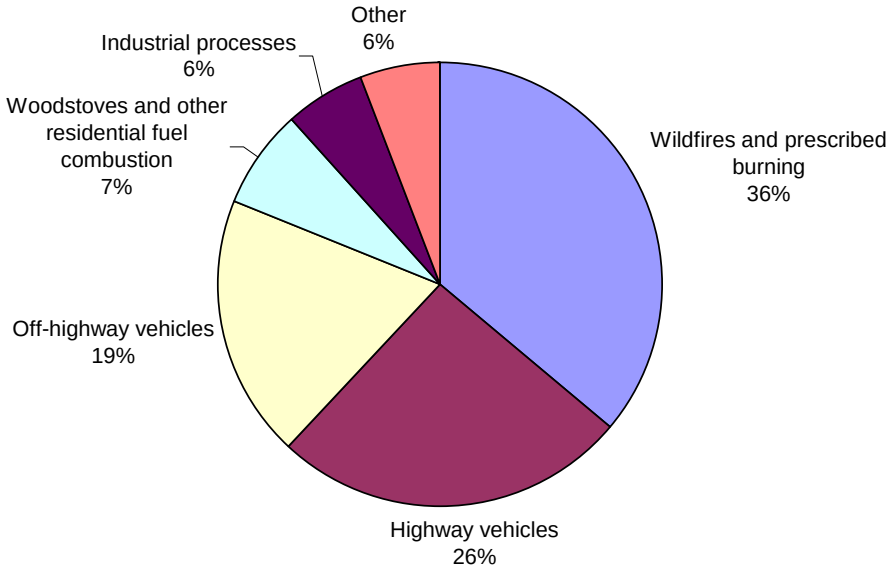
The chemical formula for formaldehyde is CH_2O with a molecular weight of 30.03. It is a colorless gas with a distinct, pungent odor at room temperature and is readily soluble in water (15).

Sources

Formaldehyde is produced both from man-made and natural sources. Burning fuels accounts for most man-made formaldehyde emissions. Formaldehyde production also occurs indirectly through the oxidation of hydrocarbons and other formaldehyde precursors. These precursors include combustion byproducts and solvent emissions. In fact, most volatile organic compounds in the atmosphere react to form formaldehyde in varying amounts and time scales (12). During the summer, indirect sources of formaldehyde can be greater than direct sources.

Direct emissions of formaldehyde in Minnesota come primarily from wildfires and prescribed burning, gasoline and diesel burning highway and off-highway vehicles, residential fuel combustion and industrial processes. Formaldehyde is used industrially to produce resins used in particleboard products and as an intermediate in the synthesis of other chemicals. In 1999, 5916 short tons of formaldehyde were released directly into Minnesota's air (14).

Figure 4.1.8: 1999 Direct Emissions of Formaldehyde.



*1999 Minnesota Air Toxics Emissions Inventory

Natural sources of formaldehyde such as forest fires, microbial products of biological processes and plant volatiles also significantly contribute to formaldehyde in ambient air (16).

Formaldehyde reacts rapidly in the air and generally breaks down in just a few hours and is probably not transported long distances. However, longer-lived formaldehyde precursors may travel to downwind locations resulting in measurable formaldehyde concentrations. People are primarily exposed to formaldehyde by breathing contaminated air (16). In Minnesota, formaldehyde is found in both rural and urban areas.

Inhalation Health Benchmarks

Acute (short-term) and chronic (long-term) inhalation exposure to formaldehyde in humans can result in respiratory symptoms, and eye, nose, and throat irritation. Limited human studies have reported an association between formaldehyde exposure and lung and nasopharyngeal cancer. Animal inhalation studies have reported an increased incidence of nasal squamous cell cancer. Recent studies also indicate a link between formaldehyde exposure and leukemia (17). EPA considers formaldehyde a probable human carcinogen (15).

The cancer health benchmark for formaldehyde is 0.8 $\mu g/m^3$. The cancer benchmark addresses the potential risk of squamous cell carcinomas of the nasal cavity. The current value was based on an EPA IRIS value and set by the MDH as an HRV. A new EPA IRIS assessment is underway in light of a 1999 Chemical Industry Institute of Toxicology analysis that supports a less conservative unit risk level on the order of 5.5×10^{-9} per $\mu g/m^3$ based on nasopharyngeal cancer (18). This value is substantially lower than the current IRIS unit risk level of 1.3×10^{-5} per $\mu g/m^3$. This new assessment is currently being reevaluated due to a recent report of a link between formaldehyde exposure and leukemia incidence (17).

The noncancer chronic benchmark for formaldehyde is 3 $\mu g/m^3$. The noncancer benchmark is based on eye, nasal, and airway irritation as well as the formation of nasal lesions. The noncancer health benchmark is a reference exposure level from California OEHHA.

The acute benchmark for formaldehyde is 94 $\mu g/m^3$ based on eye and respiratory irritation. The acute benchmark is also an HRV set by the MDH.

Concentrations

Formaldehyde was detected at all monitoring locations in the state. The mean concentration ranged from 0.85 $\mu g/m^3$ in Holloway to 2.5 $\mu g/m^3$ in Minneapolis. See Appendix D for a complete list of concentration results. The annual mean concentrations of formaldehyde are given in figure 4.1.9. Figure 4.1.10 shows a map of median formaldehyde concentrations in the state. The mean concentrations were highest in Minneapolis (2.5 $\mu g/m^3$), Grand Rapids (2.3 $\mu g/m^3$), Winona (2.2 $\mu g/m^3$), St. Paul (2.2 $\mu g/m^3$), Granite Falls (2.0 $\mu g/m^3$), and Duluth 7551 (1.9 $\mu g/m^3$). The mean formaldehyde concentration at all monitoring locations exceeded a 1 in 100,000 cancer risk level.

Figure 4.1.9: Mean Formaldehyde Concentrations in Minnesota (1996-2001).

This chart shows the mean concentration of formaldehyde for the monitoring year at each site. The dot gives the mean concentration. The bars show the range where it is 95% certain that the true mean of the data falls. The sites are arranged by monitoring year: Starting with the 1996-97 monitoring year and ending with the 2000-01 monitoring year. Within each monitoring year the sites are arranged by region, starting with the Northeast Region and ending with the Twin Cities. The sites added for geographic coverage are last.

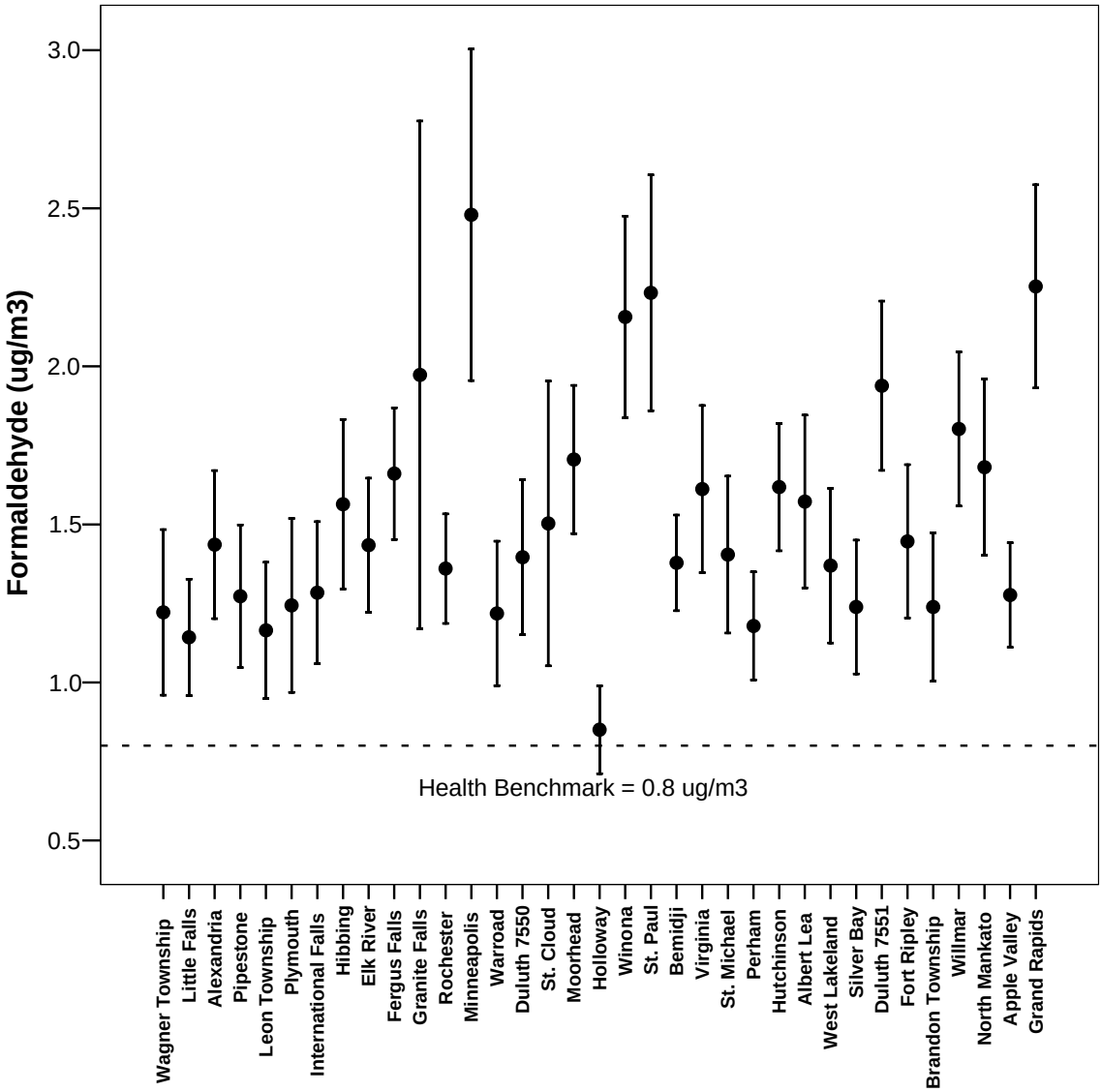
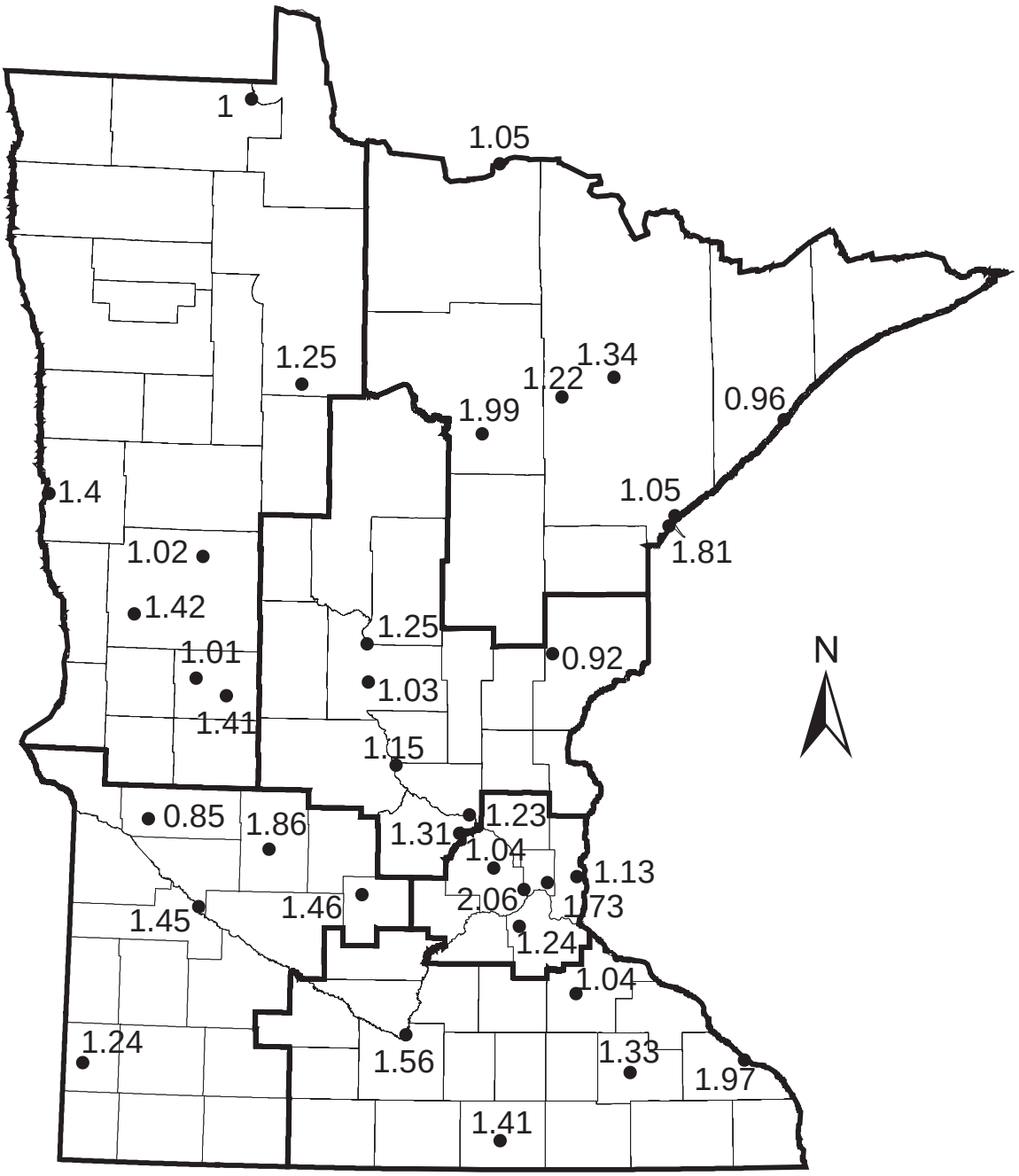
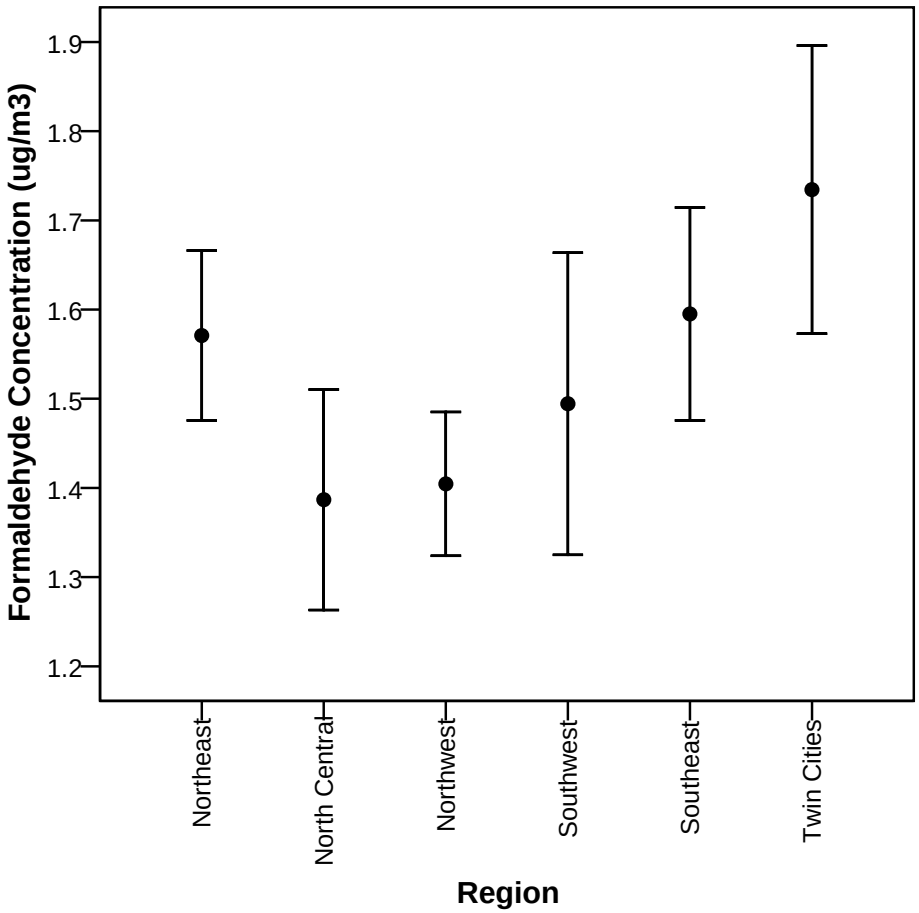


Figure 4.1.10: Median Formaldehyde Concentrations across Minnesota (1996- 2001).



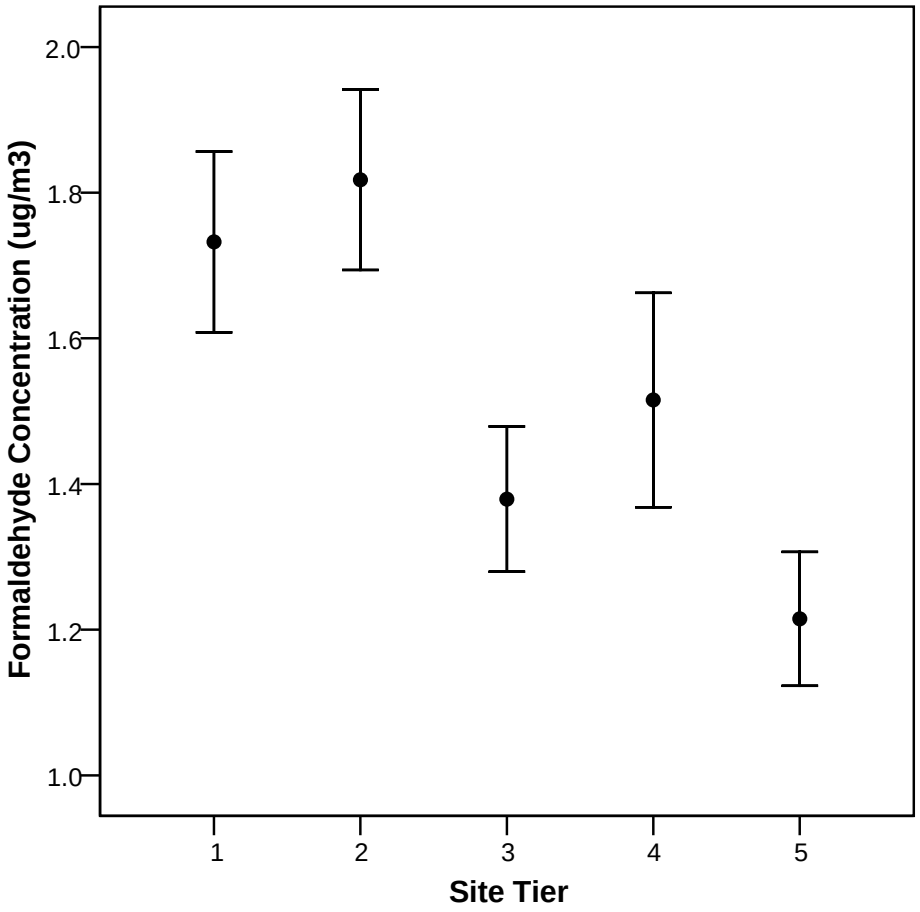
The data was explored to look for differences between regions. The Twin Cities region had a significantly higher formaldehyde concentration than the North Central region. The remaining regions were not significantly different at a 95% confidence level. The regional differences are shown in Figure 4.1.11.

Figure 4.1.11: Mean Formaldehyde Concentrations by Region (1996-2001).
The point in the middle is the mean concentration. The bars show the range where it is 95% certain that the true mean of the data falls.



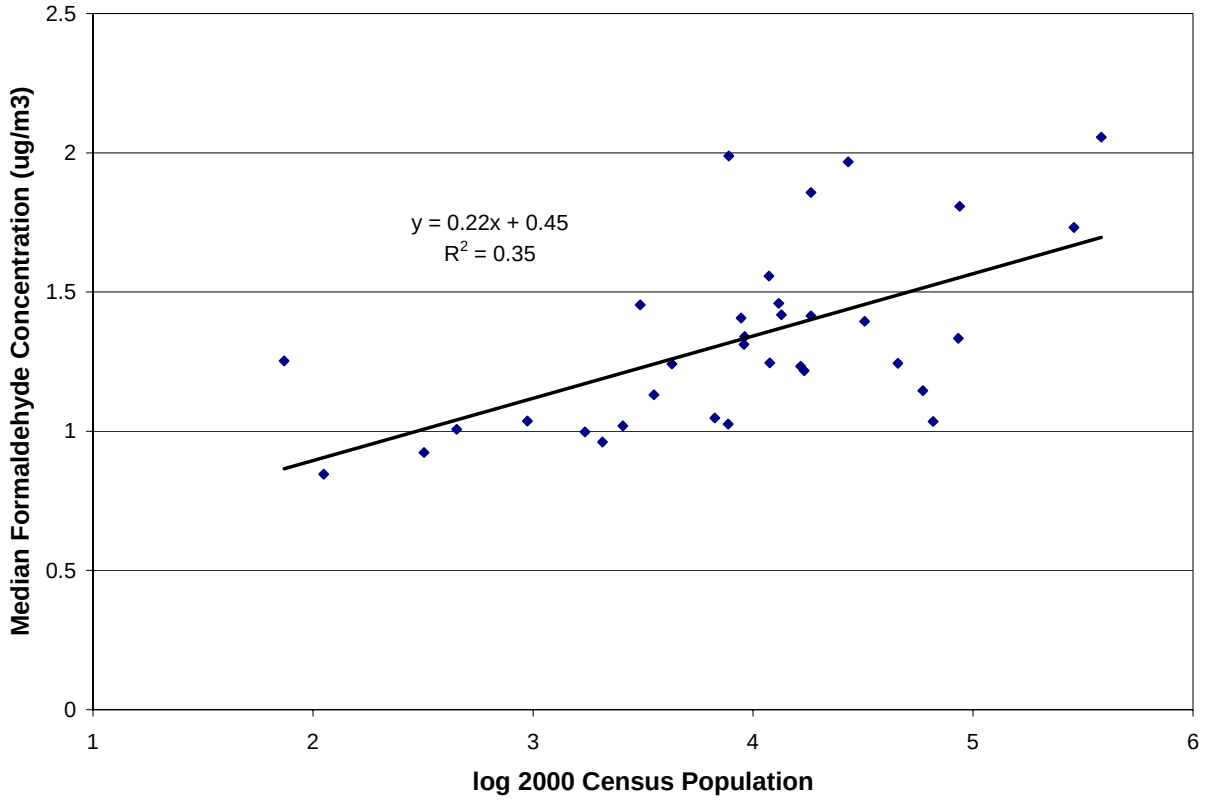
The difference in formaldehyde concentrations between regions may be due to differences in population, local sources of formaldehyde, or increased transport of formaldehyde precursors from other states. Formaldehyde concentrations were compared to population. Population contributions to concentration were explored by analyzing formaldehyde concentrations by tier. The lower tiers (1-3) generally include cities and townships with higher populations. Higher tiers (4-5), generally encompass very small towns and rural areas. Figure 4.1.12 shows significantly higher concentrations in tier 1 and 2, with significantly lower concentrations in the rural tier 5 monitoring sites.

Figure 4.1.12: Formaldehyde Concentrations by Tier (1996-2001).
The point in the middle is the mean concentration. The bars show the range where it is 95% certain that the true mean of the data falls.



The scatter plot in Figure 4.1.13 compares median formaldehyde concentrations to log 2000 census populations. The plot shows some correlation with population as the lowest concentrations are found in the most rural locations and the highest concentrations are found in Minneapolis. However, in between these extremes, the correlation is not particularly good. This may be due to the variation in sources for formaldehyde. A significant amount of formaldehyde comes from biogenic sources which would exist in both rural and urban locations. In addition, formaldehyde is a break-down product for many compounds which might be transported long distances to locations which have few local sources. In general, formaldehyde appears to be influenced by population and its accompanying increase in local sources, but concentrations may also be influenced significantly by local sources, biogenic sources and transport.

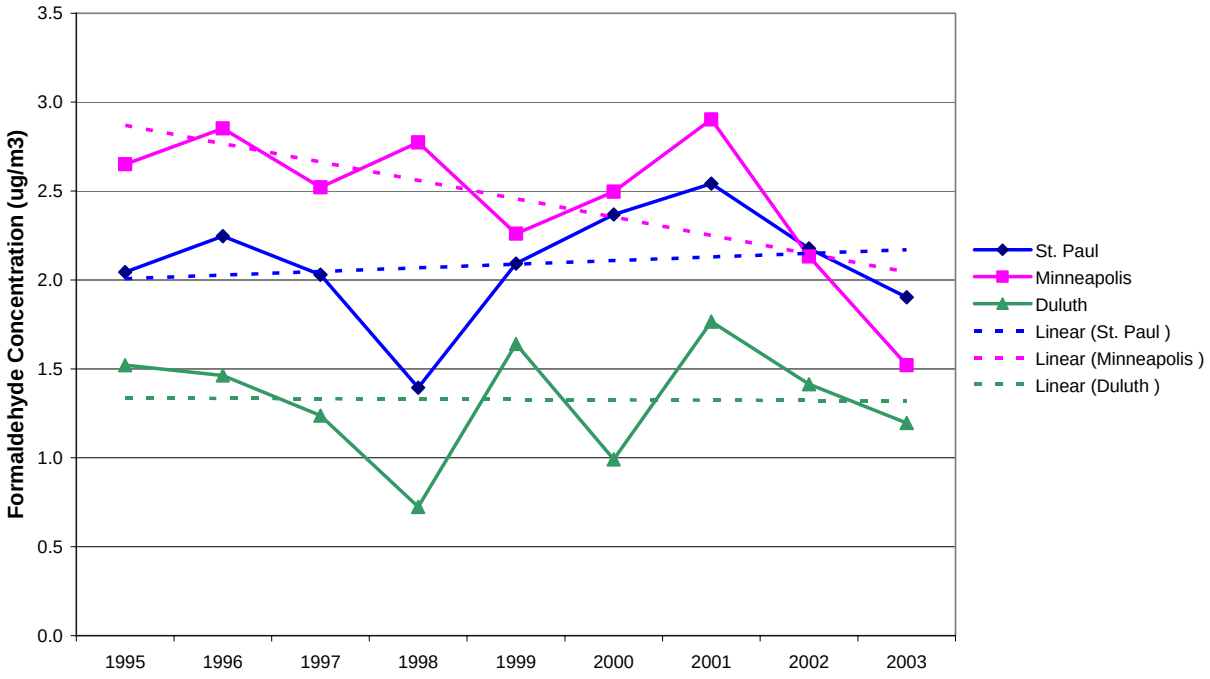
Figure 4.1.13: Median Formaldehyde Concentration Compared to log Population (1996-2001).



Temporal Trends

The SATM study was not set up to follow temporal trends since the sites rotated each year. However, several other monitors which were not part of the SATM study began monitoring for formaldehyde as early as 1991. The monitoring method changed in 1995. Data prior to 1995 cannot be compared to later data due to bias from the method change (19). The long-term sites are located in downtown Minneapolis, St. Paul and Duluth. The formaldehyde trend data is shown in Figure 4.1.14. Only the downtown Minneapolis site shows a slight downward trend. The St. Paul and Duluth formaldehyde concentrations have remained relatively constant since 1995.

Figure 4.1.14: Trends in Minnesota Formaldehyde Concentrations (1991-2003).



Summary

Formaldehyde is a probable human carcinogen which is detected at all monitors in the state. Formaldehyde poses a greater than 1 in 100,000 increased lifetime cancer risk across Minnesota. The highest concentrations were found in Minneapolis, Grand Rapids, Winona, St. Paul, Granite Falls and Duluth. The higher concentrations found in Minneapolis, St. Paul and Duluth may be due to their size as the three largest cities in Minnesota. However, Grand Rapids, Winona and Granite Falls are not particularly populous towns and are located in different regions of the state. The increased concentrations at these sites are likely due to factors other than emissions due to dense populations. Overall, formaldehyde concentrations demonstrate only a limited correlation with population size. Other factors affecting formaldehyde concentration may include local point or area sources, combustion sources, biogenic sources or transport of formaldehyde precursors. Formaldehyde has been reliably monitored in Minneapolis, St. Paul and Duluth since 1995. During that time period, concentrations have remained relatively constant.

Carbon Tetrachloride

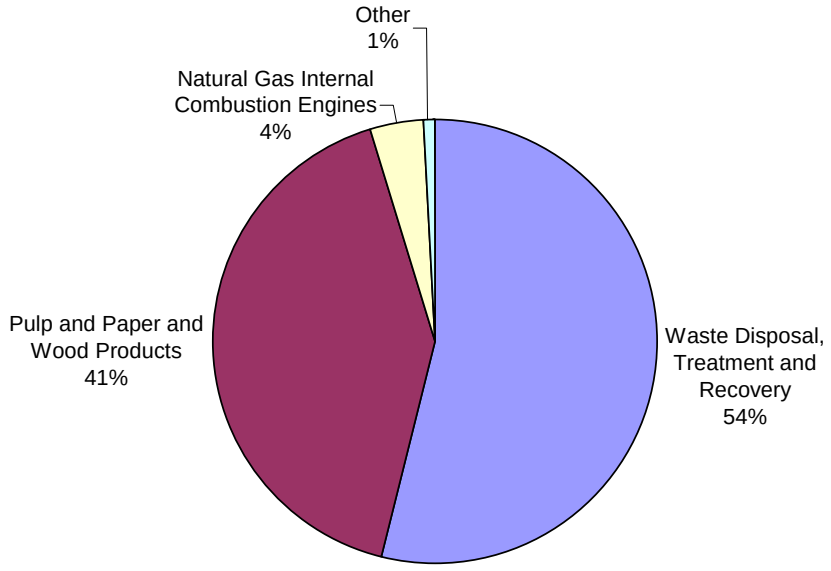
The chemical formula for carbon tetrachloride is CCl_4 with a molecular weight of 153.82. It is a clear, nonflammable liquid with a sweet odor which is almost insoluble in water.

Sources

Carbon tetrachloride primarily comes from direct emissions of man-made sources. In the past, carbon tetrachloride was used as a feedstock in the production of chlorofluorocarbons, as a solvent in cleaning fluids, as a degreaser, and as a grain fumigant. Due to its toxicity, the FDA banned the use of carbon tetrachloride in household products. In addition, carbon tetrachloride is an ozone-depleting chemical which was included in the Montreal Protocol. In accordance with the Protocol, all non-feedstock production of carbon tetrachloride was phased out in 1996. Currently, carbon tetrachloride is manufactured by a single company at two plants (20).

Since all non-feedstock production of carbon tetrachloride was phased out in 1996, the majority of carbon tetrachloride currently in the atmosphere is from past emissions. A few small sources of carbon tetrachloride remain in Minnesota. These sources include waste disposal of past stocks, the pulping process of paper production and the use of industrial natural gas internal combustion engines. In 1999, 0.8 short tons of carbon tetrachloride were directly emitted into Minnesota's air (14).

Figure 4.1.15: 1999 Direct Emissions of Carbon Tetrachloride.



*1999 Minnesota Air Toxics Emissions Inventory

Carbon tetrachloride is volatile at ambient temperatures and found primarily in the air. It is a stable compound and does not tend to break down in the troposphere. Carbon tetrachloride is generally destroyed in the stratosphere. The average total atmospheric lifetime is about 50 years. Due to its stability, carbon tetrachloride is distributed globally and low concentrations are found throughout the United States (20).

Inhalation Health Benchmarks

Carbon tetrachloride primarily affects the liver, kidneys, and central nervous system. Exposure symptoms include headache, weakness, lethargy, nausea, and vomiting. Short-term exposures to higher levels and long-term inhalation exposure to carbon tetrachloride produces liver and kidney damage in humans. Studies in animals have shown that ingestion of carbon tetrachloride increases the risk of liver cancer. EPA has classified carbon tetrachloride as a probable human carcinogen.

The cancer health benchmark for carbon tetrachloride is 0.67 $\mu g/m^3$. The current value comes from EPA's IRIS database.

The noncancer chronic benchmark is 40 $\mu g/m^3$. The noncancer benchmark is based on effects on the liver. Effects on the central nervous system and development may also occur due to carbon tetrachloride exposure. The noncancer health benchmark is a reference exposure level from California OEHHA.

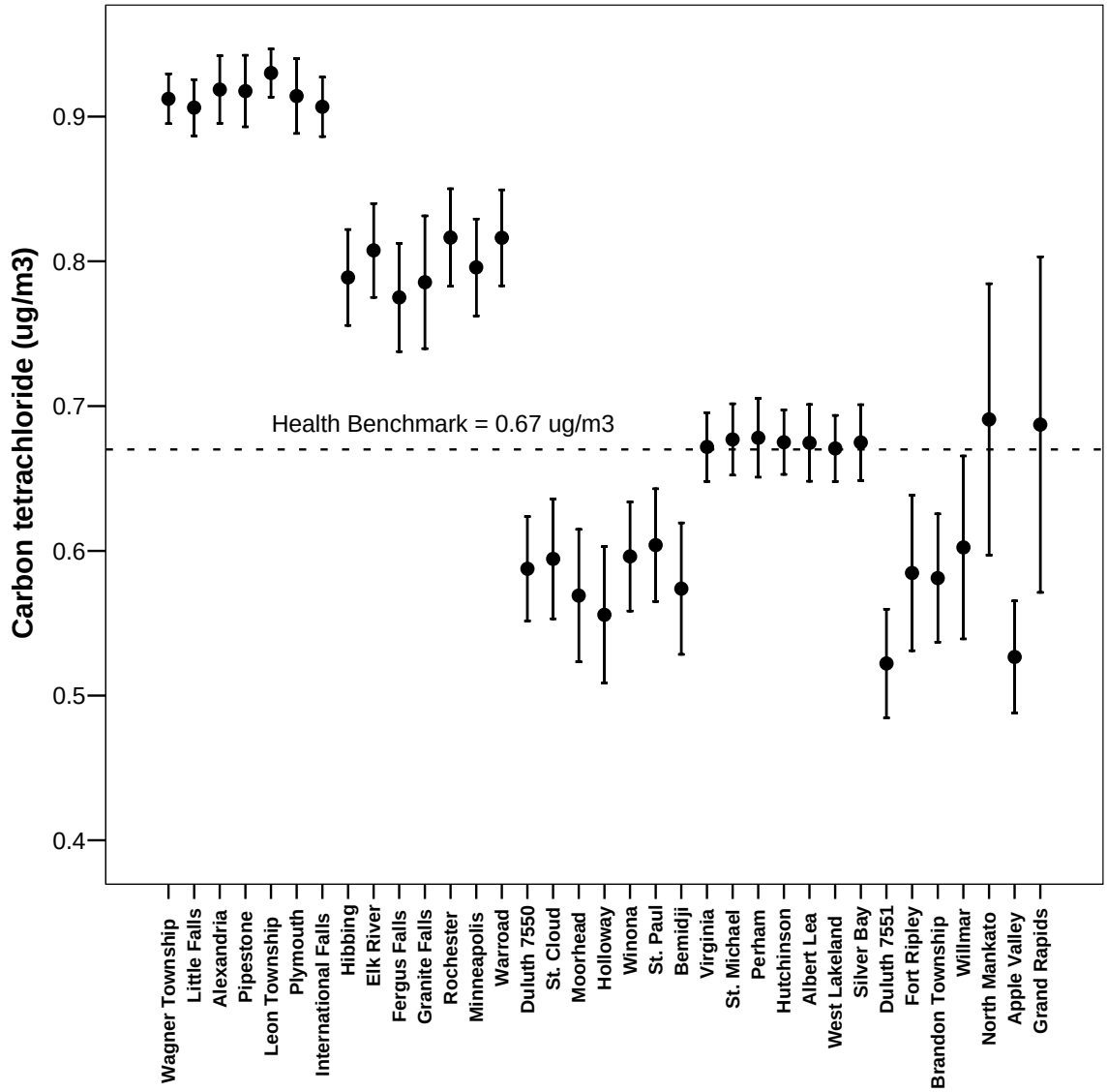
The acute benchmark for carbon tetrachloride is 1900 $\mu g/m^3$ based on developmental effects. High short-term exposures to carbon tetrachloride may also affect the liver and nervous system. The acute health benchmark is a reference exposure level from OEHHA.

Concentrations in Minnesota

Carbon tetrachloride was detected at all monitoring locations in the state. See Appendix D for a complete list of concentration results. The annual mean concentrations of carbon tetrachloride are given in Figure 4.1.16. The sites are closely grouped for each monitoring year. Only Grand Rapids and North Mankato were significantly different than Apple Valley and Duluth in the 2000-2001 monitoring year. In the other monitoring years there were no significant differences between sites. The mean carbon tetrachloride concentrations exceeded a 1 in 100,000 cancer risk level in the 1995-1996, 1996-1997, and 1999-2000 monitoring years at all monitoring locations. Grand Rapids and North Mankato also exceeded the health benchmark in the 2000-2001 monitoring year.

Figure 4.1.16: Mean Carbon Tetrachloride Concentrations in Minnesota (1996-2001).

This chart shows the mean concentration of carbon tetrachloride for the monitoring year at each site. The point is the mean concentration. The bars show the range where it is 95% certain that the true mean of the data falls. The sites are arranged by monitoring year: Starting with the 1996-97 monitoring year and ending with the 2000-01 monitoring year. Within each monitoring year the sites are arranged by region, starting with the Northeast Region and ending with the Twin Cities. The sites added for geographic coverage are last.



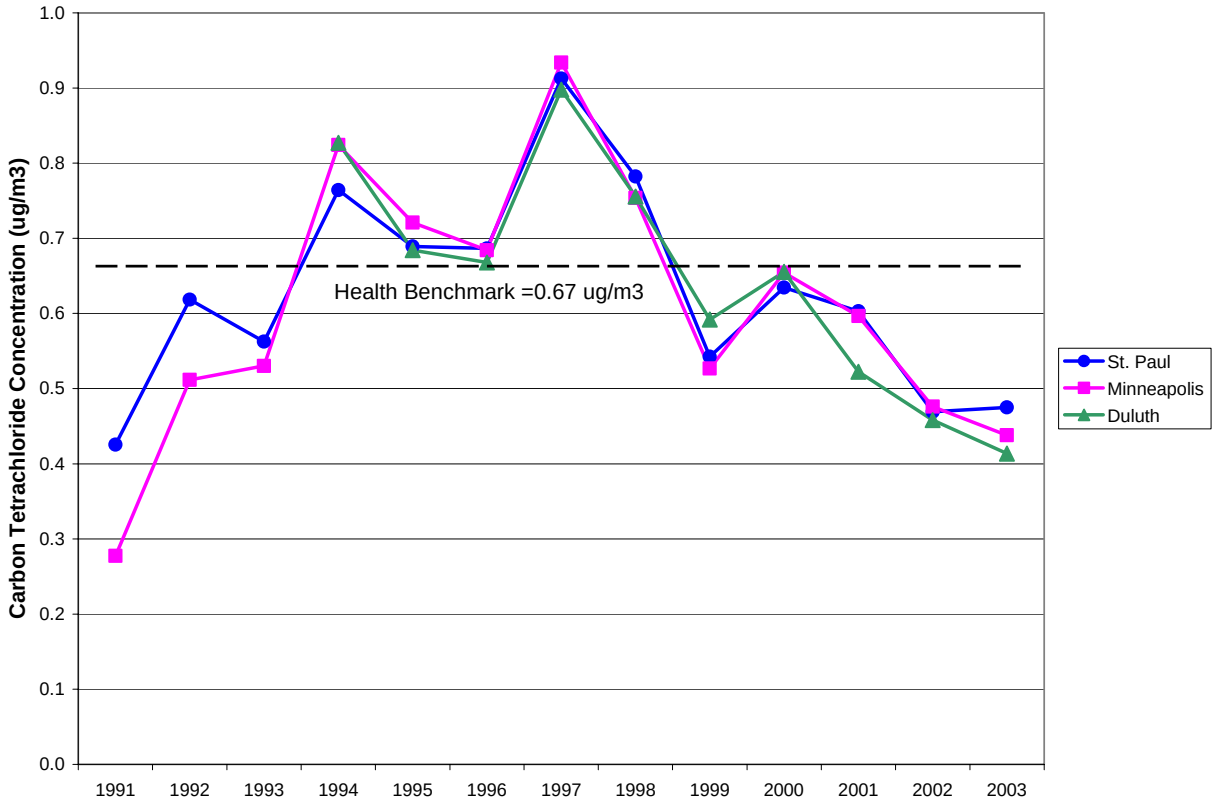
Carbon tetrachloride is expected to be well mixed globally since most production ended in 1996. There is no significant difference in concentration by population or by region in the state. The difference between sites is almost entirely driven by the monitoring year. The scatter in the 2000-2001 monitoring year may be explained by one of two factors. First, an analysis change in 2000 resulted in the detection limit changing from 0.1-0.2ug/m^3 to nearly 0.6 ug/m^3. This detection limit is close to the concentration of

carbon tetrachloride found in ambient air and may have led to more scatter in the data. Another possible explanation is a local source of carbon tetrachloride in North Mankato and Grand Rapids.

Temporal Trends

The SATM study was not set up to follow temporal trends since the sites rotated each year. However, several other monitors which were not part of the SATM study began monitoring for carbon tetrachloride as early as 1991. The long-term sites are located in downtown Minneapolis, St. Paul and Duluth. The trends for these locations are shown in Figure 4.1.17. The concentrations at the three sites are very similar as would be expected when the main source is global background. Concentrations peaked in 1997 and have gradually decreased since then. These results correspond to the 1996 phase-out of carbon tetrachloride emissions. Current concentrations are below the inhalation health benchmark.

Figure 4.1.17: Trends in Minnesota Carbon Tetrachloride Concentrations (1991-2003).



Summary

Carbon tetrachloride is a probable human carcinogen which is detected at all monitors in the state. In the past, carbon tetrachloride posed a greater than 1 in 100,000 increased lifetime cancer risk across Minnesota; however, current concentrations are below health benchmarks. Carbon tetrachloride is found at similar levels across the state since its main source is global background after the 1996 phase-out of chemical usage. Carbon tetrachloride concentrations have been decreasing in Minneapolis, St. Paul and Duluth since 1997.

Ethylene Dibromide

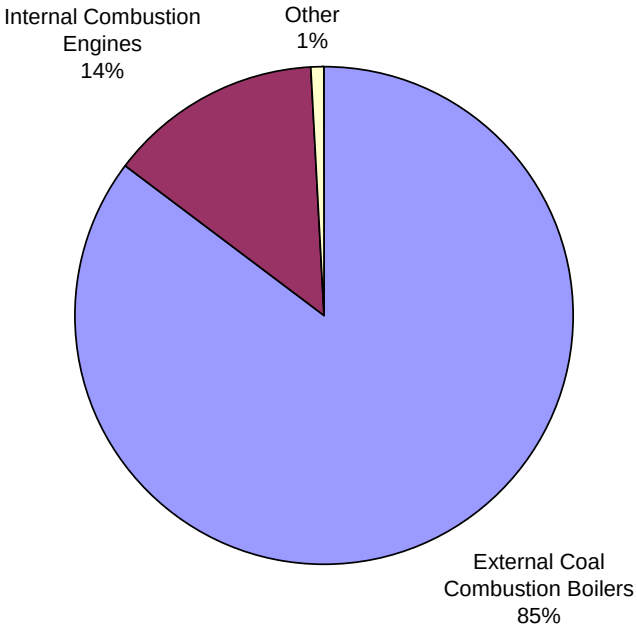
The chemical formula for ethylene dibromide is $C_2H_4Br_2$ with a molecular weight of 188. Ethylene dibromide is a volatile, colorless liquid with a mild sweet odor that is slightly soluble in water.

Sources

In the past, ethylene dibromide was used as a fumigant for citrus, grain and soil and was included as a lead scavenger in anti-knock agents in leaded gasoline. Due to its toxicity, use as a fumigant was discontinued in 1984. As leaded gasoline has been phased out, ethylene dibromide emissions have also declined. Nationally, ethylene dibromide is used as a solvent for resins, gums and waxes; as a chemical intermediate in the synthesis of dyes and pharmaceuticals; and as a precursor for vinyl chloride. Ethylene dibromide also appears to be created naturally through microalgae growth (21) (22).

In Minnesota, ethylene dibromide emissions are primarily from external coal combustion boilers and internal combustion engines. In 1999, 0.28 short tons of ethylene dibromide were emitted into Minnesota's air (14).

Figure 4.1.18: 1999 Direct Emissions of Ethylene Dibromide.



*1999 Minnesota Air Toxics Emissions

Ethylene dibromide volatilizes readily from soil and surface water. It is found as a vapor in the air and is degraded by reacting slowly with hydroxyl radicals in the atmosphere, with a half-life for this reaction of approximately 60 days. Ethylene dibromide is expected to be relatively persistent in the atmosphere.

Inhalation Health Benchmarks

Ethylene dibromide is a likely human carcinogen and reproductive toxicant. There is also limited evidence that suggest it may also have neurobehavioral developmental effects and potentially cause endocrine disruption. Some of these effects can occur at very low levels (22).

The cancer health benchmark for ethylene dibromide is 0.05 $\mu g/m^3$. The MDH set the cancer health benchmark as an HRV.

The noncancer chronic benchmark is 9 $\mu g/m^3$. The noncancer value is from the EPA's IRIS database. The noncancer benchmark is based on nasal inflammation. There is no short-term benchmark available for ethylene dibromide.

Concentrations in Minnesota

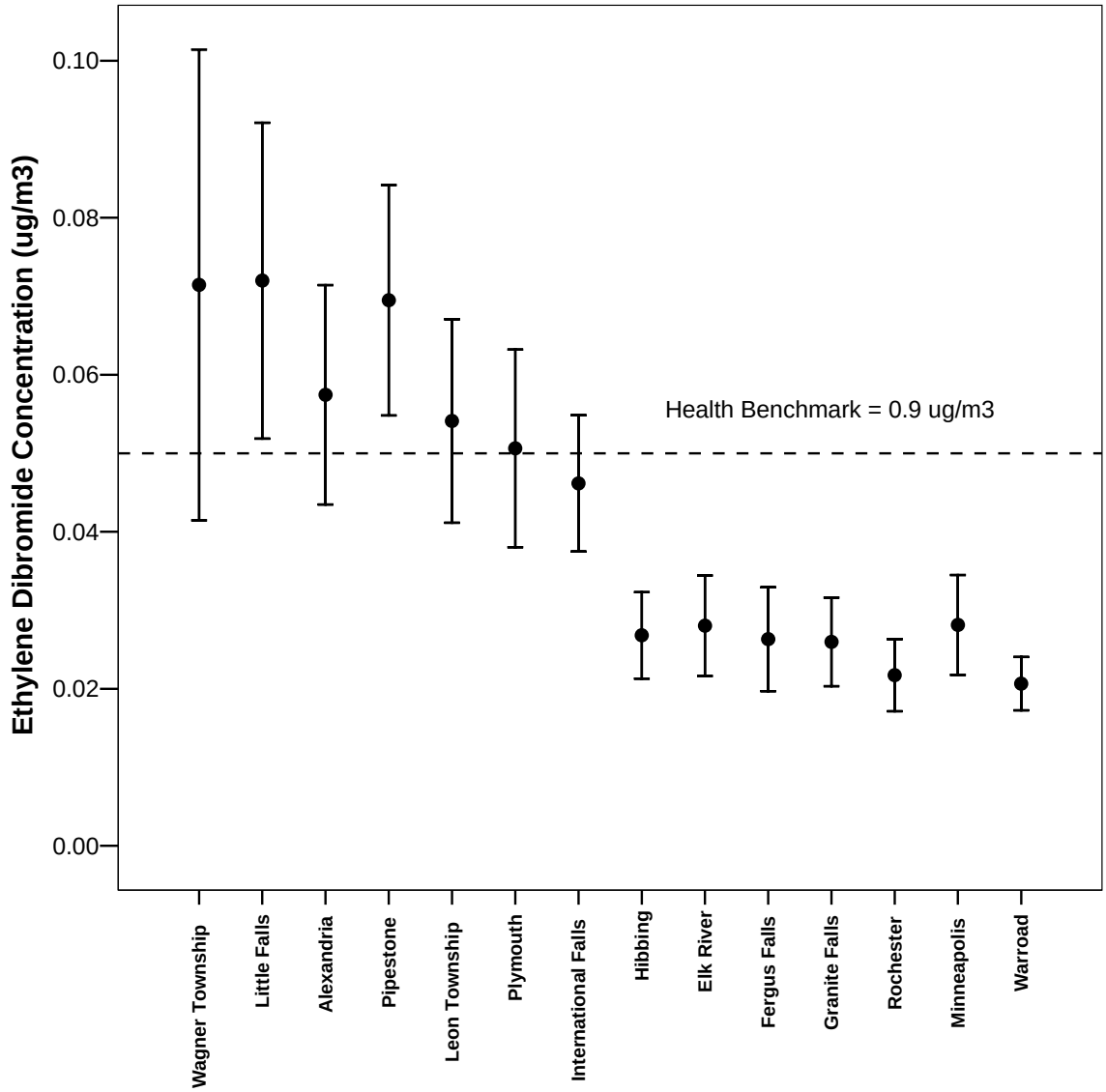
The concentration of ethylene dibromide tends to be near or below the detection limit of MPCA's analytical equipment. Only the 1996-1997 and 1997-1998 monitoring years had sufficient non-zero data to be evaluated. The 1996-1997 data had 36-55% of the data above the detection limit. The 1997-1998 data had 13-26% of the data above the detection limit. In January 1999, a new mass spectrometer went on line. The new mass spectrometer had a detection limit between 0.15-0.2 ug/m3. This detection limit was over five times higher (less sensitive) than the previous detection limit and the concentration of ethylene dibromide in Minnesota is below the detection limit. Therefore, ethylene dibromide could not be reliably quantitated after January 1999.

Figure 4.1.19 shows data for the 1996-97 and 1997-98 monitoring years. Ethylene dibromide levels appear to hover near or below the health benchmark. Since the current detection limit is 2-4 times higher than the inhalation health benchmark, we cannot definitively determine if ethylene dibromide is above or below levels of concern. There does not appear to be significant differences between sites in any given monitoring year. Changes in detection limits between years make it impossible to compare sites between years.

The electron multiplier was replaced on December 12, 1997. The older multiplier had to be run at a higher voltage than the new one. At higher voltages, there is more background noise. For compounds, such as ethylene dibromide which are near their detection limits, the higher values in the 1996-1997 monitoring year may be due to background noise.

Figure 4.1.19: Mean Ethylene Dibromide Concentrations in Minnesota (1996-1998).

This chart shows the mean concentration of ethylene dibromide for the monitoring year at each site. The bars show the range where it is 95% certain that the true mean of the data falls. The sites are arranged by monitoring year: Starting with the 1996-97 monitoring year and ending with the 1997-98 monitoring year. Within each monitoring year the sites are arranged by region, starting with the Northeast Region and ending with the Twin Cities. The sites added for geographic coverage are last.



Summary

Ethylene dibromide is a likely human carcinogen. Emission levels have lowered dramatically in the last two decades since the phase-out of leaded gasoline and its use as a fumigant. Ethylene dibromide was measured above a 1 in 100,000 additional cancer risk level at 6 out of 7 locations in the 1996-1997 monitoring year. None of the sites in the 1997-1998 monitoring year were above the inhalation health benchmark. Ethylene dibromide has rarely been seen above the detection limit since analytical changes in

1999. It is unlikely that ethylene dibromide is currently above inhalation health benchmarks, but the detection limit of 2-4 times higher than the benchmark make this impossible to determine definitively.

4.2. Air Toxics near Benchmarks

The majority of pollutants measured in the Minnesota statewide monitoring study were not above an approved health benchmark at any monitoring site. However, with every breath, people inhale hundreds of chemicals. In combination with other compounds, even pollutants below their health benchmark may pose a risk to human health. For the purposes of this study, it was assumed that pollutants with concentrations greater than one-tenth of their health benchmark might still pose a human health risk when inhaled in a mixture of other compounds.

The charts in this section show the mean concentration of the pollutants at each site. The dot shows the mean concentration over the year, while the lines give a range over which it is 95% certain that the true mean would fall. The sites are arranged by monitoring year, starting with the 1996-97 monitoring year and ending with the 2000-01 monitoring year. Within each monitoring year, the sites are arranged by region, starting with the Northeast Region and ending with the Twin Cities. The sites added for geographic coverage are last.

In some cases, changes in monitoring or analysis methodology resulted in all the data for a given year having less than 25 percent of the data above the detection limit. When an entire year was affected, this data is not included in the graph. If only a few sites had a low detection rate in a given year, they are still included for comparison purposes.

For several pollutants there is a discernable pattern of higher, more variable concentrations in the 1996-1997 monitoring year, followed by lower, less variable concentrations in the 1997-1998 monitoring year. This may be due to the electron multiplier being replaced in late 1997. The older multiplier had to be run at a higher voltage than the new one. At higher voltages, there is more background noise. For compounds near their detection limits, the higher values in the 1996-1997 monitoring year are likely due to background noise.

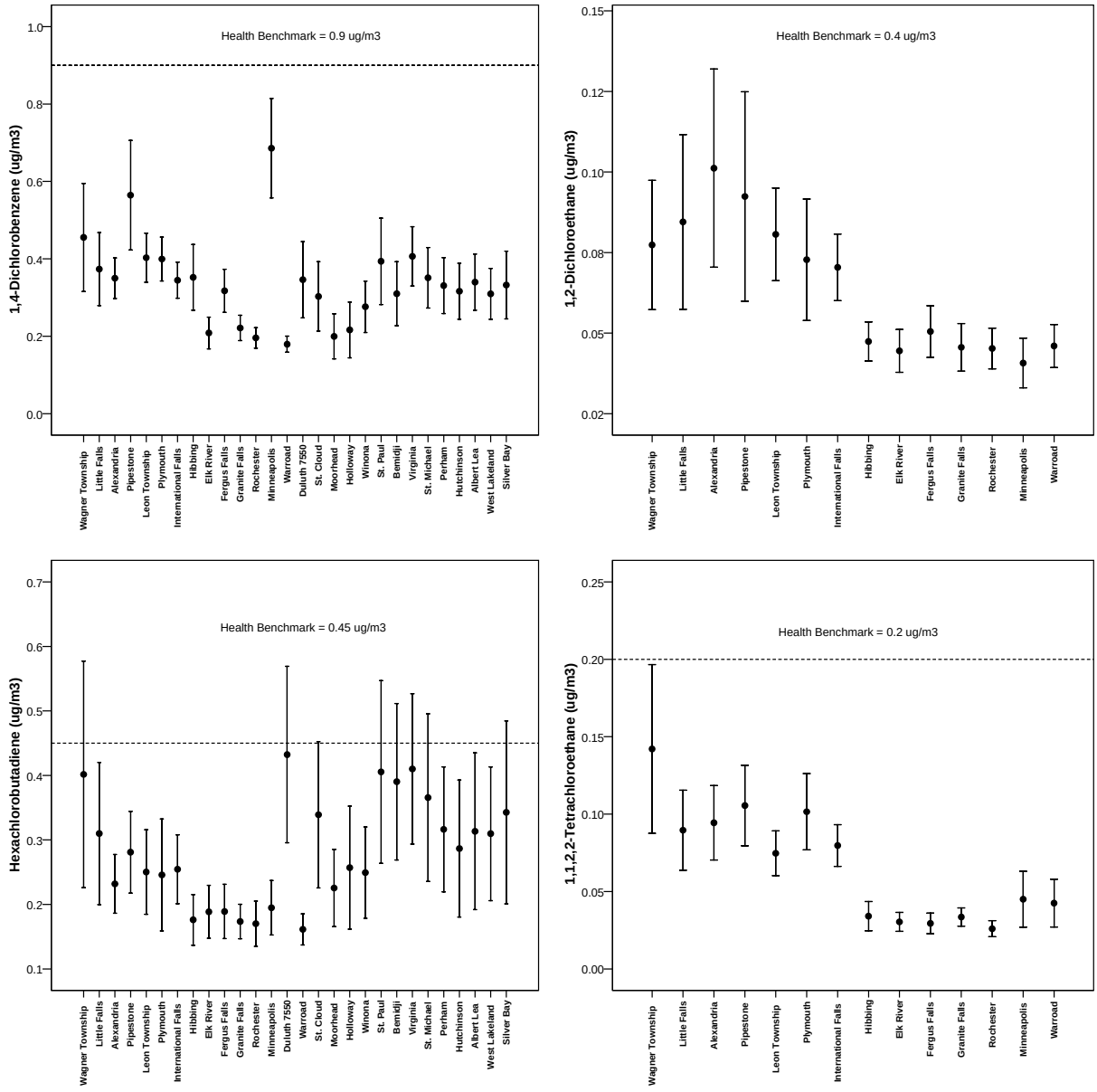
For most of these pollutants, the sites are not significantly different from one another. A few exceptions are listed in Table 4.7.

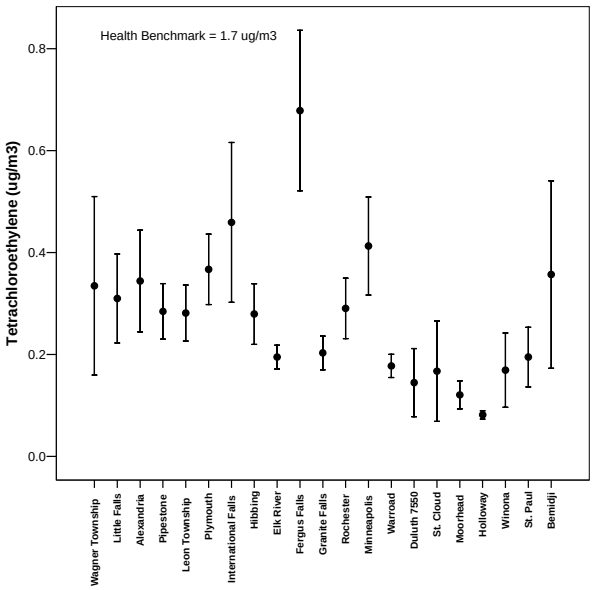
Table 4.7: Sites with Significantly Elevated Air Toxics near Benchmarks.

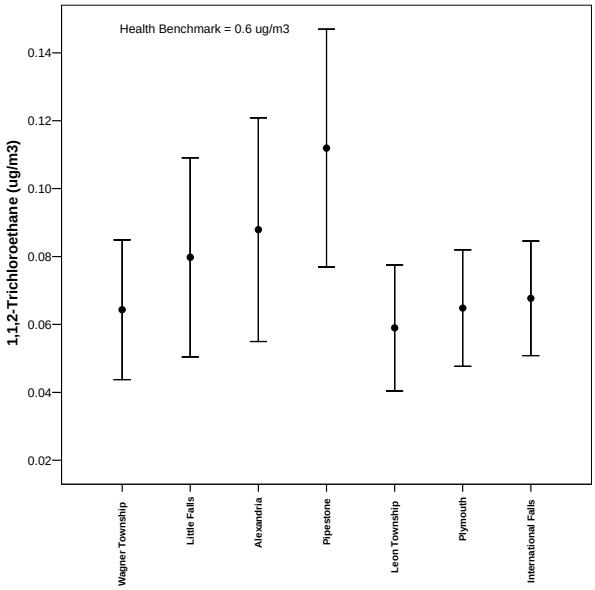
Site	Pollutants Significantly Elevated*
Minneapolis	1,4-Dichlorobenzene
Fergus Falls	Tetrachloroethylene
Virginia	Manganese
Little Falls	Trichloroethylene
Plymouth	Trichloroethylene

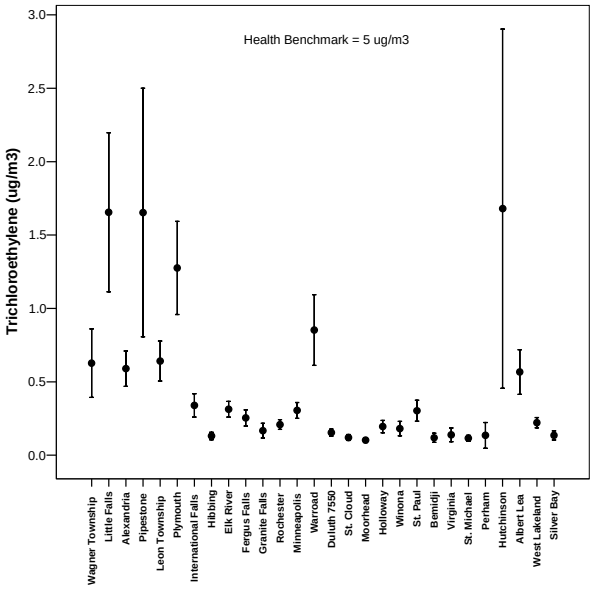
*95% confident that the concentration of pollutant at this site is higher than the concentration at most other sites monitored.

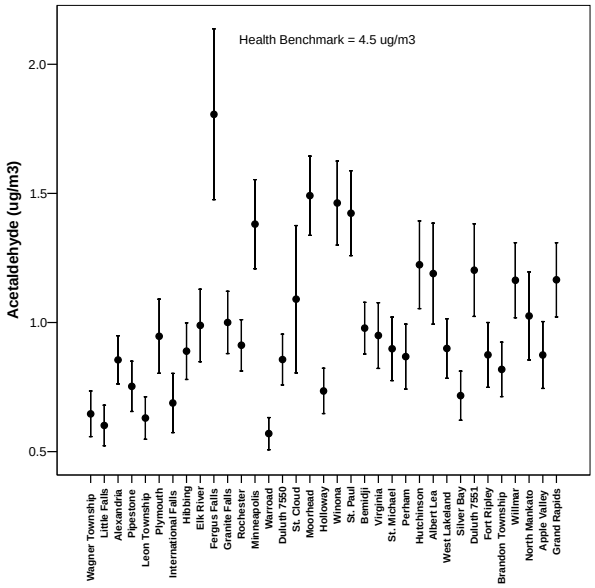
Figure 4.2: Mean Concentrations of Air Toxics near Benchmark Values in Minnesota (1996-2001).

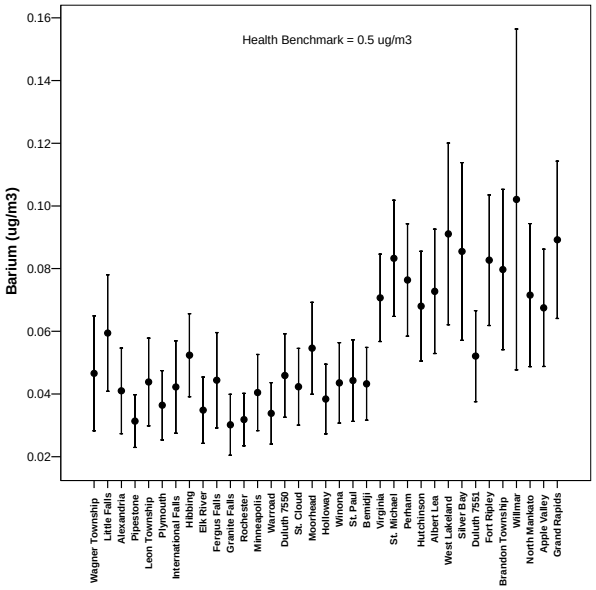


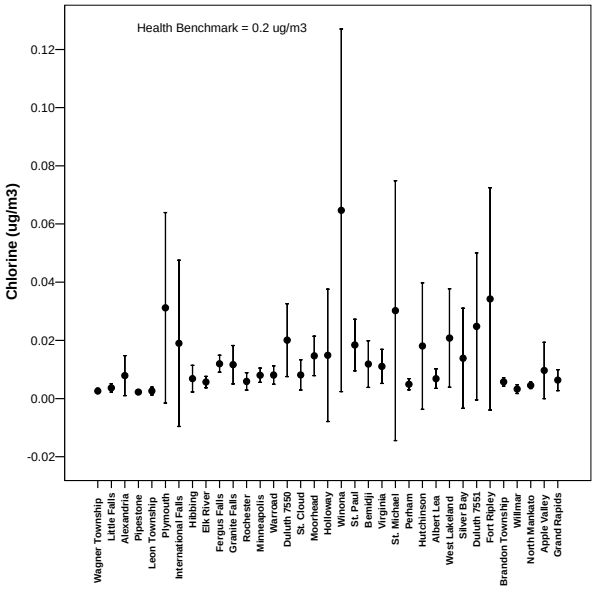

Health Benchmark = 1.7 ug/m3
Tetrachloroethylene (ug/m3)
0.0
0.2
0.4
0.6
0.8
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji

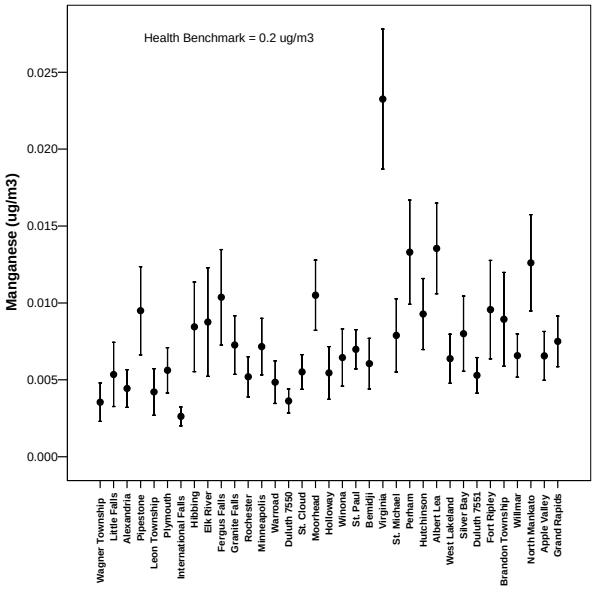

Health Benchmark = 0.6 ug/m3
1,1,2-Trichloroethane (ug/m3)
0.02
0.04
0.06
0.08
0.10
0.12
0.14
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls


Health Benchmark = 5 ug/m3
Trichloroethylene (ug/m3)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
Perham
Hutchinson
Albert Lea
West Lakeland
Silver Bay


Health Benchmark = 4.5 ug/m3
Acetaldehyde (ug/m3)
0.5
1.0
1.5
2.0
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7950
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
Perham
Hutchinson
Albert Lea
West Lakeland
Silver Bay
Duluth 7951
Fort Ripley
Brandon Township
Willmar
North Mankato
Apple Valley
Grand Rapids


Health Benchmark = 0.5 ug/m3
Barium (ug/m3)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
Perham
Hutchinson
Albert Lea
West Lakeland
Silver Bay
Duluth 7551
Fort Ripley
Brandon Township
Willmar
North Mankato
Apple Valley
Grand Rapids


Health Benchmark = 0.2 ug/m3
Chlorine (ug/m3)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
-0.02
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
Perham
Hutchinson
Albert Lea
West Lakeland
Silver Bay
Duluth 7551
Fort Ripley
Brandon Township
Willmar
North Mankato
Apple Valley
Grand Rapids


Health Benchmark = 0.2 ug/m3
Manganese (ug/m3)
0.025
0.020
0.015
0.010
0.005
0.000
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
Perham
Hutchinson
Albert Lea
West Lakeland
Silver Bay
Duluth 7551
Fort Ripley
Brandon Township
Willmar
North Mankato
Apple Valley
Grand Rapids

4.3. Air Toxics below Benchmarks

The measured concentrations of the pollutants in this section were all less than 10 percent of their available inhalation health benchmark. They would not be expected to contribute significantly to human health risk, even when inhaled with a mixture of other pollutants.

The charts in this section show the mean concentration of the pollutants at each site. The dot shows the mean concentration over the year, while the lines give a range over which it is 95% certain that the true mean would fall. The sites are arranged by monitoring year, starting with the 1996-97 monitoring year and ending with the 2000-01 monitoring year. Within each monitoring year, the sites are arranged by region, starting with the Northeast Region and ending with the Twin Cities. The sites added for geographic coverage are last.

In some cases, changes in monitoring or analysis methodology resulted in all the data for a given year having less than 25 percent of the data above the detection limit. When an entire year was affected, this data is not included in the graph. If only a few sites had a low detection rate in a given year, they are still included for comparison purposes.

For several VOCs there is a discernable pattern of higher, more variable concentrations in the 1996-1997 monitoring year, followed by lower, less variable concentrations in the 1997-1998 monitoring year. This may be due to the electron multiplier being replaced in late 1997. The older multiplier had to be run at a higher voltage than the new one. At higher voltages, there is more background noise. For compounds near their detection limits, the higher values in the 1996-1997 monitoring year are likely due to background noise.

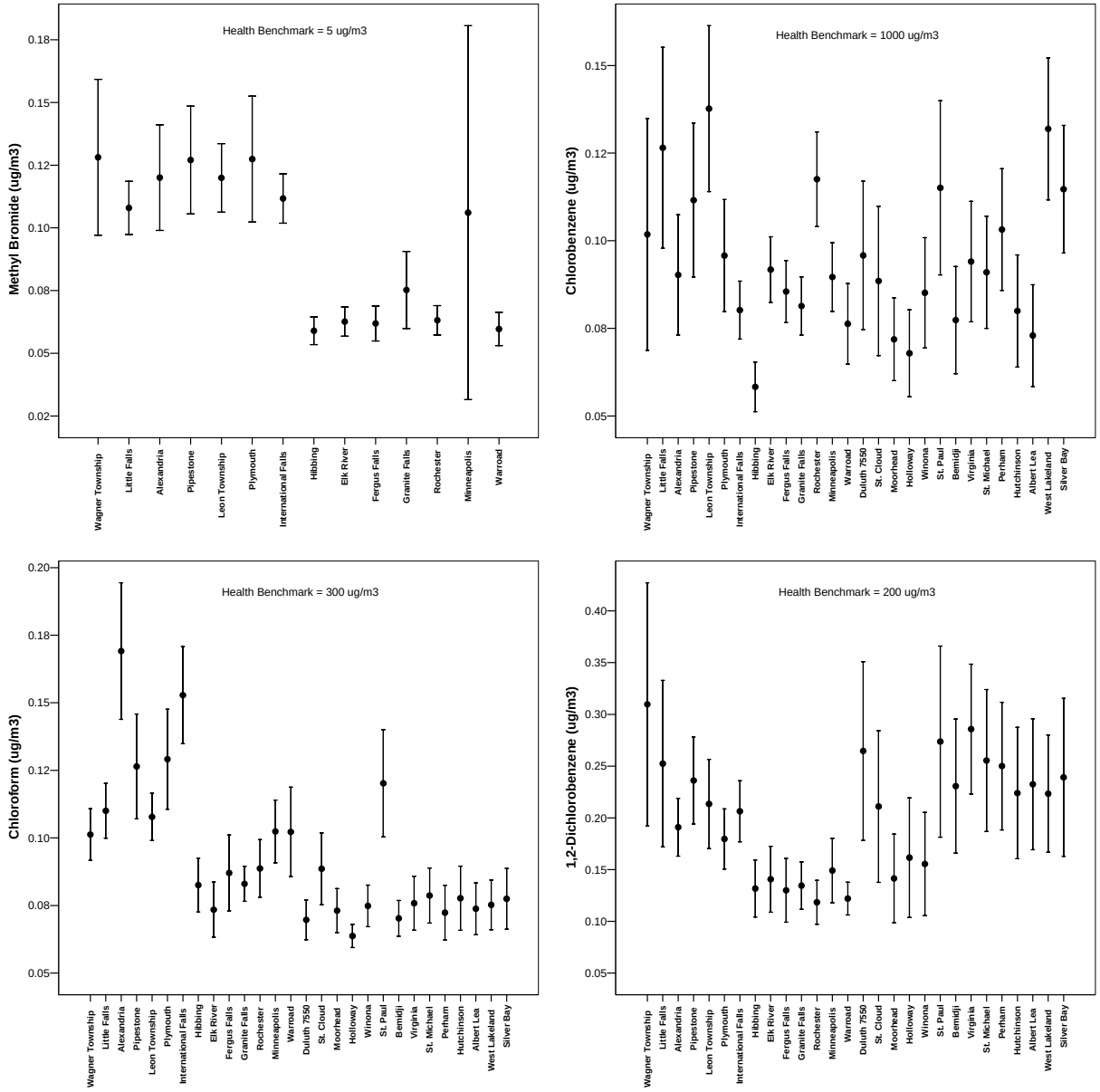
For most pollutants, the sites are not significantly different from one another. A few exceptions are given in Table 4.8.

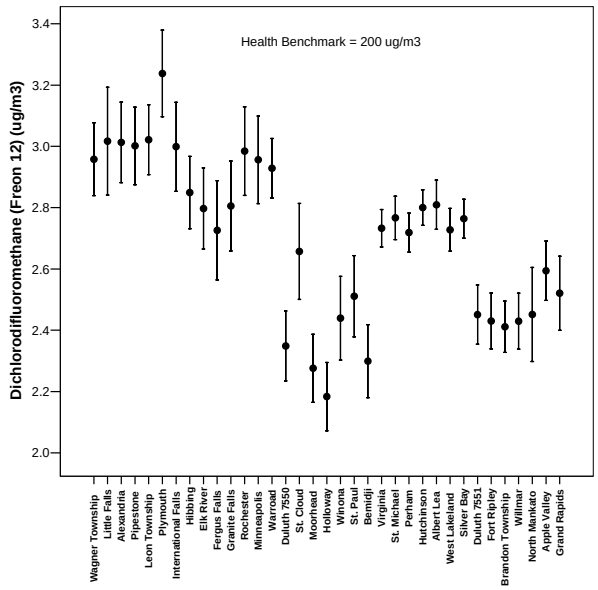
Table 4.8: Sites with Significantly Elevated Air Toxics below Benchmarks.

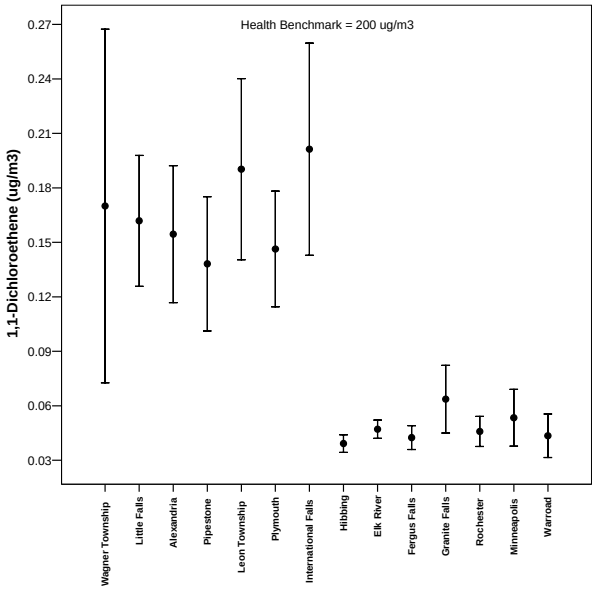
Site	Pollutants Significantly Elevated*
Alexandria	Chloroform
International Falls	Chloroform, Trichlorofluoromethane (Freon 11), Trichlorotrifluoroethane (Freon 113)
Plymouth	Dichloromethane
Minneapolis	Ethylbenzene, Xylenes
Little Falls	Styrene, Trichlorotrifluoroethane (Freon 113)
Pipestone	Styrene
St. Paul	Toluene

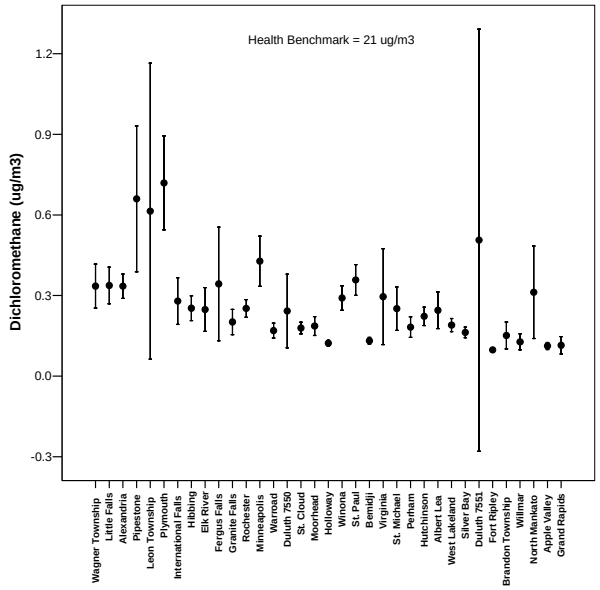
*95% confident that the concentration of pollutant at this site is higher than the concentration at most other sites monitored.

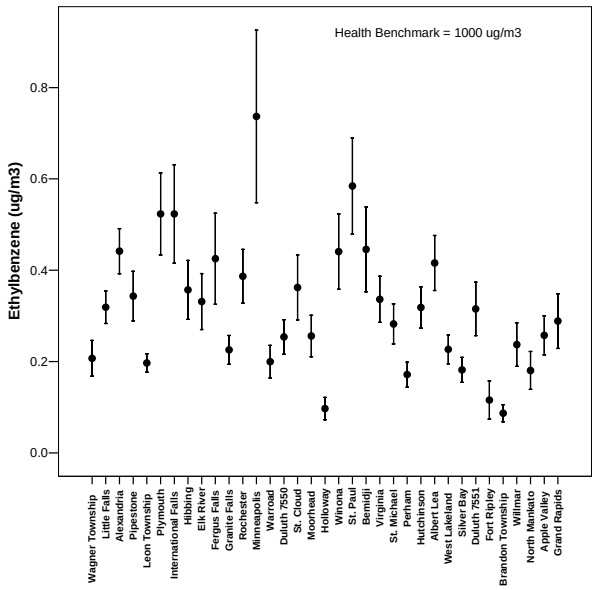
Figure 4.3: Mean Concentrations of Air Toxics below Benchmark Values in Minnesota (1996-2001).

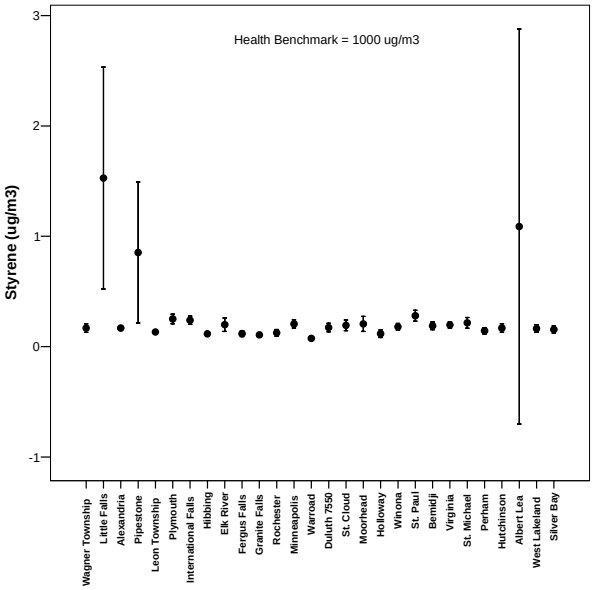


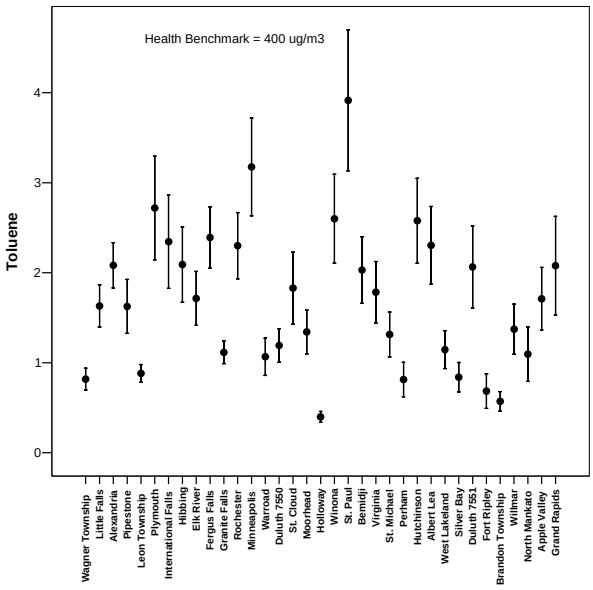

Health Benchmark = 200 ug/m3
Dichlorodifluoromethane (Freon 12) (ug/m3)
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
Perham
Hutchinson
Albert Lea
West Lakeland
Silver Bay
Duluth 7551
Fort Ripley
Brandon Township
Willmar
North Mankato
Apple Valley
Grand Rapids

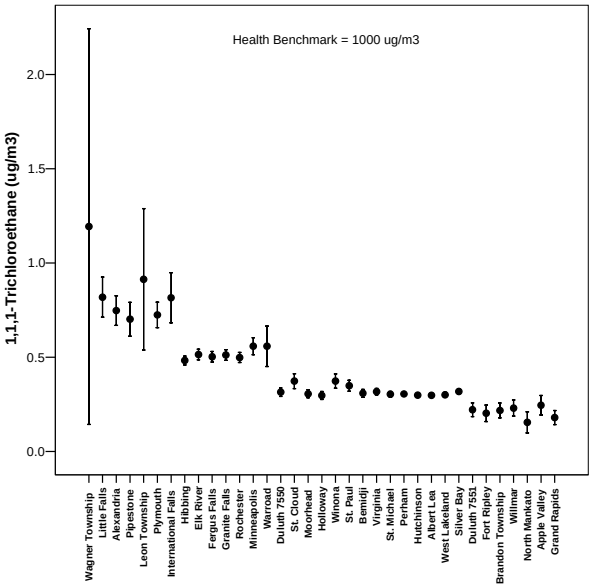

Health Benchmark = 200 ug/m3
1,1-Dichloroethene (ug/m3)
0.27
0.24
0.21
0.18
0.15
0.12
0.09
0.06
0.03
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad

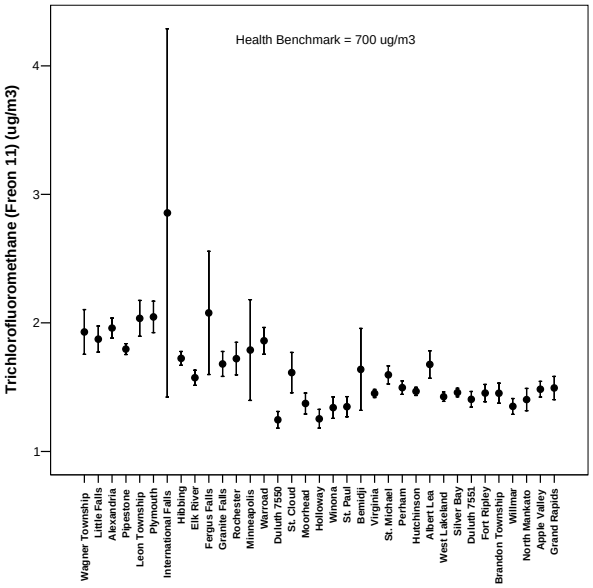

Health Benchmark = 21 ug/m3
Dichloromethane (ug/m3)
1.2
0.9
0.6
0.3
0.0
-0.3
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
Perham
Hutchinson
Albert Lea
West Lakeland
Silver Bay
Duluth 7551
Fort Ripley
Brandon Township
Willmar
North Mankato
Apple Valley
Grand Rapids

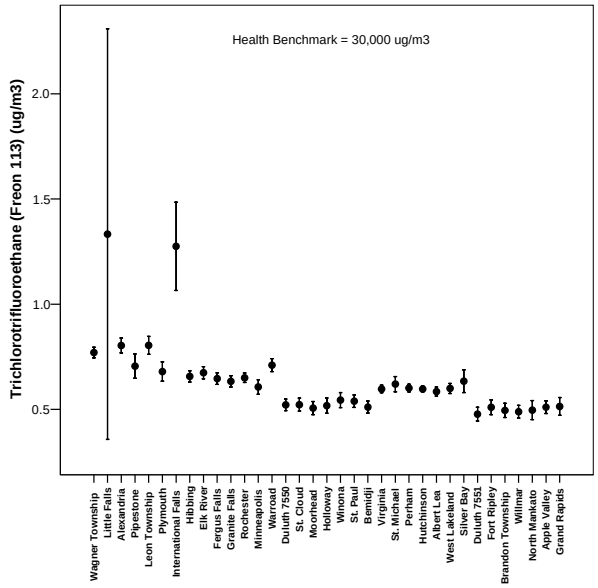

Health Benchmark = 1000 ug/m3
Ethylbenzene (ug/m3)
0.8
0.6
0.4
0.2
0.0
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
Perham
Hutchinson
Albert Lea
West Lakeland
Silver Bay
Duluth 7551
Fort Ripley
Brandon Township
Willmar
North Mankato
Apple Valley
Grand Rapids

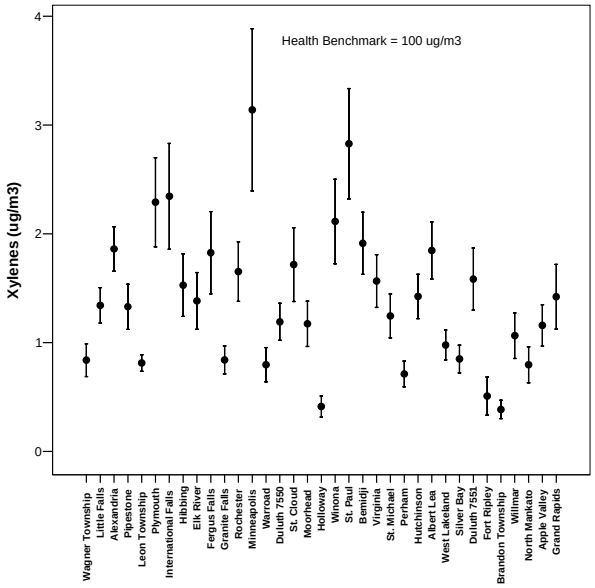

Health Benchmark = 1000 ug/m3
Styrene (ug/m3)
3
2
1
0
-1
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
Perham
Hutchinson
Albert Lea
West Lakeland
Silver Bay

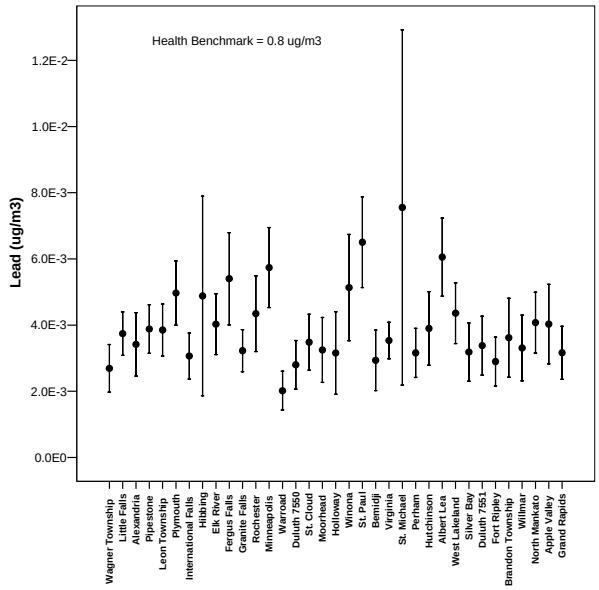

Health Benchmark = 400 ug/m3
Toluene
4
3
2
1
0
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
Perham
Hutchinson
Albert Lea
West Lakeland
Silver Bay
Duluth 7551
Fort Ripley
Brandon Township
Willmar
North Mankato
Apple Valley
Grand Rapids


Health Benchmark = 1000 ug/m3
1,1,1-Trichloroethane (ug/m3)
2.0
1.5
1.0
0.5
0.0
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
Perham
Hutchinson
Albert Lea
West Lakeland
Silver Bay
Duluth 7551
Fort Ripley
Brandon Township
Willmar
North Mankato
Apple Valley
Grand Rapids


Health Benchmark = 700 ug/m3
Trichlorofluoromethane (Freon 11) (ug/m3)
4
3
2
1
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
Perham
Hutchinson
Albert Lea
West Lakeland
Silver Bay
Duluth 7551
Fort Ripley
Brandon Township
Willmar
North Mankato
Apple Valley
Grand Rapids


Health Benchmark = 30,000 ug/m3
Trichlorotrifluoroethane (Freon 113) (ug/m3)
2.0
1.5
1.0
0.5
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
Perham
Hutchinson
Albert Lea
West Lakeland
Silver Bay
Duluth 7551
Fort Ripley
Brandon Township
Willmar
North Mankato
Apple Valley
Grand Rapids


Health Benchmark = 100 ug/m3
Xylenes (ug/m3)
4
3
2
1
0
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
Perham
Hutchinson
Albert Lea
West Lakeland
Silver Bay
Duluth 7551
Fort Ripley
Brandon Township
Willmar
North Mankato
Apple Valley
Grand Rapids


Health Benchmark = 0.8 ug/m3
Lead (ug/m3)
1.2E-2
1.0E-2
8.0E-3
6.0E-3
4.0E-3
2.0E-3
0.0E0
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
Perham
Hutchinson
Albert Lea
West Lakeland
Silver Bay
Duluth 7551
Fort Ripley
Brandon Township
Willmar
North Mankato
Apple Valley
Grand Rapids

4.4. Air Toxics Lacking Benchmarks

Many of the compounds we monitor do not have an approved health benchmark. In these cases, we cannot calculate the risk to human health. However, in general, health benchmarks have been developed for the compounds we believe are most likely to pose a risk to human health.

The charts in this section show the mean concentration of the pollutants at each site. The dot shows the mean concentration over the year, while the lines give a range over which it is 95% certain that the true mean would fall. The sites are arranged by monitoring year, starting with the 1996-97 monitoring year and ending with the 2000-01 monitoring year. Within each monitoring year, the sites are arranged by region, starting with the Northeast Region and ending with the Twin Cities. The sites added for geographic coverage are last.

In some cases, changes in monitoring or analysis methodology resulted in all the data for a given year having less than 25 percent of the data above the detection limit. When an entire year was affected, this data is not included in the graph. If only a few sites had a low detection rate in a given year, they are still included for comparison purposes.

For several VOCs there is a discernable pattern of higher, more variable concentrations in the 1996-1997 monitoring year, followed by lower, less variable concentrations in the 1997-1998 monitoring year. This may be due to the electron multiplier being replaced in late 1997. The older multiplier had to be run at a higher voltage than the new one. At higher voltages, there is more background noise. For compounds near their detection limits, the higher values in the 1996-1997 monitoring year are likely due to background noise.

For most pollutants, the sites are not significantly different from one another. A few exceptions are listed in Table 4.9.

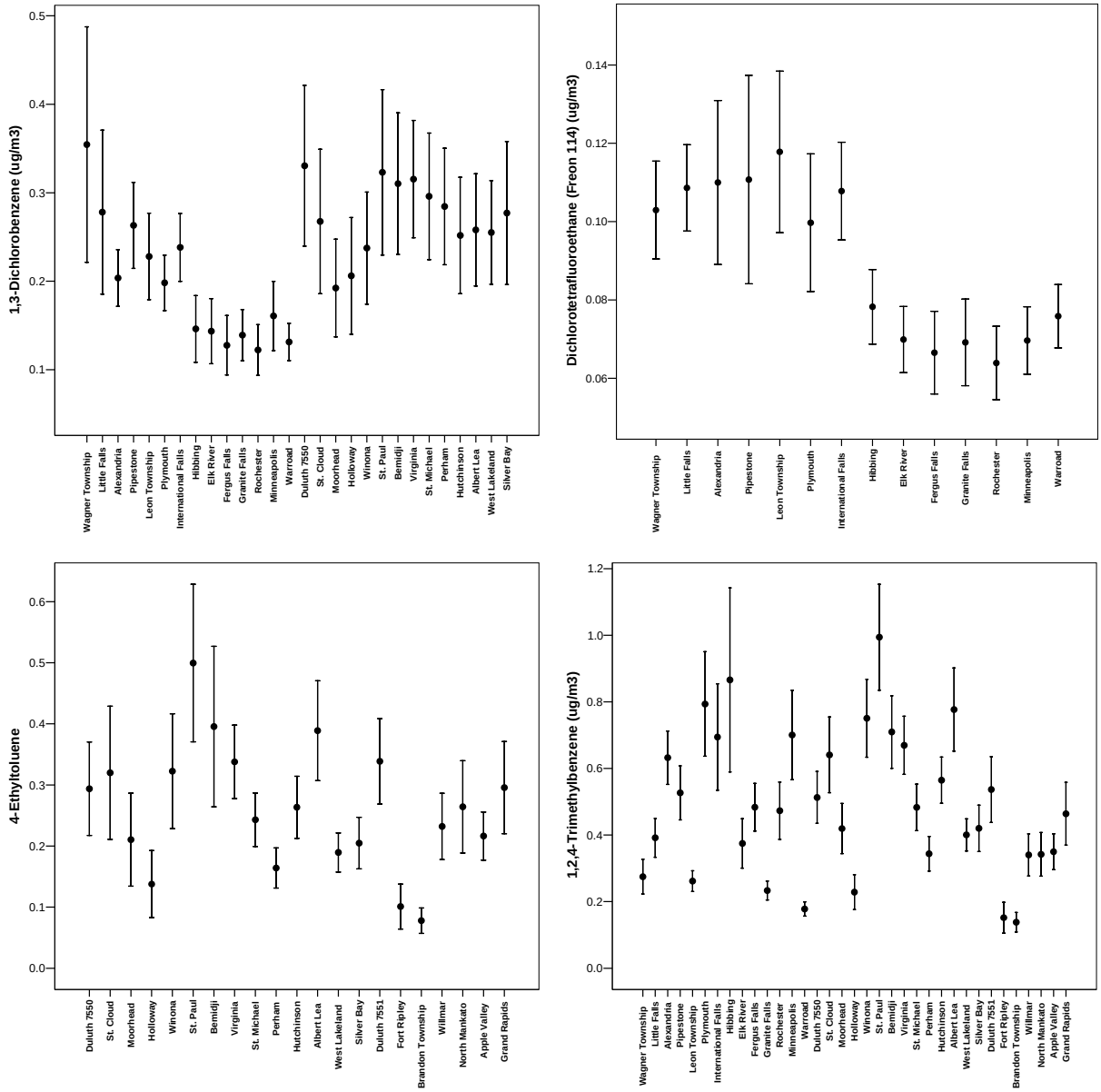
Table 4.9: Sites with Significantly Elevated Air Toxics Lacking Benchmarks.

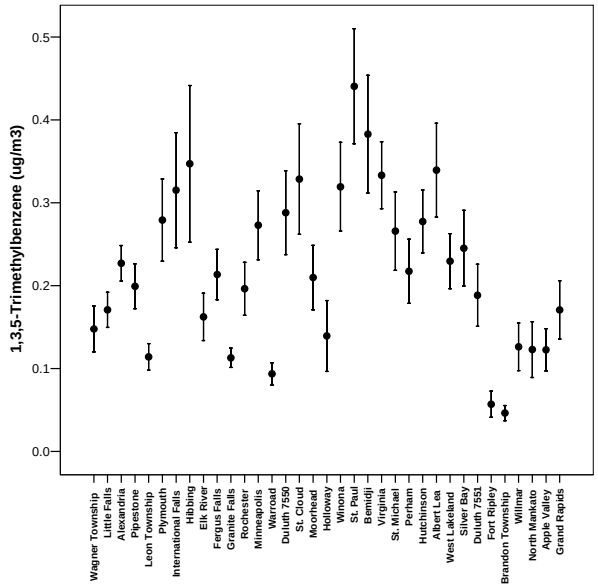
Site	Pollutants Significantly Elevated*
Hutchinson	Butyraldehyde
Albert Lea	Calcium
Virginia	Iron, Cobalt
Silver Bay	Iron, Cobalt

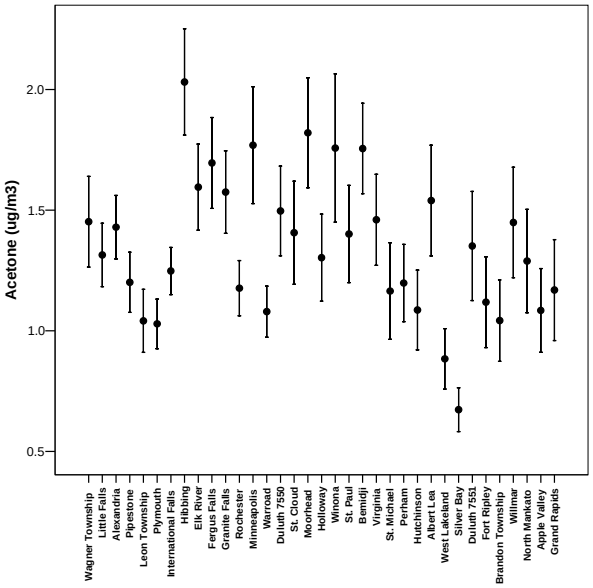
*95% confident that the concentration of pollutant at this site is higher than the concentration at most other sites monitored.

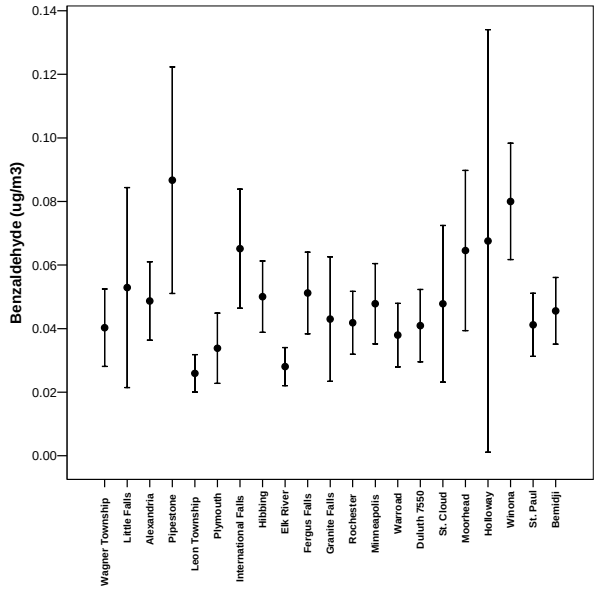
One sample day was omitted for Silver Bay. The data on April 30, 2000 was up to 70 times higher for some metals than the average day. It severely skewed the data and was removed as an outlier. It is unknown if the concentrations were actually elevated that day in Silver Bay or if the high values were a result of equipment malfunction.

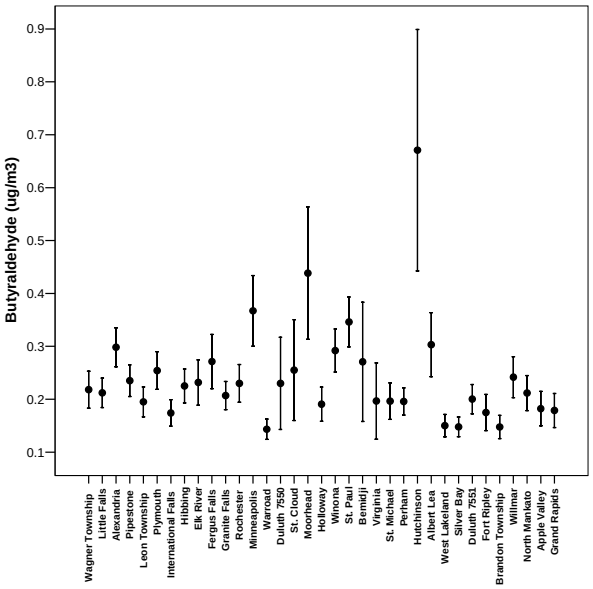
Figure 4.4: Mean Concentrations of Air Toxics Lacking Benchmark Values in Minnesota (1996-2001).

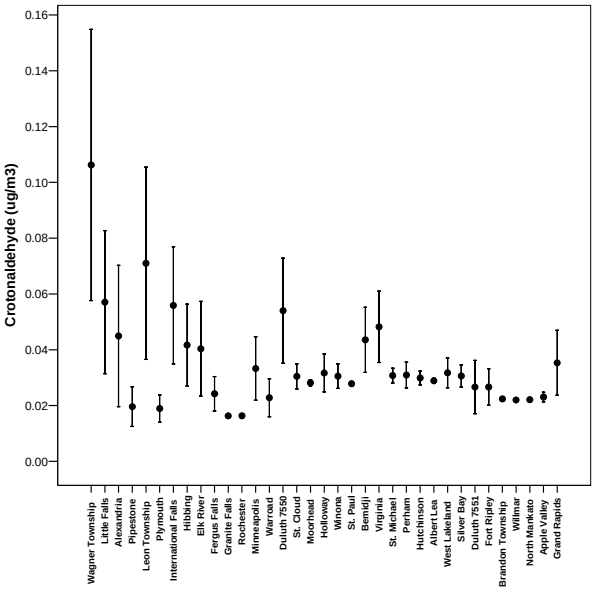


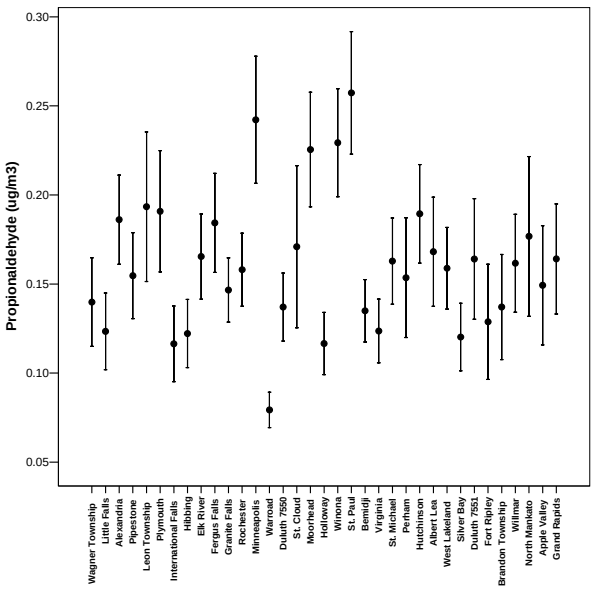

1,3,5-Trimethylbenzene (ug/m3)
0.0
0.1
0.2
0.3
0.4
0.5
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
Perham
Hutchinson
Albert Lea
West Lakeland
Silver Bay
Duluth 7551
Fort Ripley
Brandon Township
Willmar
North Mankato
Apple Valley
Grand Rapids

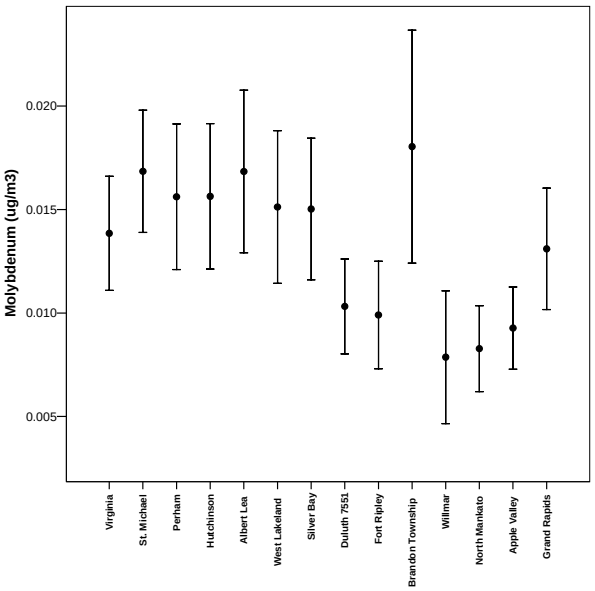

Acetone (ug/m3)
0.5
1.0
1.5
2.0
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
Perham
Hutchinson
Albert Lea
West Lakeland
Silver Bay
Duluth 7551
Fort Ripley
Brandon Township
Willmar
North Mankato
Apple Valley
Grand Rapids

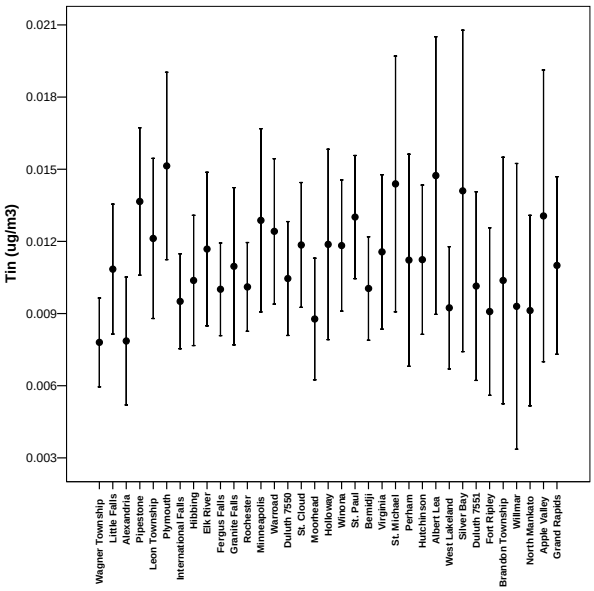

Benzaldehyde (ug/m3)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji


Butyraldehyde (ug/m3)
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
Perham
Hutchinson
Albert Lea
West Lakeland
Silver Bay
Duluth 7551
Fort Ripley
Brandon Township
Willmar
North Mankato
Apple Valley
Grand Rapids


Crotonaldehyde (ug/m3)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
Perham
Hutchinson
Albert Lea
West Lakeland
Silver Bay
Duluth 7551
Fort Ripley
Brandon Township
Willmar
North Mankato
Apple Valley
Grand Rapids


Propionaldehyde (ug/m3)
0.30
0.25
0.20
0.15
0.10
0.05
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
Perham
Hutchinson
Albert Lea
West Lakeland
Silver Bay
Duluth 7551
Fort Ripley
Brandon Township
Willmar
North Mankato
Apple Valley
Grand Rapids


Molybdenum (ug/m3)
0.020
0.015
0.010
0.005
Virginia
St. Michael
Perham
Hutchinson
Albert Lea
West Lakeland
Silver Bay
Duluth 7551
Fort Ripley
Brandon Township
Willmar
North Mankato
Apple Valley
Grand Rapids


Tin (ug/m3)
0.021
0.018
0.015
0.012
0.009
0.006
0.003
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
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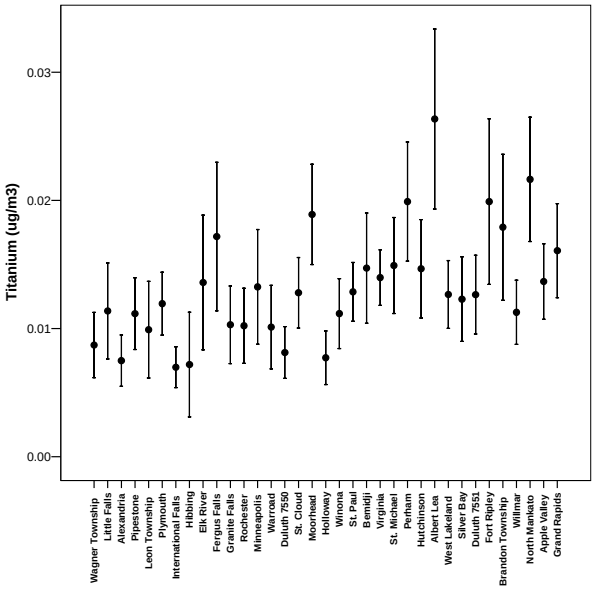
Silver Bay
Duluth 7551
Fort Ripley
Brandon Township
Willmar
North Mankato
Apple Valley
Grand Rapids


Titanium (ug/m3)
0.03
0.02
0.01
0.00
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
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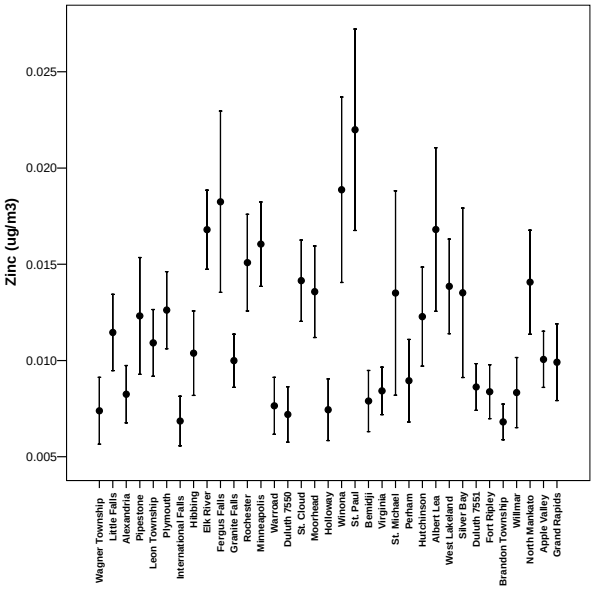
Fort Ripley
Brandon Township
Willmar
North Mankato
Apple Valley
Grand Rapids


Zinc (ug/m3)
0.025
0.020
0.015
0.010
0.005
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
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Fort Ripley
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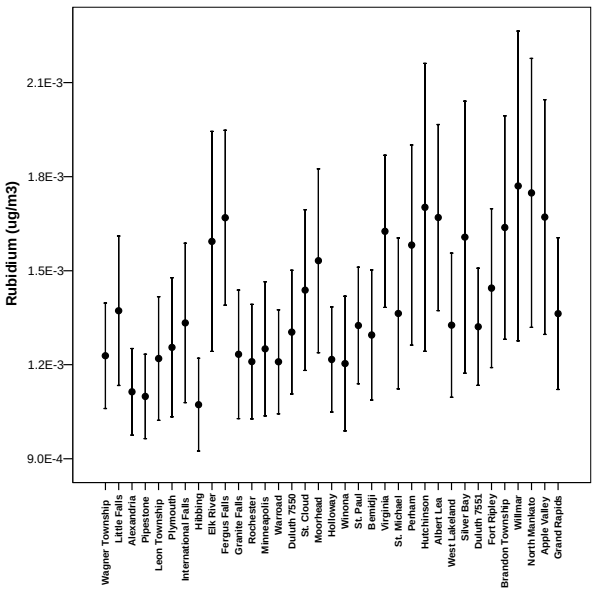
North Mankato
Apple Valley
Grand Rapids


Rubidium (ug/m3)
2.1E-3
1.8E-3
1.5E-3
1.2E-3
9.0E-4
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
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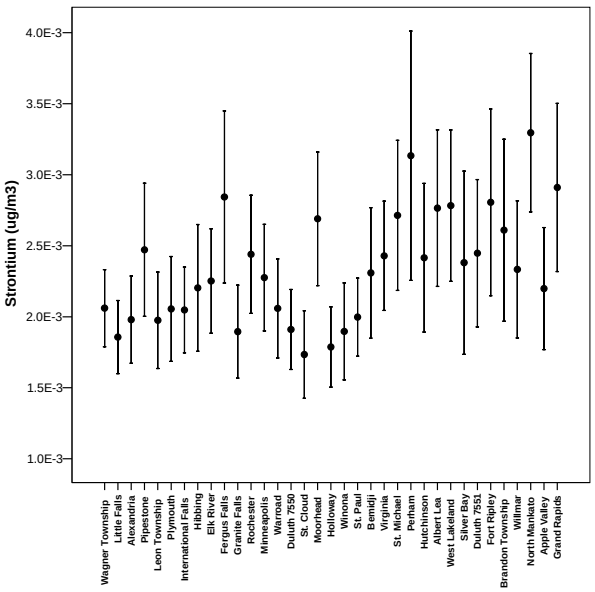
Fort Ripley
Brandon Township
Willmar
North Mankato
Apple Valley
Grand Rapids


Strontium (ug/m3)
4.0E-3
3.5E-3
3.0E-3
2.5E-3
2.0E-3
1.5E-3
1.0E-3
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
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St. Paul
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St. Michael
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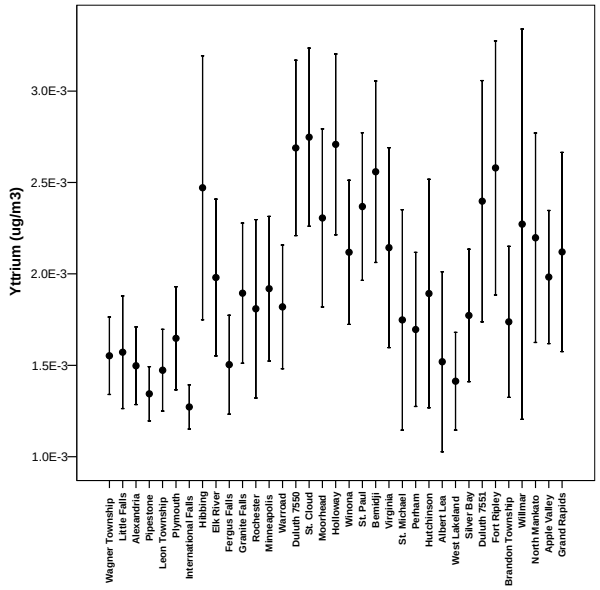
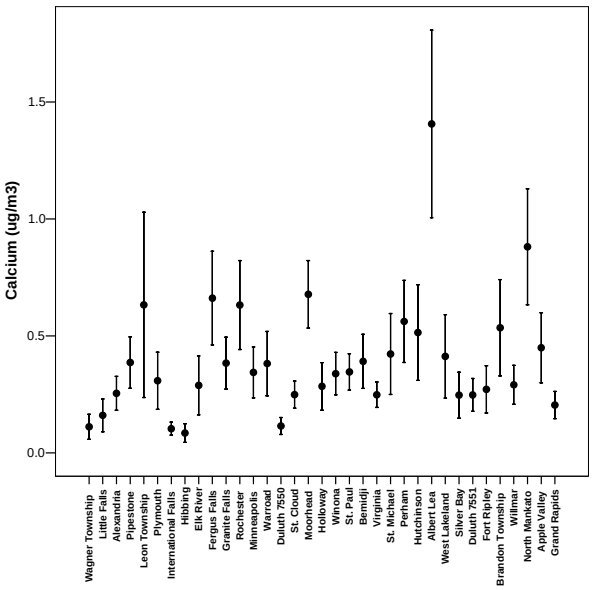
Apple Valley
Grand Rapids


Yttrium (ug/m3)
3.0E-3
2.5E-3
2.0E-3
1.5E-3
1.0E-3
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
Perham
Hutchinson
Albert Lea
West Lakeland
Silver Bay
Duluth 7551
Fort Ripley
Brandon Township
Willmar
North Mankato
Apple Valley
Grand Rapids


Calcium (ug/m3)
1.5
1.0
0.5
0.0
Wagner Township
Little Falls
Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
Perham
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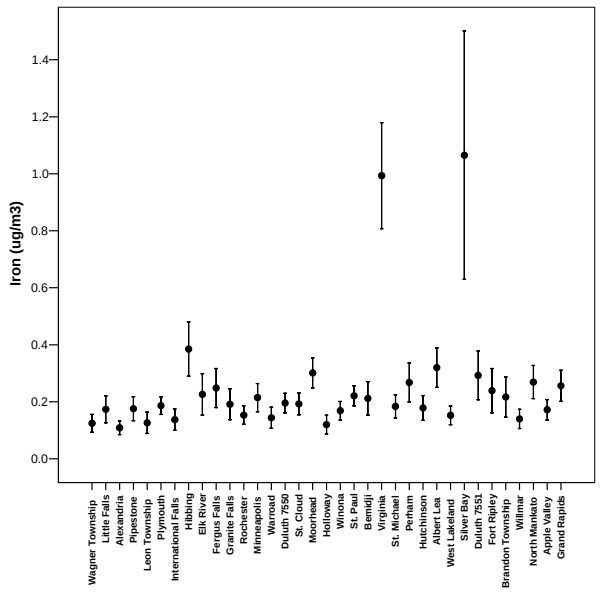
Apple Valley
Grand Rapids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0.6
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Pipestone
Leon Township
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International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
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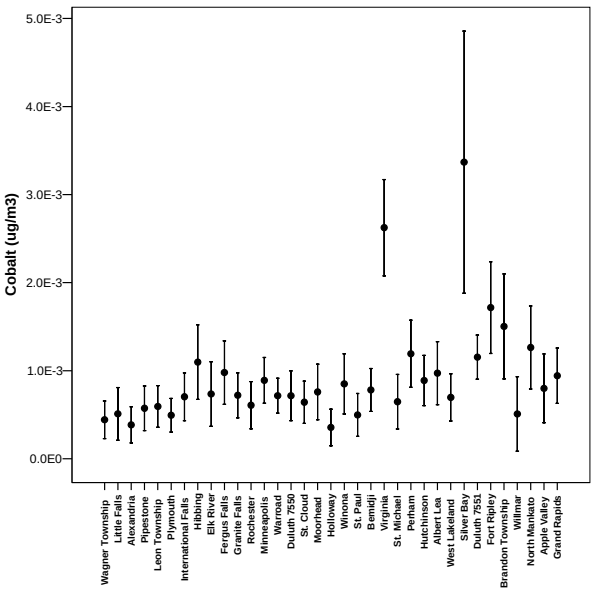
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Alexandria
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Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7550
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
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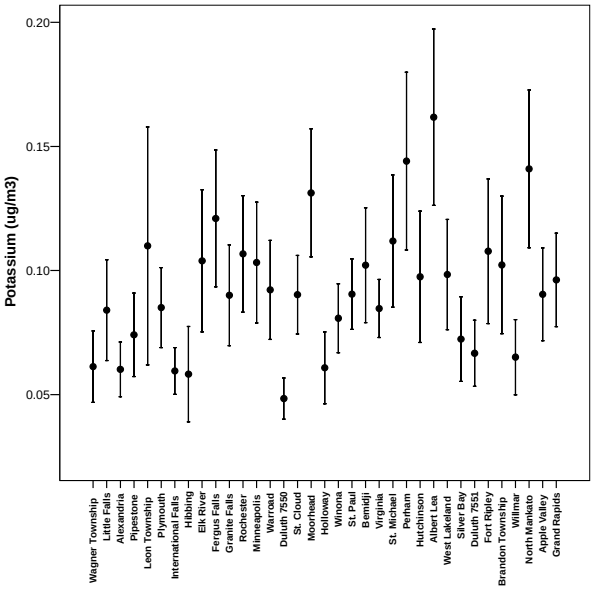
Apple Valley
Grand Rapids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Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7590
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
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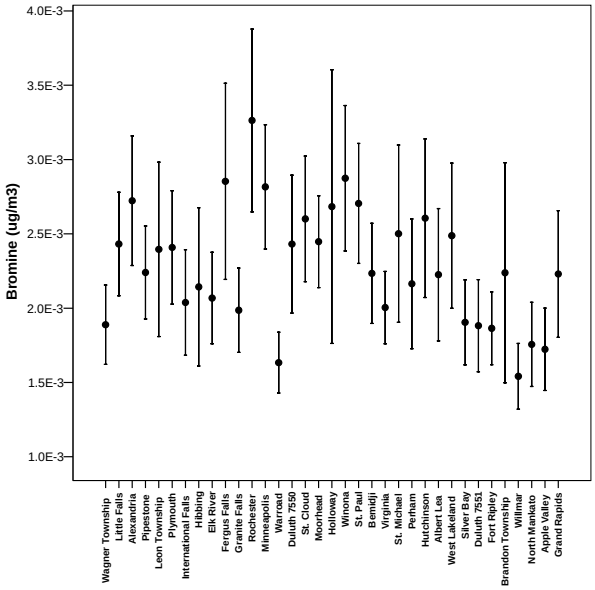
Apple Valley
Grand Rapids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Alexandria
Pipestone
Leon Township
Plymouth
International Falls
Hibbing
Elk River
Fergus Falls
Granite Falls
Rochester
Minneapolis
Warroad
Duluth 7590
St. Cloud
Moorhead
Holloway
Winona
St. Paul
Bemidji
Virginia
St. Michael
Perham
Hutchinson
Albert Lea
West Lakeland
Silver Bay
Duluth 7551
Fort Ripley
Brandon Township
Willmar
North Mankato
Apple Valley
Grand Rapids

5. Discussion

5.1. Risk

Citizens of Minnesota are not exposed individually to chemicals. Instead, hundreds of pollutants are inhaled with every breath. As a result, it is necessary to try to understand the risk of breathing a mixture of chemicals. Chemicals react to each other within the body in complex ways. Some react in a way that makes them more toxic together than individually (synergism), while others are less toxic in concert (antagonism). Since the mode of action in the body and reaction between chemicals is often poorly understood, risk assessors may simplify this complex relationship by assuming the risk of individual chemicals is unchanged when multiple pollutant exposure occurs (additivity).

In the case of the SATM study, the risk from all carcinogens was added together to obtain a risk for each monitoring location. The risk from all chronic noncarcinogens was also added together. In general, noncarcinogens should be divided by the target organ or mode of action when available. However, all noncarcinogens can be added together for a screening risk assessment. If the hazard index is below one, there is no need to subdivide the noncarcinogens.

There is a great deal of uncertainty around risk values calculated in this way. Obviously, the additivity model does not reflect reality. In addition, there is uncertainty around each health benchmark where the risk may be overestimated by several orders of magnitude. There is also the possibility that chemicals may pose currently unknown risks and; therefore, the health benchmark may underestimate risk. Furthermore, centrally located monitors rarely reflect true exposure. Most people spend the majority of their time indoors or in microenvironments such as their cars. Outdoor ambient monitors do not reflect the concentrations of pollutants in those other environments.

However, using additivity to calculate risks at different sites is a useful tool in comparing locations. While the true risk may be quite different than the calculated risk, the site risks are calculated in the same way and allow for comparisons between sites. In this way, we can try to understand if certain regions or sites pose a higher risk than others.

Due to the changes in detection limits across the years, in many cases pollutants that could be detected in one year could not be detected in another. Therefore, if all pollutants were included, the risk would be driven by the monitoring year rather than by the location of the monitoring site. To avoid this bias, only pollutants that could be reliably monitored above the detection limit throughout the 5-year study were included in the cumulative risk assessment for each site. Thus, the risks presented here may underestimate risk levels. The compounds included in the risk estimation are shown in Table 5.1.

Table 5.1: List of Air Toxics Included in Cumulative Risk Calculation.

Acetaldehyde	Dichlorodifluoromethane	Toluene
Acetone	Ethylbenzene	1,1,1-Trichloroethane
Barium	Formaldehyde	Trichlorofluoromethane
Benzene	Iron	Trichlorotrifluoroethane
Butyraldehyde	Lead	1,2,4-Trimethylbenzene
Calcium	Manganese	1,3,5-Trimethylbenzene
Carbon tetrachloride	Potassium	Xylenes
Chlorine	Propionaldehyde	Zinc
Cobalt	Titanium	

In the case of the SATM study, all the carcinogens were added together to calculate a total inhalation cancer risk for each site. They ranged from 2.5-5.8 in 100,000 additional cancer risk. The lowest risk was in Holloway. The highest cancer risk was in Minneapolis. Chronic noncancer hazard quotients were also added to calculate a hazard index for each monitoring site. The hazard indices ranged from .59 in Holloway to 1.4 in Winona. When broken down by target endpoint, only St. Paul, Minneapolis and Winona had upper respiratory hazard indices slightly over one. Winona also had a lower respiratory hazard index over one.

Appendix E summarizes the risks calculated for each monitoring location.

Figure 5.1 shows the cumulative cancer risk at each monitoring locations. Figure 5.2 shows the chronic noncancer hazard index value.

Figure 5.1: Cumulative Cancer Risk at SATM Monitoring Sites (1996-2001).

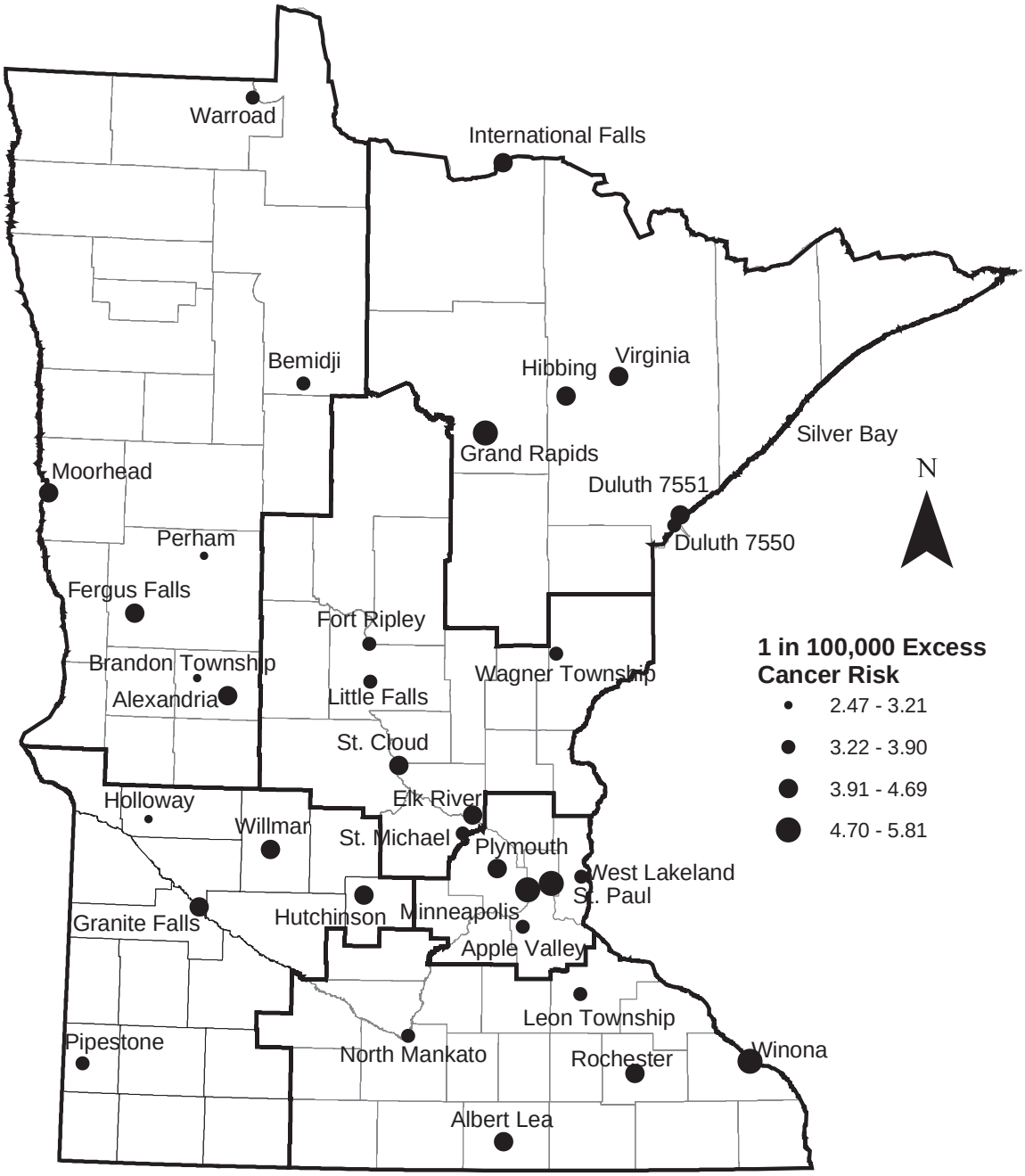
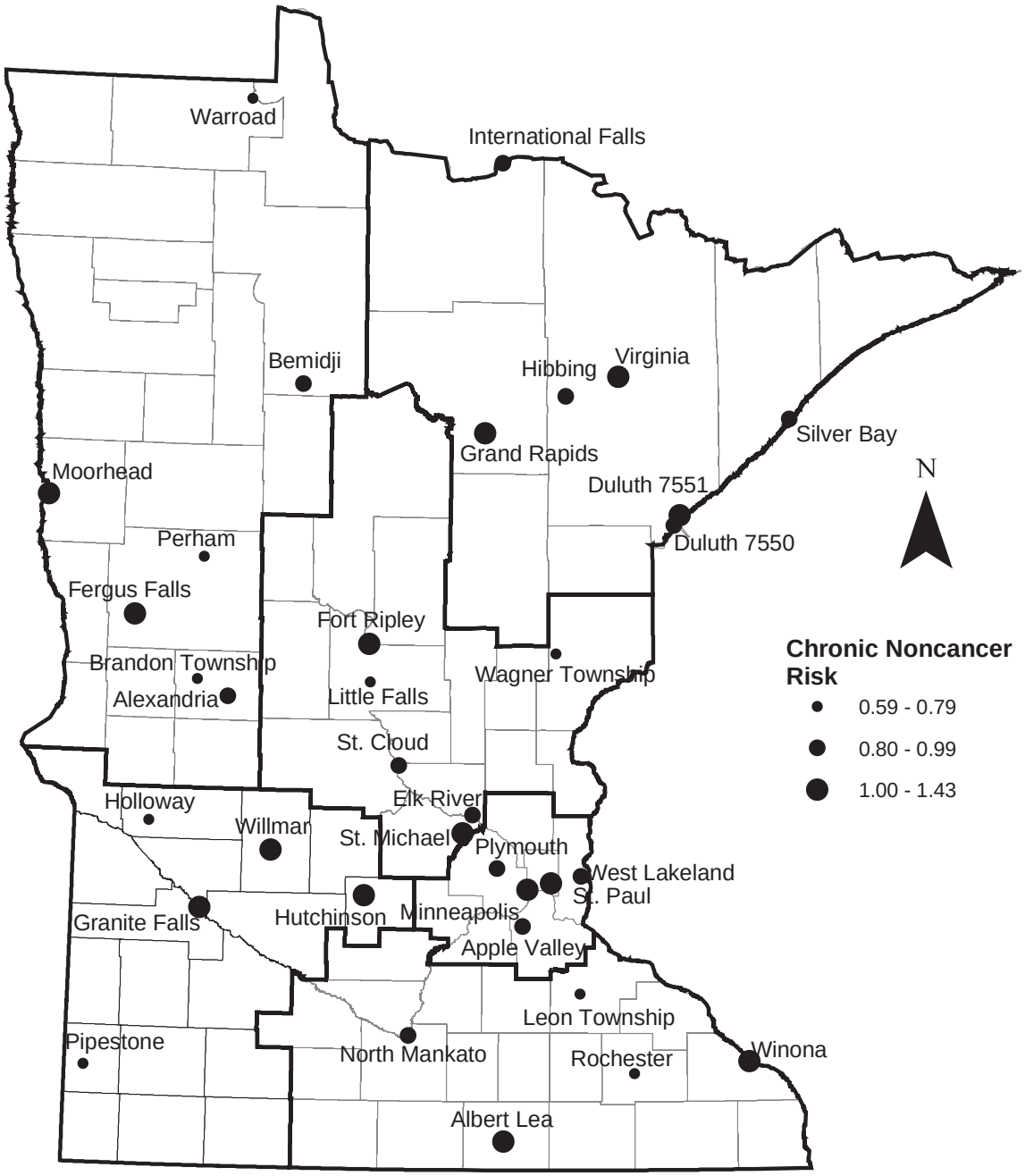


Figure 5.2: Chronic Noncancer Hazard Indices at SATM Monitoring Sites (1996-2001).



The excess cancer risk and noncancer hazard indices were plotted against log concentration (Figures 5.3-5.4). In general, as population increases, cancer risk also tends to increase. Although not quite as significantly as cancer risk, noncancer hazard indices also tend to increase with population.

Figure 5.3: Cumulative Cancer Risk Compared to log Population (1996-2001).

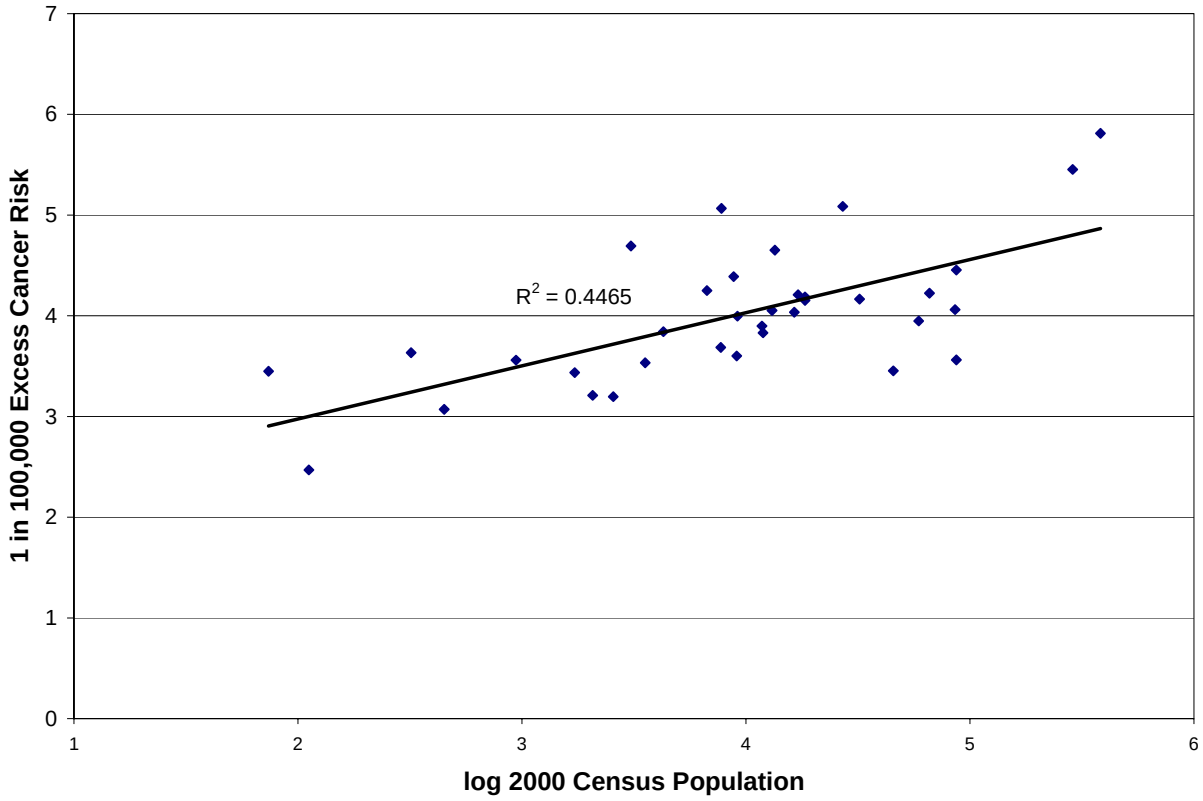
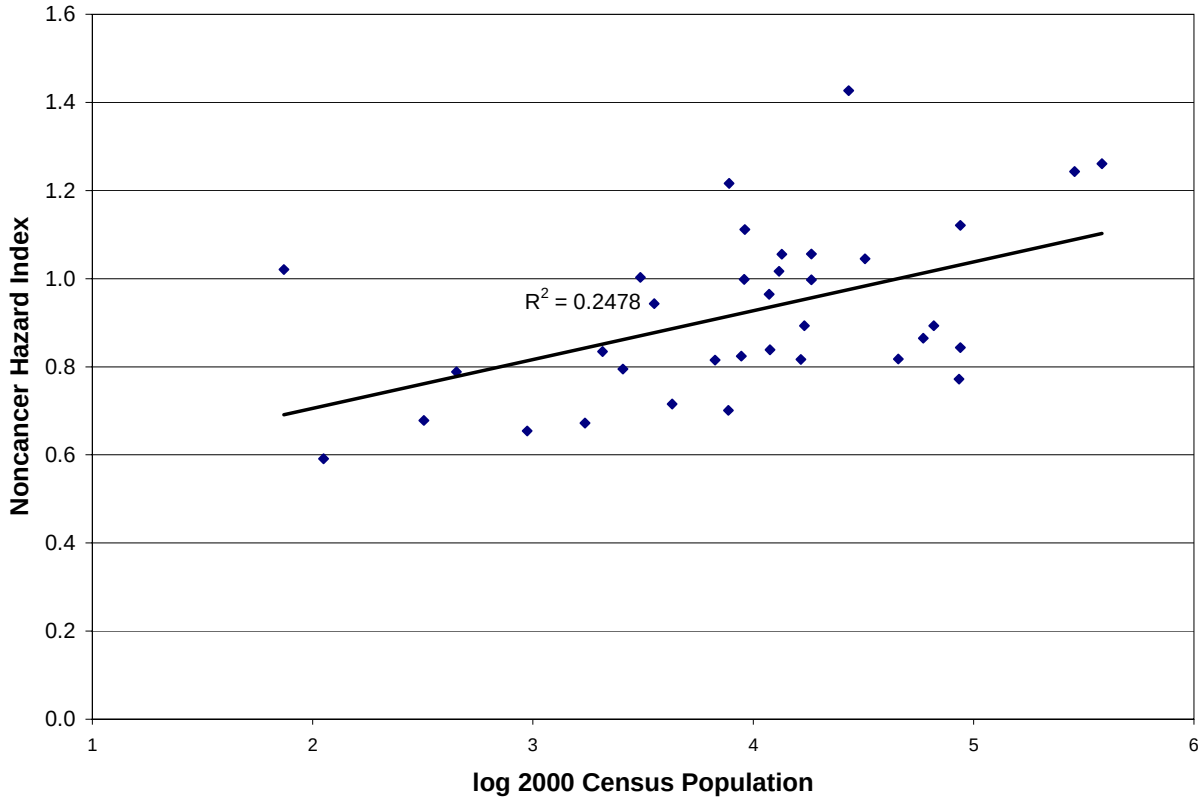


Figure 5.4: Chronic Noncancer Hazard Indices Compared to log Population (1996-2001).



There was no significant difference between cancer risk and hazard indices between regions, although the Twin Cities are slightly higher than the other regions. Figures 5.5 and 5.6 compare the risk between regions.

Figure 5.5: Cancer Risk by Region (1996-2001).

The point in the middle is the mean cancer risk. The bars show the range where it is 95% certain that the true mean of the data falls.

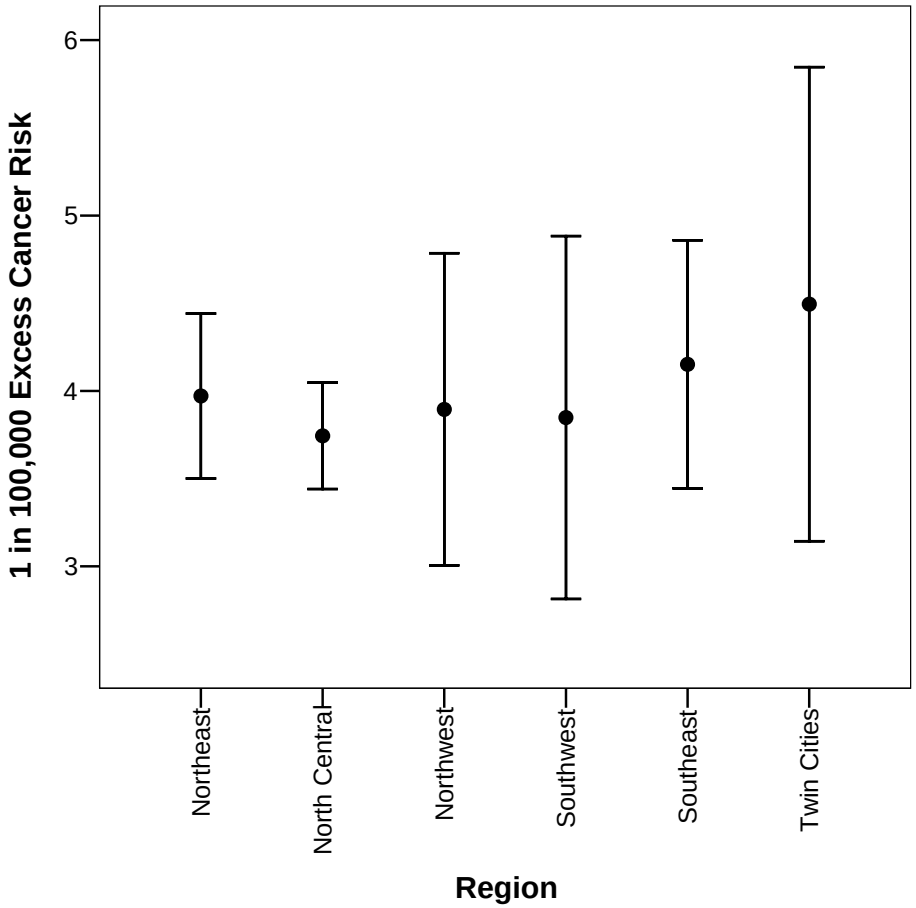
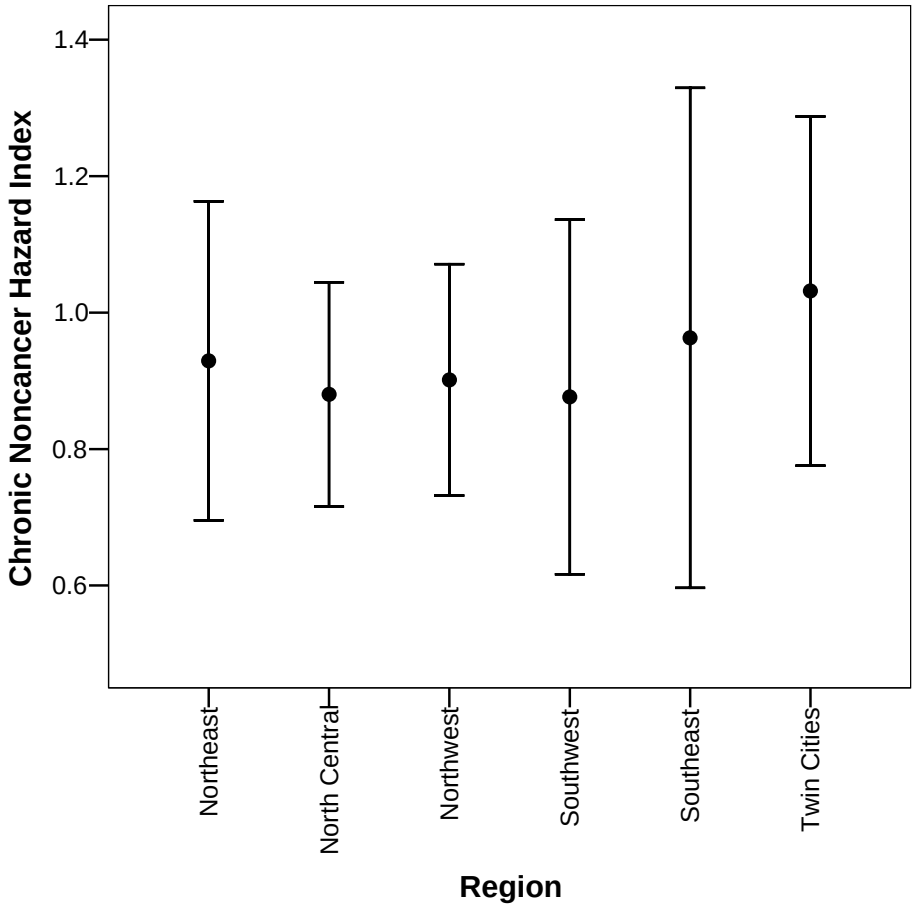


Figure 5.6: Noncancer Hazard Indices by Region (1996-2001)

The point in the middle is the mean hazard index. The bars show the range where it is 95% certain that the true mean of the data falls.



5.2. Mobile Sources

Motor vehicles are a major source of air toxics and health risks from outdoor air pollutants. Some air toxics such as benzene, toluene and xylene are present in gasoline and are emitted into the air when gasoline evaporates or passes through the engine as unburned fuel. Other air toxics, such as formaldehyde, acetaldehyde and 1,3-butadiene are not present in fuel, but are by-products of incomplete combustion (23). Metal air toxics may also result from engine wear or impurities of fuel additives in oil or gasoline.

The EPA has determined a list of mobile source air toxics (MSATs) to signify those air toxics emitted by nonroad engines and on-highway motor vehicles. The list of MSATs is given in Table 5.2.

Table 5.2: Mobile Source Air Toxics.

Acetaldehyde*	Diesel Particulate Matter + Diesel Exhaust Organic Gases	Methyl tert-butyl ether (MTBE)
Acrolein	Ethylbenzene*	Naphthalene
Arsenic Compounds*	Formaldehyde*	Nickel Compounds*
Benzene*	n-Hexane	Polycyclic Organic Matter (POM)
1,3-Butadiene*	Lead Compounds*	Styrene*
Chromium Compounds*	Manganese Compounds*	Toluene*
Dioxin/Furans	Mercury Compounds	Xylene*

*Air Toxics Monitored in SATM study.

Table 5.3 lists the primary sources of the MSATs monitored in Minnesota. Point sources are typically large stationary sources with relatively high emissions; for example, power plants and refineries. Area sources are also often stationary, but are generally smaller sources of emissions such as dry cleaners, gasoline service stations and fireplaces. Mobile sources include both cars and trucks used on the road and non-road sources such as lawn and garden equipment, construction equipment, aircraft and locomotives. Of the MSAT pollutants measured in the SATM study, all of the carbonyls and VOCs except styrene come predominately from mobile (on-road and non-road) sources. Styrene and metals are primarily emitted from point sources.

Table 5.3: Sources of Mobile Source Air Toxics in Minnesota*.

Pollutant	Point (%)	Area (%)	Mobile (%)
Acetaldehyde	3	30	66
Arsenic Compounds	92		7
Benzene	1	27	72
1,3-Butadiene	0	35	64
Chromium Compounds	94	5	1
Ethylbenzene	5	2	94
Formaldehyde	7	43	50
Lead Compounds	72	7	22
Manganese Compound	97	3	0
Nickel Compounds	79	17	4
Styrene	73		28
Toluene	4	19	77
Xylenes	7	24	69

*1999 Minnesota Air Toxics Emissions Inventory.

Of the air toxics monitored in the SATM study, arsenic, 1,3-butadiene, chromium and nickel had insufficient data above the detection limit for analysis. The other measured SATM median concentrations were compared to the site populations. The graphs showing the correlation of MSAT concentrations with the log of the population can be found in Appendix F. All of the pollutants that are emitted primarily from mobile sources show a good correlation with population. As population increases, concentrations, in general, increase. The pollutants emitted primarily from point sources show less correlation with population. Compounds emitted from mobile sources are found at all monitoring locations. This makes sense since vehicles are an integral part of our society. Concentrations increase as the number and density of vehicle use increases.

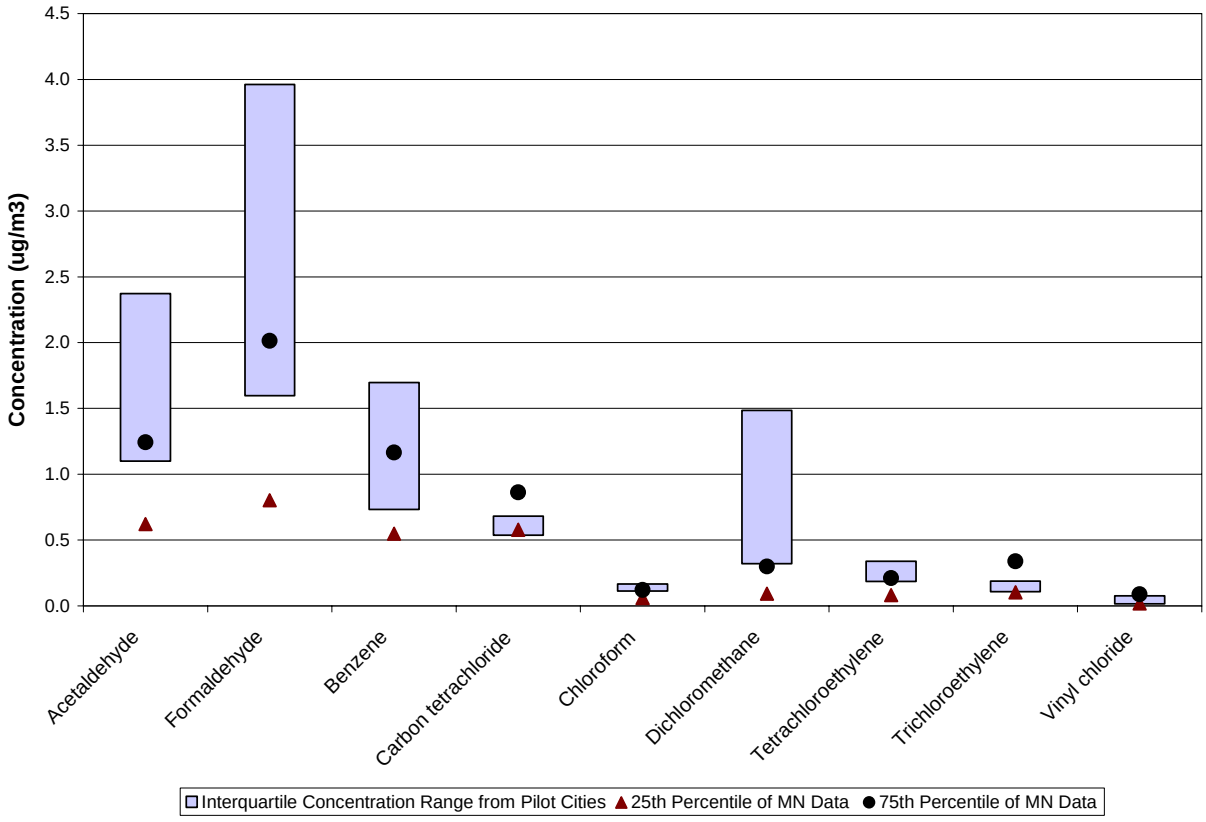
5.3. National Comparisons

One topic of interest is how Minnesota concentrations of air toxics compare to national concentrations. Nationwide comparisons can be difficult since states may use different monitor siting criteria, sampling equipment and analysis techniques. However, comparisons can give a rough idea of how Minnesota air toxic levels compare nationwide.

The EPA has funded 10 Pilot Cities to monitor a handful of air toxics. The analysis of this data is intended to help guide the final design of the national air toxics monitoring program. The ten cities include: Providence, Rhode Island; Charleston, West Virginia; Tampa Bay, Florida; San Juan, Puerto Rico; Detroit, Michigan; Cedar Rapids, Iowa; Grand Junction, Colorado; Rio Rancho, New Mexico; San Jacinto, California; and Seattle, Washington. Interquartile ranges (middle 25-75% of the data) for select air toxics from 2001 were available for analysis (11).

Figure 5.7 shows the 2001 Pilot City data compared to the interquartile range of the randomly selected sites from the SATM study. The bars show the interquartile range of the Pilot City data. The triangles are the 25th percentile from the SATM study and the circles are the 75th percentile.

Figure 5.7: National Pilot City Concentrations Compared to Minnesota SATM Study Results.



In general, the Minnesota interquartile ranges are similar to or lower than the Pilot study ranges. However, the Pilot Cities tend to be larger in population than the cities in the MN SATM study.

6. Conclusions

6.1. Air Toxics of Concern

Of the 73 chemicals collected and analyzed in the SATM study, at one site or more, 4 were above MPCA approved inhalation health benchmarks, 11 were near the health benchmarks, 15 were at least 10 times lower than health benchmarks at all sites, 22 lacked approved MPCA benchmarks and 21 were unable to be analyzed due to insufficient data above the health benchmark.

The four pollutants found above health benchmarks at one site or more were benzene, formaldehyde, carbon tetrachloride and ethylene dibromide. Each of these pollutants posed greater than a 1 in a 100,000 increased cancer risk at one or more monitoring sites. Benzene exceeded the cancer inhalation health benchmark at Plymouth, Minneapolis, St. Paul, International Falls and Winona. However, levels of benzene in Minnesota have been decreasing since 1996. In 2003, monitors in Minneapolis, St. Paul and Duluth showed concentrations of benzene below health benchmarks.

Formaldehyde exceeded the cancer inhalation health benchmark at all 35 monitoring locations during the SATM study. The highest concentrations were found at Minneapolis, Grand Rapids, Winona, St. Paul, Granite Falls, and Duluth. Current monitors continue to show formaldehyde levels well above the health benchmark.

Twenty-three of the 35 monitoring sites had concentrations of carbon tetrachloride above the cancer benchmark. The highest exceedences occurred in the first two years of monitoring. Most production of carbon tetrachloride ended in 1996 due to the Montreal Protocol. Since then, levels of the pollutant have been decreasing in the atmosphere. Monitors in St. Paul, Minneapolis and Duluth have shown concentrations below health benchmarks since 2001.

In the first year of monitoring (1996-97) in the SATM study, concentrations of ethylene dibromide at six of the seven monitoring locations were above the cancer health benchmark. However, concentrations in 1997-98 were all below the benchmark. Ethylene dibromide has rarely been seen above the detection limit since 1999. The high values in 1996-97 may have been due to high background noise due to the analytical equipment.

Of the four air toxics found to be above health benchmarks in the SATM study, carbon tetrachloride and ethylene dibromide are currently below levels of concern. Benzene is generally below health benchmarks at current monitors; however, since it is a known human carcinogen, it may still be of concern in areas with elevated concentrations such as near gas stations and busy roadways. Formaldehyde continues to be found at levels of concern across the state.

Four other air toxics had detection limits which were higher than the inhalation health benchmark. Of these, available data indicates that arsenic and cadmium may have exceeded a 1 in 100,000 cancer risk at one or more sites. 1,3-butadiene and chromium VI appear unlikely to exceed benchmarks.

6.2. Regional and Population Variation

One of the goals of this study was to determine if there are differences in air toxics concentrations between the different regions of Minnesota. Overall, regional differences were minimal. The Twin Cities tended to have higher concentrations for many pollutants. This was expected since the Twin Cities area is much more populated and contains many more emission sources than the other regions of Minnesota. For

example, either the Minneapolis or St. Paul sites had the highest concentration of 11 out of the 52 air toxics that could be quantitated. There were not statistical differences between the other regions.

Ultimately, most of the pollutants fell into one of three categories: pollutants which tend to be emitted from sources such as cars and trucks, gas stations, and dry cleaners which are found in most cities and townships; pollutants which are nationally or globally distributed; and pollutants which are emitted from particular point sources which vary by city and township.

The air toxics, especially the VOCs, which were found in most cities and townships tended to have at least a partial correlation with population. In general, as population increased concentration increased. This was particularly true for the very sparsely populated areas and the very densely populated areas. Holloway, with 112 people, often had the lowest concentrations while the Twin City sites often were amongst the highest in concentration. Many of the pollutants which were detected at most cities and townships and were well correlated with population are primarily emitted by motor vehicles. These compounds include acetaldehyde, benzene, ethylbenzene, formaldehyde, toluene and xylenes. The area and mobile sources that often emit these VOCs are ubiquitous in cities and towns. So while the concentration may increase as the density of sources increases, the pollutants are still found across Minnesota.

Some compounds are either no longer emitted or emitted only in minute amounts in Minnesota, but have a long atmospheric lifespan. Pollutants such as carbon tetrachloride and the freons were all banned or given limited use by the Montreal protocol. The concentrations of these compounds tend to be similar across sites in a given year, although they may vary across years due to atmospheric conditions or decreasing levels as the compounds gradually break down.

Some sites were also influenced by emissions from point sources. These results were relatively rare since the monitoring locations were carefully chosen to avoid the influences of point sources. These compounds such as arsenic, lead, manganese, nickel, and styrene were much less likely to have increasing levels with increasing population. Concentrations within cities can vary depending on the vicinity of point sources and major roadways. Several cities had significantly elevated concentrations of certain pollutants. A list is given in Table 6.1. None of the elevated pollutants were above health benchmarks.

Table 6.1: Sites with Significantly Elevated Air Toxics Concentrations.

Site	Pollutants significantly elevated*
Albert Lea	Calcium
Alexandria	Chloroform
Fergus Falls	Tetrachloroethylene
St. Paul	Toluene
Hutchinson	Butyraldehyde
International Falls	Chloroform, Trichlorofluoromethane (Freon11), Trichlorotrifluoroethane (Freon 113)
Little Falls	Trichloroethylene, Styrene, Trichlorotrifluoroethane (Freon 113)
Minneapolis	1,4-Dichlorobenzene, Ethylbenzene, Xylenes
Pipestone	Styrene
Plymouth	Dichloromethane, Trichloroethylene
Silver Bay	Iron
Virginia	Iron, Manganese

*95% confident that the concentration of pollutant at this site is higher than the concentration at most other sites monitored

6.3. Risk

The cumulative 1 in 100,000 excess cancer risk for the monitoring sites ranged from 2.5 to 5.8 with Holloway with the lowest risk and Minneapolis with the highest risk. A 1 in a 100,000 excess cancer risk from air toxics is generally considered acceptable by the MPCA. Chronic, noncancer indices ranged from 0.59 in Holloway to 1.4 in Winona. Noncancer hazard indices less than one are not expected to cause an adverse effect to human health. If a quotient or index is greater than one, adverse effects are possible. When the hazard index was broken down to take into account target endpoints, St. Paul, Minneapolis and Winona had upper respiratory endpoints slightly over one. Winona also had a lower respiratory hazard index over one. Because of insufficient data above detection limits, only 26 pollutants were used to calculate the cumulative risk. As a result, the calculated risks are likely an underestimate of the risk from breathing ambient air.

As with many of the individual pollutants, the total cumulative risk tended to increase somewhat with population. The correlation was better for cancer risk than for noncancer risk. While population size is an important indicator of risk, other factors such as point sources and monitor location are also important. For example, Winona, Grand Rapids and Fort Ripley, had higher risk levels than would have been expected from their population size.

Although the Twin Cities appeared slightly higher, there was no significant difference between risk levels in the different regions of Minnesota.

6.4. National Comparisons

The Minnesota SATM data was compared to National Pilot City data that was collected in 2001. Overall, Minnesota concentrations appear to be lower than or similar to air toxic concentrations found nationwide.

6.5. Summary

Minnesota concentrations of air toxics were generally below health benchmarks. Only two of the 73 compounds monitored, benzene and formaldehyde, continue to be over health benchmarks. However, benzene concentrations have been decreasing since 1996 and are currently below benchmarks at most monitoring locations. Another two, arsenic and cadmium, should continue to be followed as detection limits are improved. Motor vehicle emissions and select point sources continue to be a cause for concern in Minnesota. Adding the risk from 26 air toxics resulted in ambient air cancer risks ranging from 2.5-6 in 100,000 and noncancer hazard indices ranging from 0.6-1.4. Overall, Minnesota concentrations appear to be lower than or similar to air toxic concentrations found nationwide. The results from this study and others will help us to focus our monitoring efforts where people are most at risk.

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Appendix A: Monitoring Site Locations

Site Name	Population (2000)	Site ID	UTM E	UTM N	Address
Albert Lea	18,356	5401	470458	4832871	Albert Lea City Hall Building, 221 E Clark St, Albert Lea MN 56007
Alexandria	8,820	2010	315319	5083591	Douglas County Courthouse, 305 8th Ave W, Alexandria MN 56308
Apple Valley	45,527	470	481218	4953694	Westview Elementary School, 225 Garden View Dr, Apple Valley MN 55124
Bemidji	11,917	2302	358000	5259270	Kitchagami Regional Library, 509 American Ave, Bemidji MN 56601
Brandon Township	450	2110	298169	5093580	7208 County Rd 16 NW, Brandon MN 55315
Duluth 7550	86,918	7550	569479	5185151	Duluth Superior Public TV Station, 1202 East University Circle, Duluth MN 55811-2420
Duluth 7551	86,918	7551	566198	5179382	Dulluth Lincoln School, 2427 W 4th St, Duluth MN 55806
Elk River	16,447	3050	453003	5016605	Elk River City Hall, 13065 Orono Parkway, Elk River MN 55330
Fergus Falls	13,471	2005	263187	5129932	City Hall Bldg, 112 West Washington, P.O. Box 868, Fergus Falls MN 56538-0868
Fort Ripley	74	3202	395087	5112998	14630 273rd St, Fort Ripley MN 56449
Grand Rapids	7,764	1105	460178	5231380	123 NE 4th St, Grand Rapids MN 55744
Granite Falls	3,070	4003	299494	4964755	108 Baldwin St, Granite Falls MN 56241
St. Paul	287,151	871	497186	4978218	Harding High School, 1540 E. Sixth St., St. Paul MN 55106
Hibbing	17,071	7014	505531	5252055	Hibbing Middle School, 23rd St and 12th Ave, Hibbing MN 55746
Holloway	112	4500	271034	5014398	1620 Highway 59, Holloway MN 56249
Hutchinson	13,080	4301	392036	4971497	Hutchinson City Hall Building, 111 Hassen St NE, Hutchinson MN 55350-2522
International Falls	6,703	1241	470050	5383450	Koochiching County Courthouse, 715 4th St, International Falls MN 56649
Leon Township	942	5356	513450	4915821	14999 420th St, Zumbrota MN 55992
Little Falls	7,719	3049	395646	5091502	Little Falls High School, 1001 5th Ave SE, Little Falls MN 56308
Minneapolis	382,618	958	483865	4974546	Minnehaha Academy, 4200 W River Parkway, Minneapolis MN 55406
Moorhead	32,177	2103	214732	5197754	Moorhead Senior High School, 2300 4th Ave S, Moorhead MN 56560
North Mankato	11,798	5109	416918	4892575	North Mankato Fire Station #2, 1885 Howard Dr. N, North Mankato MN 56003
Perham	2,559	2012	302048	5162284	Prairie Winds Middle School, 480 Coney St, Perham MN 56573
Pipestone	4,280	4002	233822	4876949	Pipestone Central School, 400 2nd Ave SW, Pipestone MN 56165
Plymouth	65,894	260	466850	4986461	Plymouth Municipal Water Plant, Corner of County Rd 9 and Zachary LN, Plymouth MN 55401
Rochester	85,806	5008	544123	4871218	Benjamin Franklin Elementary School, 1801 9th Ave S.E., Rochester MN 55904
Silver Bay	2,068	7608	631244	5239359	Minnesota Veterans Home, 45 Banks Blvd, Silver Bay MN 56601
St. Cloud	59,107	3052	411532	5044428	Talahi Community School, 1321 Michigan Ave N., St. Cloud MN 56304
St. Michael	9,099	3201	447560	5006227	St. Michael Elementary School, 101 Central Ave W, St. Michael MN 55376
Virginia	9,157	1300	534902	5263146	Virginia City Hall Building, 327 1st St S, Virginia MN 55792
Wagner Township	320	1400	500021	5107317	Audubon Center of the North Woods, 54165 Audubon Dr, Sandstone MN 55072
Warroad	1,722	2401	329420	5420030	Warroad Middle School, 510 Cedar Ave, Warroad MN 56763
West Lakeland Township	3,547	301	514010	4981836	2946 Oakgreen Ave, Stillwater MN 55106
Willmar	18,351	4110	339526	4997224	Willmar Junior High School, 201 SE Willmar Ave, Willmar MN 56201
Winona	27,069	5210	608769	4878199	Winona Middle School, 166 W. Broadway, Winona MN 55987

Appendix B-1: Lower Detection Limits Used in SATM Study for VOCs

Compound	CAS #	Lower Detection Limits (ug/m3) Used for Data Analyzed Between						
		1996-Aug1997	Sept 1997-1998*	Jan-Sept 1999**	Oct 1999-July 2000	Aug 2000-Mar 20, 2001	Mar 21, 2001-Oct 2001***	Nov-Dec 2001
1,1,1-Trichloroethane	71-55-6	0.07	0.06	0.11	0.11	0.38	0.16	0.54
1,1,2,2-Tetrachloroethane	79-34-5	0.06	0.04	0.17	0.19	0.22	0.36	0.49
1,1,2-Trichloroethane	79-00-5	0.06	0.04	0.16	0.18	0.15	0.27	0.40
1,1-Dichloroethane	75-34-3	0.08	0.03	0.12	0.19	0.37	0.56	0.69
1,1-Dichloroethene	75-35-4	0.05	0.03	0.14	0.14	0.25	0.29	0.34
1,2,4-Trimethylbenzene	95-63-6	0.02	0.04	0.14	0.12	0.09	0.16	0.28
1,2-dichloroethane	107-06-2	0.06	0.05	0.22	0.09	0.15	0.32	0.30
1,2-Dichloropropane	78-87-5	0.09	0.05	0.21	0.31	0.27	0.84	0.48
1,3,5-Trimethylbenzene	108-67-8	0.03	0.02	0.07	0.06	0.06	0.12	0.11
1,3-Butadiene	106-99-0			0.41	0.39	0.83	0.82	0.50
1,4-Dichlorobenzene	106-46-7	0.14	0.17	0.21	0.26	0.10	0.32	0.30
1,3-Dichlorobenzene	541-73-1	0.11	0.12	0.27	0.10	0.13	0.32	0.30
1,2-Dichlorobenzene	95-50-1	0.10	0.13	0.21	0.14	0.09	0.30	0.19
4-Ethyltoluene	622-96-8			0.16	0.22	0.15	0.57	0.24
Benzene	71-43-2	0.07	0.23	0.13	0.12	0.09	0.21	0.20
Carbon tetrachloride	56-23-5	0.09	0.02	0.16	0.22	0.14	0.59	0.42
Chlorobenzene	108-90-7	0.05	0.04	0.13	0.13	0.09	0.20	0.39
Chloroform	67-66-3	0.07	0.05	0.12	0.09	0.08	0.54	0.34
cis-1,2-Dichloroethene	156-59-2	0.15	0.03	0.14	0.14	0.31	0.40	0.37
cis-1,3-Dichloropropene	10061-01-5	0.09	0.03	0.19	0.27	0.09	0.38	0.44
Dichlorodifluoromethane (Freon 12)	75-71-8	0.06	0.12	0.12	0.16	0.12	0.30	0.52
Dichloromethane	75-09-2	0.06	0.08	0.18	0.15	0.16	0.19	0.55
Dichlorotetrafluoroethane (Freon 114)	76-14-2	0.05	0.02	0.30	0.15	0.36	0.48	0.63
Ethylbenzene	100-41-4	0.03	0.04	0.12	0.07	0.09	0.13	0.33
Ethylene dibromide	106-93-4	0.05	0.03	0.21	0.16	0.14	0.53	0.41
Hexachlorobutadiene	87-68-3	0.16	0.24	0.34	0.18	0.21	0.82	0.81
m & p-Xylene	108-38-3	0.05	0.13	0.19	0.23	0.30	0.32	0.42
Methyl bromide	74-83-9	0.02	0.03	0.11	0.12	0.15	0.31	0.14
o-Xylene	95-47-6	0.03	0.06	0.13	0.08	0.08	0.18	0.35
Styrene	100-42-5	0.04	0.06	0.16	0.06	0.08	0.23	0.20
Tetrachloroethylene	127-18-4	0.12	0.08	0.16	0.10	0.26	0.31	0.50
Toluene	108-88-3	0.03	0.10	0.09	0.08	0.11	0.25	0.27
trans-1,3-Dichloropropene	10061-02-6	0.27	0.18	0.12	0.17	0.14	0.36	0.37
Trichloroethylene	79-01-6	0.03	0.05	0.32	0.25	0.20	0.35	0.27
Trichlorofluoromethane (Freon 11)	75-69-4	0.04	0.04	0.18	0.24	0.23	0.45	0.40
Trichlorotrifluoroethane (Freon 113)	76-13-1	0.07	0.04	0.41	0.20	0.32	0.43	0.64
Vinyl chloride	75-01-4	0.03	0.07	0.15	0.18	0.18	0.31	0.41

*Electron multiplier replaced on December 12, 1997

**New GC/MS went on-line January 1999

***Sample size decreased to prevent water accumulation on column, March 21, 2001

Appendix B-2: Lower Detection Limits Used in SATM Study for Carbonyls

Compound	CAS #	Lower Detection Limits (ug/m3) Used for Data Analyzed Between						
		1996-Jan 1997	Feb 1997-Jan 1998	Feb 1998-Oct 1998	Nov 1998-Nov 1999	Dec 1999-Oct 2000	Nov 2000-Oct 2001	Nov 2001-2002
Formaldehyde	50-00-0	0.018	0.029	0.010	0.027	0.015	0.011	0.012
Acetaldehyde	75-07-0	0.012	0.013	0.021	0.022	0.025	0.020	0.014
Acetone	123-38-6	0.023	0.021	0.033	0.020	0.036	0.021	0.014
Propionaldehyde	123-72-8	0.047	0.026	0.036	0.088	0.077	0.041	0.015
Crotonaldehyde	123-73-9	0.025	0.027	0.036	0.057	0.057	0.043	0.029
Butyraldehyde-	67-64-1	0.023	0.036	0.029	0.028	0.019	0.028	0.007
Benzaldehyde	100-52-7	0.028	0.034	0.041	0.054	0.117	0.052	0.022

Appendix B-3: Lower Detection Limits Used in SATM Study for Metals

Compound	Lower Detection Limits (ug/m3)
Antimony (Sb)	0.01513
Arsenic (As)	0.00529
Barium (Ba)	0.03312
Bromine (Br)	0.00322
Cadmium (Cd)	0.01577
Calcium (Ca)	0.00203
Chlorine (Cl)	0.00225
Chromium (Cr)	0.00217
Cobalt (Co)	0.00003
Gallium (Ga)	0.00529
Indium (In)	0.01577
Iron (Fe)	0.00004
Lanthanum (La)	0.05728
Lead (Pb)	0.00011
Manganese (Mn)	0.00005
Molybdenum (Mo)	0.01326
Nickel (Ni)	0.00220
Palladium (Pd)	0.01543
Phosphorus (P)	0.00316
Potassium (K)	0.02917
Rubidium (Rb)	0.00178
Selenium (Se)	0.00529
Silver (Ag)	0.01543
Strontium (Sr)	0.00278
Tin (Sn)	0.01775
Titanium (Ti)	0.00176
Vanadium (V)	0.00009
Yttrium (Y)	0.00236
Zinc (Zn)	0.00062
Zirconium (Zr)	0.01326

Appendix C: Inhalation Health Benchmarks

CAS # or MPCA#	Chemical Name	Acute						Cancer						Chronic Noncancer					
		Tox Value Source	Acute Air Conc. (ug/m3)	Toxic Endpoint	Surrogate?	Surrogate CAS	Surrogate Name	Tox Value Source	Unit Risk (ug/m3)-1	10-5 Cancer-based Air Conc (ug/m3)	Surrogate?	Surrogate CAS	Surrogate Name	Tox Value Source	Reference Conc. (ug/m3)	Toxic Endpoint	Surrogate?	Surrogate CAS	Surrogate Name
75-07-0	Acetaldehyde							HRV	2.2E-06	4.5E+00				IRIS	9	Olfactory epithelium degeneration			
67-64-1	Acetone																		
7440-36-0	Antimony													HRV	0.2	Lower respiratory system	X	1309-64-4	Antimony trioxide
7440-38-2	Arsenic	CAL EPA	0.19	Reproductive/developmental				HRV	4.3E-03	2.3E-03				CAL EPA	0.03	Development; cardiovascular system; nervous system	X	7440-38-2	Arsenic and compounds
7440-39-3	Barium													HEAST	0.5	Fetotoxicity			
100-52-7	Benzaldehyde																		
71-43-2	Benzene	HRV	1000	Developmental				HRV	7.8E-06	1.3E+00				IRIS	30	Decreased lymphocyte count			
106-99-0	Butadiene, 1,3-							HBV	3.6E-05	2.8E-01				IRIS	2	Reproductive system			
123-72-8	Butyraldehyde																		
7440-43-9	Cadmium							HRV	1.8E-03	5.6E-03				CAL EPA	0.02	Kidney; respiratory system	X	7440-43-9	Cadmium & compounds
7440-70-2	Calcium																		
56-23-5	Carbon tetrachloride	CAL EPA	1900	Developmental				IRIS	1.5E-05	6.7E-01				CAL EPA	40	Alimentary system; development; nervous system			
7782-50-5	Chlorine	HRV	290	Irritant - respiratory system										CAL EPA	0.2	Respiratory system			
108-90-7	Chlorobenzene													CAL EPA	1000	Alimentary system; kidney; reproductive system			
67-66-3	Chloroform	HRV	150	Developmental										CAL EPA	300	Alimentary system; kidney; development			
0-00-5	Chromium Compounds							HRV	1.2E-02	8.3E-04	X	18540-29-9	Chromic acid mists and dissolved Cr(VI) aerosols	IRIS	0.008	Respiratory system	X	18540-29-9	Chromic acid mists and dissolved Cr(VI) aerosols
7440-48-4	Cobalt																		
123-73-9	Crotonaldehyde																		
541-73-1	Dichlorobenzene(m), 1,3-																		
95-50-1	Dichlorobenzene(o), 1,2-													HEAST	200	Decreased body weight gain			
106-46-7	Dichlorobenzene(p), 1,4-							CAL EPA	1.1E-05	9.1E-01				IRIS	800	Increased liver weight			
75-71-8	Dichlorodifluoromethane (Freon 12)													HEAST	200	Liver			
75-34-3	Dichloroethane, 1,1-							CAL EPA	1.6E-06	6.3E+00				HEAST	500	Kidney damage			
107-06-2	Dichloroethane, 1,2-							IRIS	2.6E-05	3.8E-01				CAL EPA	400	Alimentary system (liver)			
156-59-2	Dichloroethene (1,2-) cis-																		
75-35-4	Dichloroethene, 1,1-													IRIS	200	Liver			

Appendix C: Inhalation Health Benchmarks

CAS # or MPCA#	Chemical Name	Acute						Cancer						Chronic Noncancer					
		Tox Value Source	Acute Air Conc. (ug/m3)	Toxic Endpoint	Surrogate?	Surrogate CAS	Surrogate Name	Tox Value Source	Unit Risk (ug/m3)-1	10-5 Cancer-based Air Conc (ug/m3)	Surrogate?	Surrogate CAS	Surrogate Name	Tox Value Source	Reference Conc. (ug/m3)	Toxic Endpoint	Surrogate?	Surrogate CAS	Surrogate Name
75-09-2	Dichloromethane	HRV	10000	CNS				HRV	4.7E-07	2.1E+01				CAL EPA	400	Cardiovascular system; nervous system			
78-87-5	Dichloropropane, 1,2-													IRIS	4	Nasal mucosa hyperplasia			
542-75-6	Dichloropropene, 1,3-							IRIS	4.0E-06	2.5E+00				HRV	20	Upper respiratory system			
76-14-2	Dichlorotetrafluoroethane (Freon 114)																		
100-41-4	Ethylbenzene	HRV	10000	Developmental										IRIS	1000	Developmental toxicity			
106-93-4	Ethylene dibromide							HRV	2.2E-04	4.5E-02				IRIS	9	Nasal inflammation			
622-96-8	Ethyltoluene, 4-																		
50-00-0	Formaldehyde	HRV	94	Irritant - eye and respiratory system				HRV	1.3E-05	7.7E-01				CAL EPA	3	Respiratory system; eyes			
87-68-3	Hexachlorobutadiene							IRIS	2.2E-05	4.5E-01									
7439-89-6	Iron																		
7439-92-1	Lead							CAL EPA	1.2E-05	8.3E-01	X	7439-92-1	Lead & compounds						
7439-96-5	Manganese													HRV	0.2	Nervous system			
74-83-9	Methyl bromide	HRV	2000	CNS										HRV	5	Upper respiratory system			
0-01-5	Nickel Compounds	HRV	11	Irritant - respiratory system				HRV	4.8E-04	2.1E-02	X	12035-72-2	Nickel subsulfide	CAL EPA	0.05	Respiratory system; hematopoietic system	X		Nickel & compounds (not nickel oxide)
7723-14-0	Phosphorus																		
7440-09-7	Potassium																		
123-38-6	Propionaldehyde																		
7784-49-2	Selenium													CAL EPA	20	Alimentary system; cardiovascular system; nervous	X		Selenium and compounds other than hydrogen selenide
7440-22-4	Silver																		
100-42-5	Styrene	HRV	21000	Irritant - eye and respiratory system										HRV	1000	Nervous system			
79-34-5	Tetrachloroethane, 1,1,2,2-							IRIS	5.8E-05	1.7E-01									
127-18-4	Tetrachloroethylene	HRV	20000	Irritant - eye, and respiratory system; CNS				CAL EPA	5.9E-06	1.7E+00				CAL EPA	35	Kidney; alimentary system (liver)			
7440-31-5	Tin																		
108-88-3	Toluene	HRV	37000	Irritant- eye and respiratory system; CNS										HRV	400	Nervous/upper respiratory sys.			
71-55-6	Trichloroethane, 1,1,1-	HRV	140000	CNS										CAL EPA	1000	Nervous system			
79-00-5	Trichloroethane, 1,1,2-							IRIS	1.6E-05	6.3E-01									
79-01-6	Trichloroethylene	HRV	2000	Developmental				CAL EPA	2.0E-06	5.0E+00				CAL EPA	600	Nervous system; eyes			
75-69-4	Trichlorofluoromethane (Freon 11)													HEAST	700	Kidney, lung			
76-13-1	Trichlorotrifluoroethane (Freon 113)													HEAST	30000	Whole body - decreased weight			

Appendix C: Inhalation Health Benchmarks

CAS # or MPCA#	Chemical Name	Acute						Cancer						Chronic Noncancer					
		Tox Value Source	Acute Air Conc. (ug/m3)	Toxic Endpoint	Surrogate?	Surrogate CAS	Surrogate Name	Tox Value Source	Unit Risk (ug/m3)-1	10-5 Cancer-based Air Conc (ug/m3)	Surrogate?	Surrogate CAS	Surrogate Name	Tox Value Source	Reference Conc. (ug/m3)	Toxic Endpoint	Surrogate?	Surrogate CAS	Surrogate Name
95-63-6	Trimethylbenzene, 1,2,4-																		
108-67-8	Trimethylbenzene, 1,3,5-																		
7440-62-2	Vanadium																		
75-01-4	Vinyl chloride	CAL EPA	180000	Irritant - eye and respiratory system; CNS				HRV	8.8E-06	1.1E+00				IRIS	100	Liver cell polymorphism			
1330-20-7	Xylenes	HRV	43000	Irritant - eye and respiratory system; CNS										IRIS	100	Impaired motor coordination (decreased rotarod performance)			
108-38-3	Xylenes, m-	HRV	43000	Irritant - eye and respiratory system; CNS	X	1330-20-7	Xylenes							IRIS	100	Impaired motor coordination (decreased rotarod performance)	X	1330-20-7	Xylenes
95-47-6	Xylenes, o-	HRV	43000	Irritant - eye and respiratory system; CNS	X	1330-20-7	Xylenes							IRIS	100	Impaired motor coordination (decreased rotarod performance)	X	1330-20-7	Xylenes
106-42-3	Xylenes, p-	HRV	43000	Irritant - eye and respiratory system; CNS	X	1330-20-7	Xylenes							IRIS	100	Impaired motor coordination (decreased rotarod performance)	X	1330-20-7	Xylenes
7440-66-6	Zinc																		

MPCA # - An identification number, smaller than 50-00-0, assigned by MPCA
HRV - Minnesota Department of Health, Health Risk Value
HBV - Minnesota Department of Health, Health Based Value
IRIS - EPA Integrated Risk Information System
CAL EPA - California Office of Environmetal Health Hazard Assessment
HEAST - EPA Health Effects Assessment Summary Tables, 1997
MPCA - Minnesota Pollution Control Agency value

Appendix D-1: VOC Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Trichlorotrifluoroethane (Freon 113)					Dichlorotetrafluoroethane (Freon 114)				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.80	0.79	1.38	0.14	58	0.11	0.09	0.47	0.08	58
International Falls	Sa	1996-1997	6703	1.28	0.81	3.41	0.79	57	0.11	0.10	0.24	0.05	57
Leon Township	S	1996-1997	942	0.80	0.80	1.64	0.16	54	0.12	0.10	0.41	0.08	54
Little Falls	S	1996-1997	7719	1.33	0.78	27.77	3.65	56	0.11	0.10	0.24	0.04	56
Pipestone	S	1996-1997	4280	0.71	0.70	1.12	0.20	47	0.11	0.09	0.47	0.09	47
Plymouth	S	1996-1997	65894	0.68	0.69	1.13	0.17	55	0.10	0.08	0.48	0.06	55
Wagner Township	S	1996-1997	320	0.77	0.78	0.91	0.09	51	0.10	0.09	0.26	0.04	51
Elk River	S	1997-1998	16447	0.67	0.67	1.11	0.11	58	0.07	0.08	0.12	0.03	58
Fergus Falls	S	1997-1998	13471	0.65	0.65	0.97	0.09	48	0.07	0.08	0.13	0.04	48
Granite Falls	S	1997-1998	3070	0.63	0.64	1.00	0.09	43	0.07	0.08	0.17	0.04	43
Hibbing	S	1997-1998	17071	0.66	0.64	1.03	0.10	59	0.08	0.08	0.17	0.04	59
Minneapolis	S	1997-1998	382618	0.61	0.58	1.23	0.13	55	0.07	0.08	0.13	0.03	55
Rochester	S	1997-1998	85806	0.65	0.66	0.86	0.08	56	0.06	0.07	0.13	0.03	56
Warroad	Sa	1997-1998	1722	0.71	0.71	1.03	0.10	47	0.08	0.08	0.12	0.03	47
Bemidji	Sa	1998-1999	11917	0.51	0.50	0.71	0.11	55	0.11	0.15	0.15	0.06	55
Duluth 7550	S	1998-1999	86918	0.52	0.51	0.71	0.11	60	0.11	0.15	0.15	0.06	60
St. Paul	S	1998-1999	287151	0.54	0.54	0.88	0.11	56	0.11	0.15	0.15	0.06	56
Holloway	S	1998-1999	112	0.52	0.51	1.01	0.13	54	0.11	0.15	0.15	0.06	54
Moorhead	S	1998-1999	32177	0.51	0.49	0.75	0.11	52	0.11	0.15	0.15	0.06	52
St. Cloud	S	1998-1999	59107	0.52	0.52	0.81	0.11	52	0.11	0.15	0.15	0.06	52
Winona	S	1998-1999	27069	0.54	0.52	0.98	0.13	51	0.11	0.15	0.15	0.06	51
Albert Lea	S	1999-2000	18356	0.58	0.59	0.74	0.08	54	0.09	0.07	0.18	0.04	54
Hutchinson	S	1999-2000	13080	0.60	0.60	0.72	0.05	57	0.09	0.07	0.18	0.04	57
Perham	S	1999-2000	2559	0.60	0.60	0.77	0.07	54	0.09	0.07	0.18	0.03	54
Silver Bay	Sa	1999-2000	2068	0.63	0.60	1.79	0.18	46	0.09	0.07	0.18	0.03	46
St. Michael	S	1999-2000	9099	0.62	0.60	1.45	0.14	60	0.08	0.07	0.18	0.04	60
Virginia	S	1999-2000	9157	0.60	0.59	0.89	0.07	58	0.09	0.07	0.18	0.04	58
West Lakeland	S	1999-2000	3547	0.60	0.58	0.96	0.09	59	0.09	0.07	0.18	0.04	59
Apple Valley	S	2000-2001	45527	0.51	0.54	0.67	0.10	42	0.21	0.24	0.24	0.04	43
Brandon Township	S	2000-2001	450	0.49	0.52	0.73	0.12	53	0.21	0.24	0.24	0.04	53
Duluth 7551	S	2000-2001	86918	0.48	0.50	0.77	0.12	55	0.20	0.18	0.24	0.04	55
Fort Ripley	S	2000-2001	74	0.51	0.52	0.82	0.12	48	0.21	0.24	0.24	0.03	49
Grand Rapids	Sa	2000-2001	7764	0.51	0.50	0.80	0.13	39	0.21	0.24	0.24	0.03	41
North Mankato	S	2000-2001	11798	0.50	0.51	0.78	0.13	32	0.21	0.24	0.24	0.05	32
Willmar	S	2000-2001	18351	0.49	0.51	0.72	0.11	52	0.21	0.24	0.24	0.03	54

Appendix D-1: VOC Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	1,3-Butadiene					Dichloromethane				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	.	.	.	.	0	0.33	0.31	0.79	0.17	58
International Falls	Sa	1996-1997	6703	.	.	.	.	0	0.28	0.23	2.43	0.33	57
Leon Township	S	1996-1997	942	.	.	.	.	0	0.61	0.30	15.03	2.02	54
Little Falls	S	1996-1997	7719	.	.	.	.	0	0.34	0.26	1.45	0.25	56
Pipestone	S	1996-1997	4280	.	.	.	.	0	0.66	0.30	4.19	0.92	47
Plymouth	S	1996-1997	65894	.	.	.	.	0	0.72	0.59	3.41	0.65	55
Wagner Township	S	1996-1997	320	.	.	.	.	0	0.34	0.25	1.85	0.29	51
Elk River	S	1997-1998	16447	.	.	.	.	0	0.25	0.20	2.36	0.31	58
Fergus Falls	S	1997-1998	13471	.	.	.	.	0	0.34	0.22	5.20	0.73	48
Granite Falls	S	1997-1998	3070	.	.	.	.	0	0.20	0.17	0.92	0.15	43
Hibbing	S	1997-1998	17071	.	.	.	.	0	0.25	0.21	1.05	0.18	59
Minneapolis	S	1997-1998	382618	.	.	.	.	0	0.43	0.36	2.33	0.35	55
Rochester	S	1997-1998	85806	.	.	.	.	0	0.25	0.26	0.63	0.12	56
Warroad	Sa	1997-1998	1722	.	.	.	.	0	0.17	0.16	0.51	0.09	47
Bemidji	Sa	1998-1999	11917	0.15	0.21	0.21	0.09	22	0.13	0.14	0.24	0.05	55
Duluth 7550	S	1998-1999	86918	0.19	0.21	0.21	0.05	25	0.24	0.15	4.19	0.53	60
St. Paul	S	1998-1999	287151	0.19	0.21	0.24	0.04	22	0.36	0.33	0.89	0.21	56
Holloway	S	1998-1999	112	0.18	0.21	0.21	0.06	23	0.12	0.11	0.21	0.04	54
Moorhead	S	1998-1999	32177	0.17	0.21	0.21	0.07	19	0.19	0.16	0.70	0.13	52
St. Cloud	S	1998-1999	59107	0.17	0.21	0.21	0.06	24	0.18	0.19	0.42	0.08	52
Winona	S	1998-1999	27069	0.17	0.21	0.21	0.07	25	0.29	0.28	0.86	0.16	51
Albert Lea	S	1999-2000	18356	0.19	0.19	0.42	0.11	54	0.25	0.19	1.51	0.25	54
Hutchinson	S	1999-2000	13080	0.18	0.19	0.42	0.11	57	0.22	0.19	0.77	0.13	57
Perham	S	1999-2000	2559	0.21	0.19	0.42	0.09	54	0.18	0.16	0.82	0.14	54
Silver Bay	Sa	1999-2000	2068	0.20	0.19	0.42	0.09	46	0.16	0.16	0.38	0.07	46
St. Michael	S	1999-2000	9099	0.20	0.19	0.42	0.11	60	0.25	0.19	2.23	0.31	60
Virginia	S	1999-2000	9157	0.19	0.19	0.42	0.10	58	0.30	0.20	5.30	0.68	58
West Lakeland	S	1999-2000	3547	0.21	0.19	0.42	0.11	59	0.19	0.20	0.47	0.09	59
Apple Valley	S	2000-2001	45527	0.41	0.41	0.42	0.04	44	0.11	0.09	0.23	0.04	43
Brandon Township	S	2000-2001	450	0.41	0.41	0.42	0.00	51	0.15	0.09	0.99	0.18	53
Duluth 7551	S	2000-2001	86918	0.41	0.41	0.42	0.05	55	0.51	0.09	21.65	2.90	55
Fort Ripley	S	2000-2001	74	0.40	0.41	0.42	0.08	49	0.10	0.09	0.21	0.03	49
Grand Rapids	Sa	2000-2001	7764	0.39	0.41	0.42	0.09	40	0.11	0.09	0.72	0.10	41
North Mankato	S	2000-2001	11798	0.39	0.41	0.42	0.09	32	0.31	0.09	2.10	0.48	32
Willmar	S	2000-2001	18351	0.39	0.41	0.42	0.09	54	0.13	0.09	0.57	0.11	54

Appendix D-1: VOC Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Chloroform					Carbon tetrachloride				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.17	0.14	0.50	0.10	58	0.92	0.91	1.20	0.09	58
International Falls	Sa	1996-1997	6703	0.15	0.14	0.52	0.07	57	0.91	0.91	1.05	0.08	57
Leon Township	S	1996-1997	942	0.11	0.11	0.20	0.03	54	0.93	0.92	1.05	0.06	54
Little Falls	S	1996-1997	7719	0.11	0.10	0.27	0.04	56	0.91	0.89	1.15	0.07	56
Pipestone	S	1996-1997	4280	0.13	0.10	0.35	0.07	47	0.92	0.91	1.20	0.08	47
Plymouth	S	1996-1997	65894	0.13	0.11	0.49	0.07	55	0.91	0.90	1.20	0.10	55
Wagner Township	S	1996-1997	320	0.10	0.10	0.20	0.03	51	0.91	0.91	1.09	0.06	51
Elk River	S	1997-1998	16447	0.07	0.07	0.21	0.04	58	0.81	0.81	1.01	0.12	58
Fergus Falls	S	1997-1998	13471	0.09	0.09	0.21	0.05	48	0.77	0.79	1.13	0.13	48
Granite Falls	S	1997-1998	3070	0.08	0.09	0.13	0.02	43	0.79	0.82	1.00	0.15	43
Hibbing	S	1997-1998	17071	0.08	0.08	0.21	0.04	59	0.79	0.79	1.03	0.13	59
Minneapolis	S	1997-1998	382618	0.10	0.10	0.25	0.04	55	0.80	0.80	1.02	0.12	55
Rochester	S	1997-1998	85806	0.09	0.08	0.21	0.04	56	0.82	0.84	1.04	0.13	56
Warroad	Sa	1997-1998	1722	0.10	0.09	0.28	0.06	47	0.82	0.81	1.10	0.11	47
Bemidji	Sa	1998-1999	11917	0.07	0.06	0.14	0.02	55	0.57	0.57	0.88	0.17	55
Duluth 7550	S	1998-1999	86918	0.07	0.06	0.19	0.03	60	0.59	0.59	0.88	0.14	60
St. Paul	S	1998-1999	287151	0.12	0.09	0.32	0.07	56	0.60	0.59	0.95	0.15	56
Holloway	S	1998-1999	112	0.06	0.06	0.11	0.02	54	0.56	0.55	0.86	0.17	54
Moorhead	S	1998-1999	32177	0.07	0.06	0.17	0.03	52	0.57	0.55	0.89	0.16	52
St. Cloud	S	1998-1999	59107	0.09	0.06	0.26	0.05	52	0.59	0.61	1.01	0.15	52
Winona	S	1998-1999	27069	0.07	0.06	0.17	0.03	51	0.60	0.59	0.92	0.13	51
Albert Lea	S	1999-2000	18356	0.07	0.07	0.19	0.04	54	0.67	0.67	1.08	0.10	54
Hutchinson	S	1999-2000	13080	0.08	0.07	0.24	0.04	57	0.68	0.65	1.00	0.08	57
Perham	S	1999-2000	2559	0.07	0.04	0.19	0.04	54	0.68	0.67	0.98	0.10	54
Silver Bay	Sa	1999-2000	2068	0.08	0.07	0.19	0.04	46	0.67	0.67	0.95	0.09	46
St. Michael	S	1999-2000	9099	0.08	0.07	0.17	0.04	60	0.68	0.66	0.95	0.10	60
Virginia	S	1999-2000	9157	0.08	0.07	0.20	0.04	58	0.67	0.66	1.04	0.09	58
West Lakeland	S	1999-2000	3547	0.08	0.07	0.18	0.04	59	0.67	0.66	0.92	0.09	59
Apple Valley	S	2000-2001	45527	0.18	0.27	0.27	0.10	42	0.53	0.54	0.73	0.12	42
Brandon Township	S	2000-2001	450	0.17	0.27	0.27	0.11	53	0.58	0.57	0.96	0.16	53
Duluth 7551	S	2000-2001	86918	0.16	0.14	0.27	0.10	55	0.52	0.52	0.92	0.14	55
Fort Ripley	S	2000-2001	74	0.18	0.27	0.27	0.11	48	0.58	0.55	1.24	0.19	49
Grand Rapids	Sa	2000-2001	7764	0.16	0.13	0.27	0.10	40	0.69	0.60	1.90	0.36	40
North Mankato	S	2000-2001	11798	0.19	0.27	0.27	0.10	34	0.69	0.63	1.29	0.25	30
Willmar	S	2000-2001	18351	0.16	0.13	0.27	0.10	54	0.60	0.55	1.11	0.22	50

Appendix D-1: VOC Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Trichlorofluoromethane (Freon 11)					1,1-Dichloroethane				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	1.96	1.87	2.87	0.30	58	0.13	0.04	0.86	0.23	58
International Falls	Sa	1996-1997	6703	2.86	1.97	42.55	5.40	57	0.07	0.04	0.77	0.14	57
Leon Township	S	1996-1997	942	2.04	1.89	4.73	0.51	54	0.10	0.04	1.30	0.21	54
Little Falls	S	1996-1997	7719	1.87	1.79	3.61	0.38	56	0.07	0.04	1.06	0.18	56
Pipestone	S	1996-1997	4280	1.80	1.80	2.08	0.14	47	0.09	0.04	0.91	0.18	47
Plymouth	S	1996-1997	65894	2.05	1.90	3.89	0.45	55	0.06	0.04	0.81	0.13	55
Wagner Township	S	1996-1997	320	1.93	1.80	4.60	0.62	51	0.07	0.04	0.65	0.12	51
Elk River	S	1997-1998	16447	1.57	1.61	2.40	0.22	58	0.02	0.02	0.09	0.01	58
Fergus Falls	S	1997-1998	13471	2.08	1.66	11.43	1.65	48	0.02	0.02	0.04	0.01	48
Granite Falls	S	1997-1998	3070	1.68	1.66	2.62	0.32	43	0.02	0.02	0.09	0.02	43
Hibbing	S	1997-1998	17071	1.72	1.70	2.25	0.20	59	0.02	0.02	0.07	0.01	59
Minneapolis	S	1997-1998	382618	1.79	1.61	11.96	1.45	55	0.02	0.02	0.07	0.01	55
Rochester	S	1997-1998	85806	1.72	1.71	4.38	0.47	56	0.02	0.02	0.04	0.01	56
Warroad	Sa	1997-1998	1722	1.86	1.77	3.56	0.35	47	0.02	0.02	0.09	0.01	47
Bemidji	Sa	1998-1999	11917	1.64	1.26	6.56	1.18	55	0.05	0.06	0.06	0.02	55
Duluth 7550	S	1998-1999	86918	1.25	1.25	1.65	0.25	60	0.05	0.06	0.06	0.02	60
St. Paul	S	1998-1999	287151	1.35	1.35	2.07	0.29	56	0.05	0.06	0.06	0.02	56
Holloway	S	1998-1999	112	1.25	1.31	2.02	0.27	54	0.05	0.06	0.06	0.02	54
Moorhead	S	1998-1999	32177	1.37	1.42	1.90	0.29	52	0.05	0.06	0.06	0.02	52
St. Cloud	S	1998-1999	59107	1.61	1.58	3.89	0.56	52	0.05	0.06	0.06	0.02	52
Winona	S	1998-1999	27069	1.34	1.31	2.33	0.30	51	0.05	0.06	0.06	0.02	51
Albert Lea	S	1999-2000	18356	1.68	1.60	3.84	0.39	54	0.11	0.09	0.19	0.04	54
Hutchinson	S	1999-2000	13080	1.47	1.45	1.78	0.12	57	0.11	0.09	0.19	0.04	57
Perham	S	1999-2000	2559	1.50	1.51	2.33	0.19	54	0.11	0.09	0.19	0.03	54
Silver Bay	Sa	1999-2000	2068	1.46	1.47	1.66	0.11	46	0.10	0.09	0.19	0.03	46
St. Michael	S	1999-2000	9099	1.60	1.53	2.48	0.27	60	0.11	0.09	0.19	0.03	60
Virginia	S	1999-2000	9157	1.45	1.45	1.74	0.12	58	0.11	0.09	0.19	0.04	58
West Lakeland	S	1999-2000	3547	1.43	1.44	1.98	0.14	59	0.11	0.09	0.19	0.04	59
Apple Valley	S	2000-2001	45527	1.48	1.51	1.99	0.19	42	0.24	0.28	0.28	0.05	43
Brandon Township	S	2000-2001	450	1.45	1.42	2.65	0.28	53	0.24	0.28	0.28	0.05	53
Duluth 7551	S	2000-2001	86918	1.41	1.38	1.84	0.22	51	0.24	0.28	0.28	0.05	55
Fort Ripley	S	2000-2001	74	1.45	1.42	1.97	0.24	49	0.24	0.28	0.28	0.05	49
Grand Rapids	Sa	2000-2001	7764	1.49	1.50	2.13	0.29	41	0.24	0.28	0.28	0.05	41
North Mankato	S	2000-2001	11798	1.40	1.38	2.07	0.24	32	0.26	0.28	0.28	0.04	32
Willmar	S	2000-2001	18351	1.35	1.32	2.28	0.23	54	0.23	0.28	0.28	0.05	54

Appendix D-1: VOC Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	1,1,1-Trichloroethane					1,2-Dichloroethane				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.75	0.66	1.59	0.30	58	0.10	0.08	0.57	0.12	58
International Falls	Sa	1996-1997	6703	0.82	0.69	3.46	0.50	57	0.07	0.07	0.16	0.04	57
Leon Township	S	1996-1997	942	0.91	0.64	10.21	1.37	54	0.08	0.07	0.25	0.05	54
Little Falls	S	1996-1997	7719	0.82	0.69	2.42	0.40	56	0.08	0.06	0.55	0.10	56
Pipestone	S	1996-1997	4280	0.70	0.65	1.75	0.31	47	0.09	0.06	0.51	0.11	47
Plymouth	S	1996-1997	65894	0.72	0.68	1.56	0.25	55	0.07	0.06	0.51	0.07	55
Wagner Township	S	1996-1997	320	1.19	0.57	27.27	3.73	51	0.08	0.06	0.38	0.07	51
Elk River	S	1997-1998	16447	0.51	0.51	0.88	0.11	58	0.04	0.04	0.11	0.03	58
Fergus Falls	S	1997-1998	13471	0.50	0.51	0.71	0.10	48	0.05	0.06	0.13	0.03	48
Granite Falls	S	1997-1998	3070	0.51	0.52	0.67	0.09	43	0.05	0.05	0.09	0.02	43
Hibbing	S	1997-1998	17071	0.48	0.51	0.65	0.09	59	0.05	0.05	0.10	0.02	59
Minneapolis	S	1997-1998	382618	0.56	0.55	1.40	0.17	55	0.04	0.02	0.13	0.03	55
Rochester	S	1997-1998	85806	0.50	0.51	0.72	0.10	56	0.05	0.05	0.09	0.02	56
Warroad	Sa	1997-1998	1722	0.56	0.51	2.94	0.37	47	0.05	0.05	0.09	0.02	47
Bemidji	Sa	1998-1999	11917	0.31	0.29	0.47	0.08	55	0.08	0.11	0.11	0.04	55
Duluth 7550	S	1998-1999	86918	0.31	0.29	0.54	0.09	60	0.08	0.11	0.16	0.04	60
St. Paul	S	1998-1999	287151	0.35	0.33	0.82	0.11	56	0.09	0.11	0.16	0.04	56
Holloway	S	1998-1999	112	0.30	0.29	0.51	0.08	54	0.08	0.11	0.11	0.04	54
Moorhead	S	1998-1999	32177	0.31	0.29	0.46	0.07	52	0.08	0.11	0.11	0.04	52
St. Cloud	S	1998-1999	59107	0.37	0.34	1.17	0.14	52	0.08	0.11	0.11	0.03	52
Winona	S	1998-1999	27069	0.37	0.34	0.94	0.14	51	0.09	0.11	0.11	0.04	51
Albert Lea	S	1999-2000	18356	0.30	0.30	0.36	0.03	54	0.05	0.04	0.10	0.02	54
Hutchinson	S	1999-2000	13080	0.30	0.30	0.38	0.03	57	0.05	0.04	0.11	0.02	57
Perham	S	1999-2000	2559	0.30	0.30	0.44	0.04	54	0.05	0.04	0.12	0.02	54
Silver Bay	Sa	1999-2000	2068	0.32	0.32	0.42	0.04	46	0.05	0.04	0.13	0.02	46
St. Michael	S	1999-2000	9099	0.30	0.30	0.62	0.06	60	0.05	0.04	0.13	0.02	60
Virginia	S	1999-2000	9157	0.32	0.31	0.64	0.07	58	0.05	0.04	0.12	0.02	58
West Lakeland	S	1999-2000	3547	0.30	0.30	0.57	0.05	59	0.05	0.04	0.13	0.02	59
Apple Valley	S	2000-2001	45527	0.25	0.23	0.62	0.17	43	0.13	0.16	0.16	0.04	43
Brandon Township	S	2000-2001	450	0.22	0.19	0.55	0.14	53	0.12	0.16	0.16	0.04	53
Duluth 7551	S	2000-2001	86918	0.22	0.19	0.49	0.14	55	0.12	0.16	0.16	0.04	55
Fort Ripley	S	2000-2001	74	0.20	0.17	0.52	0.15	49	0.12	0.16	0.16	0.04	49
Grand Rapids	Sa	2000-2001	7764	0.18	0.18	0.50	0.12	41	0.12	0.16	0.16	0.04	41
North Mankato	S	2000-2001	11798	0.15	0.08	0.52	0.16	32	0.15	0.16	0.16	0.03	32
Willmar	S	2000-2001	18351	0.23	0.19	0.53	0.16	54	0.12	0.16	0.16	0.04	54

Appendix D-1: VOC Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Tetrachloroethylene					1,1,2,2-Tetrachloroethane				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.34	0.24	2.85	0.38	58	0.09	0.07	0.51	0.09	58
International Falls	Sa	1996-1997	6703	0.46	0.22	3.19	0.59	57	0.08	0.07	0.23	0.05	57
Leon Township	S	1996-1997	942	0.28	0.22	0.99	0.20	54	0.07	0.06	0.24	0.05	54
Little Falls	S	1996-1997	7719	0.31	0.24	2.31	0.33	56	0.09	0.07	0.70	0.10	56
Pipestone	S	1996-1997	4280	0.28	0.22	0.92	0.19	47	0.11	0.07	0.47	0.09	47
Plymouth	S	1996-1997	65894	0.37	0.27	1.42	0.26	55	0.10	0.08	0.48	0.09	55
Wagner Township	S	1996-1997	320	0.33	0.17	4.31	0.62	51	0.14	0.08	0.92	0.19	51
Elk River	S	1997-1998	16447	0.20	0.18	0.51	0.09	58	0.03	0.02	0.12	0.02	58
Fergus Falls	S	1997-1998	13471	0.68	0.56	2.53	0.54	48	0.03	0.02	0.14	0.02	48
Granite Falls	S	1997-1998	3070	0.20	0.18	0.72	0.11	43	0.03	0.03	0.08	0.02	43
Hibbing	S	1997-1998	17071	0.28	0.21	1.36	0.23	59	0.03	0.02	0.25	0.04	59
Minneapolis	S	1997-1998	382618	0.41	0.34	2.43	0.36	55	0.05	0.03	0.49	0.07	55
Rochester	S	1997-1998	85806	0.29	0.21	1.13	0.22	56	0.03	0.02	0.13	0.02	56
Warroad	Sa	1997-1998	1722	0.18	0.15	0.50	0.08	47	0.04	0.03	0.34	0.05	47
Bemidji	Sa	1998-1999	11917	0.36	0.08	3.48	0.68	55	0.08	0.09	0.26	0.05	55
Duluth 7550	S	1998-1999	86918	0.14	0.08	2.02	0.26	60	0.11	0.09	0.51	0.11	60
St. Paul	S	1998-1999	287151	0.19	0.08	1.11	0.22	56	0.11	0.09	0.59	0.12	56
Holloway	S	1998-1999	112	0.08	0.08	0.16	0.03	54	0.08	0.09	0.39	0.06	54
Moorhead	S	1998-1999	32177	0.12	0.08	0.55	0.10	52	0.07	0.09	0.36	0.05	52
St. Cloud	S	1998-1999	59107	0.17	0.08	2.60	0.35	52	0.09	0.09	0.41	0.08	52
Winona	S	1998-1999	27069	0.17	0.08	1.72	0.26	51	0.08	0.09	0.35	0.06	51
Albert Lea	S	1999-2000	18356	0.07	0.05	0.13	0.03	54	0.10	0.09	0.30	0.03	54
Hutchinson	S	1999-2000	13080	0.07	0.05	0.13	0.03	57	0.11	0.09	0.42	0.05	57
Perham	S	1999-2000	2559	0.06	0.05	0.13	0.03	54	0.11	0.09	0.33	0.04	54
Silver Bay	Sa	1999-2000	2068	0.06	0.05	0.26	0.04	46	0.10	0.09	0.34	0.04	46
St. Michael	S	1999-2000	9099	0.06	0.05	0.13	0.03	60	0.11	0.09	0.39	0.04	60
Virginia	S	1999-2000	9157	0.07	0.05	0.13	0.03	58	0.11	0.09	0.36	0.05	58
West Lakeland	S	1999-2000	3547	0.06	0.05	0.13	0.03	59	0.11	0.09	0.34	0.05	59
Apple Valley	S	2000-2001	45527	0.14	0.15	0.15	0.01	43	0.15	0.18	0.18	0.03	43
Brandon Township	S	2000-2001	450	0.14	0.15	0.15	0.01	53	0.15	0.18	0.18	0.04	53
Duluth 7551	S	2000-2001	86918	0.14	0.15	0.15	0.01	55	0.15	0.18	0.18	0.04	55
Fort Ripley	S	2000-2001	74	0.14	0.15	0.15	0.01	49	0.15	0.18	0.18	0.04	49
Grand Rapids	Sa	2000-2001	7764	0.21	0.15	2.69	0.40	41	0.15	0.18	0.18	0.04	41
North Mankato	S	2000-2001	11798	0.15	0.15	0.15	0.01	32	0.17	0.18	0.18	0.03	32
Willmar	S	2000-2001	18351	0.14	0.15	0.28	0.02	54	0.15	0.18	0.18	0.04	54

Appendix D-1: VOC Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Methyl bromide					1,1,2-Trichloroethane				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.12	0.10	0.41	0.08	58	0.088	0.038	0.546	0.125	58
International Falls	Sa	1996-1997	6703	0.11	0.12	0.17	0.04	57	0.068	0.044	0.398	0.064	57
Leon Township	S	1996-1997	942	0.12	0.11	0.29	0.05	54	0.059	0.038	0.475	0.068	54
Little Falls	S	1996-1997	7719	0.11	0.10	0.22	0.04	56	0.080	0.044	0.589	0.109	56
Pipestone	S	1996-1997	4280	0.13	0.10	0.37	0.07	47	0.112	0.071	0.507	0.119	47
Plymouth	S	1996-1997	65894	0.13	0.10	0.60	0.09	55	0.065	0.044	0.355	0.063	55
Wagner Township	S	1996-1997	320	0.13	0.10	0.55	0.11	51	0.064	0.044	0.327	0.073	51
Elk River	S	1997-1998	16447	0.06	0.06	0.15	0.02	58	0.024	0.022	0.049	0.009	58
Fergus Falls	S	1997-1998	13471	0.06	0.06	0.11	0.02	48	0.024	0.022	0.066	0.010	48
Granite Falls	S	1997-1998	3070	0.08	0.07	0.31	0.05	43	0.022	0.022	0.049	0.007	43
Hibbing	S	1997-1998	17071	0.06	0.06	0.10	0.02	59	0.022	0.022	0.044	0.006	59
Minneapolis	S	1997-1998	382618	0.11	0.06	2.07	0.28	55	0.024	0.022	0.055	0.009	55
Rochester	S	1997-1998	85806	0.06	0.07	0.11	0.02	56	0.021	0.022	0.044	0.007	56
Warroad	Sa	1997-1998	1722	0.06	0.06	0.10	0.02	47	0.021	0.022	0.049	0.006	47
Bemidji	Sa	1998-1999	11917	0.04	0.05	0.09	0.02	55	0.066	0.080	0.098	0.026	55
Duluth 7550	S	1998-1999	86918	0.04	0.05	0.08	0.02	60	0.069	0.080	0.169	0.033	60
St. Paul	S	1998-1999	287151	0.05	0.05	0.13	0.02	56	0.074	0.080	0.322	0.048	56
Holloway	S	1998-1999	112	0.05	0.05	0.12	0.02	54	0.068	0.080	0.136	0.027	54
Moorhead	S	1998-1999	32177	0.04	0.05	0.19	0.03	52	0.064	0.080	0.080	0.027	52
St. Cloud	S	1998-1999	59107	0.04	0.05	0.10	0.02	52	0.067	0.080	0.153	0.029	52
Winona	S	1998-1999	27069	0.04	0.05	0.08	0.02	51	0.069	0.080	0.120	0.025	51
Albert Lea	S	1999-2000	18356	0.04	0.06	0.08	0.02	54	0.087	0.090	0.090	0.008	54
Hutchinson	S	1999-2000	13080	0.05	0.06	0.08	0.02	57	0.090	0.090	0.153	0.013	57
Perham	S	1999-2000	2559	0.05	0.06	0.08	0.02	54	0.089	0.090	0.136	0.009	54
Silver Bay	Sa	1999-2000	2068	0.04	0.06	0.08	0.02	46	0.089	0.090	0.098	0.004	46
St. Michael	S	1999-2000	9099	0.05	0.05	0.26	0.03	60	0.088	0.090	0.142	0.010	60
Virginia	S	1999-2000	9157	0.05	0.06	0.08	0.02	58	0.089	0.090	0.115	0.008	58
West Lakeland	S	1999-2000	3547	0.05	0.06	0.11	0.02	59	0.089	0.090	0.142	0.010	59
Apple Valley	S	2000-2001	45527	0.12	0.16	0.16	0.05	43	0.111	0.134	0.134	0.029	43
Brandon Township	S	2000-2001	450	0.11	0.08	0.16	0.05	53	0.106	0.134	0.134	0.029	53
Duluth 7551	S	2000-2001	86918	0.12	0.16	0.16	0.04	55	0.106	0.134	0.134	0.029	55
Fort Ripley	S	2000-2001	74	0.12	0.16	0.16	0.04	48	0.108	0.134	0.134	0.029	49
Grand Rapids	Sa	2000-2001	7764	0.12	0.16	0.16	0.05	41	0.108	0.134	0.134	0.029	41
North Mankato	S	2000-2001	11798	0.14	0.16	0.16	0.03	32	0.123	0.134	0.134	0.023	32
Willmar	S	2000-2001	18351	0.12	0.16	0.16	0.04	54	0.106	0.134	0.134	0.029	54

Appendix D-1: VOC Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Dichlorodifluoromethane (Freon 12)					Trichloroethylene				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	3.013	3.081	5.049	0.500	58	0.590	0.419	2.080	0.458	58
International Falls	Sa	1996-1997	6703	2.999	3.076	4.080	0.547	57	0.340	0.215	1.757	0.300	57
Leon Township	S	1996-1997	942	3.022	3.071	3.645	0.418	54	0.642	0.521	2.203	0.498	54
Little Falls	S	1996-1997	7719	3.017	3.036	6.735	0.657	56	1.655	1.102	14.198	2.023	56
Pipestone	S	1996-1997	4280	3.002	2.997	4.283	0.431	47	1.653	0.478	14.708	2.882	47
Plymouth	S	1996-1997	65894	3.238	3.229	4.431	0.523	55	1.276	0.849	5.734	1.173	55
Wagner Township	S	1996-1997	320	2.958	3.056	3.887	0.423	51	0.628	0.333	3.918	0.829	51
Elk River	S	1997-1998	16447	2.797	2.913	4.114	0.503	58	0.313	0.285	1.338	0.201	58
Fergus Falls	S	1997-1998	13471	2.726	2.834	4.154	0.557	48	0.254	0.226	0.854	0.189	48
Granite Falls	S	1997-1998	3070	2.805	2.933	3.749	0.477	43	0.167	0.108	0.666	0.163	43
Hibbing	S	1997-1998	17071	2.849	2.923	3.650	0.452	59	0.131	0.091	0.537	0.099	59
Minneapolis	S	1997-1998	382618	2.956	3.002	4.411	0.528	55	0.305	0.263	1.295	0.201	55
Rochester	S	1997-1998	85806	2.984	3.061	4.233	0.540	56	0.209	0.194	0.554	0.124	56
Warroad	Sa	1997-1998	1722	2.929	2.898	3.595	0.330	47	0.853	0.468	2.768	0.820	47
Bemidji	Sa	1998-1999	11917	2.299	2.428	3.150	0.440	55	0.119	0.161	0.849	0.117	55
Duluth 7550	S	1998-1999	86918	2.349	2.369	3.180	0.442	60	0.154	0.161	0.516	0.094	60
St. Paul	S	1998-1999	287151	2.511	2.532	3.570	0.495	56	0.303	0.210	1.386	0.268	56
Holloway	S	1998-1999	112	2.183	2.191	3.051	0.409	54	0.196	0.161	0.747	0.154	54
Moorhead	S	1998-1999	32177	2.276	2.265	3.066	0.399	52	0.103	0.124	0.161	0.057	52
St. Cloud	S	1998-1999	59107	2.657	2.651	4.377	0.563	52	0.121	0.145	0.269	0.072	52
Winona	S	1998-1999	27069	2.439	2.468	3.333	0.486	51	0.182	0.161	1.069	0.174	51
Albert Lea	S	1999-2000	18356	2.809	2.799	3.709	0.295	54	0.567	0.339	2.966	0.559	54
Hutchinson	S	1999-2000	13080	2.800	2.769	3.284	0.219	57	1.680	0.220	27.622	4.610	57
Perham	S	1999-2000	2559	2.719	2.700	3.249	0.234	54	0.135	0.108	2.429	0.322	54
Silver Bay	Sa	1999-2000	2068	2.764	2.735	3.175	0.213	46	0.135	0.127	0.672	0.106	46
St. Michael	S	1999-2000	9099	2.767	2.715	3.669	0.274	60	0.116	0.127	0.408	0.077	60
Virginia	S	1999-2000	9157	2.733	2.715	3.412	0.233	58	0.139	0.118	1.376	0.180	58
West Lakeland	S	1999-2000	3547	2.728	2.700	3.511	0.267	59	0.222	0.204	0.726	0.133	59
Apple Valley	S	2000-2001	45527	2.594	2.621	3.269	0.314	43	0.218	0.177	2.354	0.343	44
Brandon Township	S	2000-2001	450	2.411	2.413	3.051	0.304	53	0.169	0.102	0.854	0.132	53
Duluth 7551	S	2000-2001	86918	2.451	2.423	3.274	0.358	55	0.151	0.177	0.634	0.079	55
Fort Ripley	S	2000-2001	74	2.430	2.408	3.294	0.311	47	0.139	0.177	0.177	0.042	49
Grand Rapids	Sa	2000-2001	7764	2.521	2.458	3.274	0.383	41	0.143	0.177	0.220	0.048	40
North Mankato	S	2000-2001	11798	2.452	2.428	3.442	0.418	31	0.201	0.177	1.419	0.224	34
Willmar	S	2000-2001	18351	2.429	2.473	3.017	0.331	53	0.147	0.118	0.683	0.090	54

Appendix D-1: VOC Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	1,1-Dichloroethylene					1,2-Dichloropropane				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.154	0.115	0.611	0.144	58	0.090	0.047	1.382	0.220	58
International Falls	Sa	1996-1997	6703	0.201	0.123	1.043	0.220	57	0.103	0.047	1.349	0.218	57
Leon Township	S	1996-1997	942	0.190	0.127	0.956	0.183	54	0.043	0.047	0.079	0.015	54
Little Falls	S	1996-1997	7719	0.162	0.119	0.611	0.135	56	0.058	0.047	0.772	0.100	56
Pipestone	S	1996-1997	4280	0.138	0.099	0.595	0.126	47	0.090	0.047	0.592	0.121	47
Plymouth	S	1996-1997	65894	0.146	0.103	0.642	0.118	55	0.071	0.047	1.192	0.158	55
Wagner Township	S	1996-1997	320	0.170	0.079	2.403	0.346	51	0.067	0.047	0.712	0.123	51
Elk River	S	1997-1998	16447	0.047	0.048	0.083	0.019	58	0.024	0.026	0.046	0.008	58
Fergus Falls	S	1997-1998	13471	0.042	0.040	0.103	0.023	48	0.027	0.026	0.069	0.012	48
Granite Falls	S	1997-1998	3070	0.064	0.052	0.341	0.061	43	0.026	0.026	0.065	0.011	43
Hibbing	S	1997-1998	17071	0.039	0.044	0.095	0.019	59	0.028	0.026	0.065	0.009	59
Minneapolis	S	1997-1998	382618	0.053	0.044	0.412	0.058	55	0.024	0.026	0.060	0.009	55
Rochester	S	1997-1998	85806	0.046	0.044	0.198	0.031	56	0.022	0.026	0.032	0.009	56
Warroad	Sa	1997-1998	1722	0.043	0.040	0.293	0.041	47	0.026	0.026	0.051	0.008	47
Bemidji	Sa	1998-1999	11917	0.057	0.071	0.071	0.024	55	0.086	0.107	0.107	0.036	55
Duluth 7550	S	1998-1999	86918	0.056	0.071	0.071	0.025	60	0.084	0.107	0.107	0.037	60
St. Paul	S	1998-1999	287151	0.057	0.071	0.071	0.023	56	0.085	0.107	0.107	0.036	56
Holloway	S	1998-1999	112	0.060	0.071	0.111	0.024	54	0.089	0.107	0.107	0.034	54
Moorhead	S	1998-1999	32177	0.055	0.071	0.071	0.025	52	0.083	0.107	0.107	0.037	52
St. Cloud	S	1998-1999	59107	0.056	0.071	0.079	0.025	52	0.083	0.107	0.107	0.037	52
Winona	S	1998-1999	27069	0.059	0.071	0.071	0.023	51	0.089	0.107	0.107	0.033	51
Albert Lea	S	1999-2000	18356	0.079	0.070	0.125	0.024	54	0.147	0.154	0.154	0.019	54
Hutchinson	S	1999-2000	13080	0.079	0.070	0.125	0.021	57	0.148	0.154	0.154	0.016	57
Perham	S	1999-2000	2559	0.077	0.070	0.125	0.019	54	0.149	0.154	0.154	0.013	54
Silver Bay	Sa	1999-2000	2068	0.074	0.070	0.125	0.018	46	0.151	0.154	0.154	0.006	46
St. Michael	S	1999-2000	9099	0.079	0.070	0.125	0.020	60	0.150	0.154	0.154	0.008	60
Virginia	S	1999-2000	9157	0.076	0.070	0.125	0.023	58	0.146	0.154	0.154	0.023	58
West Lakeland	S	1999-2000	3547	0.079	0.070	0.125	0.022	59	0.148	0.154	0.154	0.018	59
Apple Valley	S	2000-2001	45527	0.136	0.143	0.143	0.009	42	0.307	0.421	0.421	0.142	43
Brandon Township	S	2000-2001	450	0.134	0.143	0.143	0.009	53	0.285	0.421	0.421	0.145	53
Duluth 7551	S	2000-2001	86918	0.134	0.143	0.143	0.009	55	0.285	0.421	0.421	0.145	55
Fort Ripley	S	2000-2001	74	0.135	0.143	0.143	0.009	49	0.292	0.421	0.421	0.144	49
Grand Rapids	Sa	2000-2001	7764	0.135	0.143	0.143	0.009	41	0.295	0.421	0.421	0.144	41
North Mankato	S	2000-2001	11798	0.140	0.143	0.143	0.007	32	0.367	0.421	0.421	0.114	32
Willmar	S	2000-2001	18351	0.134	0.143	0.143	0.009	54	0.283	0.421	0.421	0.145	54

Appendix D-1: VOC Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	trans-1,3-Dichloropropene					cis-1,3-Dichloropropene				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.125	0.137	0.713	0.124	58	0.043	0.044	0.318	0.040	58
International Falls	Sa	1996-1997	6703	0.123	0.123	1.484	0.191	57	0.057	0.041	0.989	0.131	57
Leon Township	S	1996-1997	942	0.112	0.137	0.427	0.069	54	0.042	0.044	0.118	0.021	54
Little Falls	S	1996-1997	7719	0.120	0.137	0.368	0.074	56	0.044	0.044	0.222	0.031	56
Pipestone	S	1996-1997	4280	0.106	0.100	0.676	0.095	47	0.048	0.044	0.340	0.050	47
Plymouth	S	1996-1997	65894	0.095	0.095	0.291	0.058	55	0.040	0.041	0.114	0.024	55
Wagner Township	S	1996-1997	320	0.109	0.137	0.327	0.062	51	0.046	0.044	0.145	0.030	51
Elk River	S	1997-1998	16447	0.093	0.092	0.404	0.053	58	0.023	0.015	0.123	0.022	58
Fergus Falls	S	1997-1998	13471	0.097	0.092	0.300	0.050	48	0.022	0.015	0.082	0.016	48
Granite Falls	S	1997-1998	3070	0.118	0.092	0.808	0.124	43	0.022	0.015	0.104	0.019	43
Hibbing	S	1997-1998	17071	0.096	0.092	0.418	0.061	59	0.025	0.015	0.159	0.024	59
Minneapolis	S	1997-1998	382618	0.091	0.092	0.295	0.059	55	0.026	0.015	0.163	0.027	55
Rochester	S	1997-1998	85806	0.094	0.092	0.449	0.071	56	0.026	0.015	0.218	0.034	56
Warroad	Sa	1997-1998	1722	0.086	0.092	0.390	0.055	47	0.016	0.015	0.036	0.007	47
Bemidji	Sa	1998-1999	11917	0.084	0.061	0.822	0.103	55	0.086	0.094	0.336	0.059	55
Duluth 7550	S	1998-1999	86918	0.077	0.061	0.236	0.035	60	0.074	0.094	0.163	0.037	60
St. Paul	S	1998-1999	287151	0.078	0.061	0.300	0.045	56	0.078	0.094	0.200	0.041	56
Holloway	S	1998-1999	112	0.068	0.061	0.092	0.013	54	0.082	0.094	0.327	0.047	54
Moorhead	S	1998-1999	32177	0.072	0.061	0.154	0.018	52	0.071	0.094	0.094	0.036	52
St. Cloud	S	1998-1999	59107	0.076	0.061	0.227	0.030	52	0.074	0.094	0.150	0.037	52
Winona	S	1998-1999	27069	0.097	0.061	1.457	0.195	51	0.077	0.094	0.094	0.033	51
Albert Lea	S	1999-2000	18356	0.084	0.086	0.145	0.012	54	0.118	0.135	0.135	0.034	54
Hutchinson	S	1999-2000	13080	0.087	0.086	0.227	0.024	57	0.120	0.135	0.150	0.034	57
Perham	S	1999-2000	2559	0.085	0.086	0.168	0.013	54	0.122	0.135	0.135	0.030	54
Silver Bay	Sa	1999-2000	2068	0.086	0.086	0.168	0.015	46	0.126	0.135	0.135	0.026	46
St. Michael	S	1999-2000	9099	0.084	0.086	0.173	0.013	60	0.120	0.135	0.135	0.033	60
Virginia	S	1999-2000	9157	0.086	0.086	0.163	0.016	58	0.117	0.135	0.135	0.034	58
West Lakeland	S	1999-2000	3547	0.086	0.086	0.204	0.019	59	0.119	0.135	0.135	0.033	59
Apple Valley	S	2000-2001	45527	0.136	0.180	0.180	0.055	43	0.134	0.192	0.192	0.071	43
Brandon Township	S	2000-2001	450	0.127	0.180	0.180	0.056	53	0.123	0.192	0.192	0.073	53
Duluth 7551	S	2000-2001	86918	0.127	0.180	0.180	0.056	55	0.123	0.192	0.192	0.073	55
Fort Ripley	S	2000-2001	74	0.130	0.180	0.180	0.056	49	0.127	0.192	0.192	0.073	49
Grand Rapids	Sa	2000-2001	7764	0.131	0.180	0.180	0.056	41	0.128	0.192	0.192	0.073	41
North Mankato	S	2000-2001	11798	0.159	0.180	0.180	0.044	32	0.164	0.192	0.192	0.057	32
Willmar	S	2000-2001	18351	0.126	0.180	0.180	0.056	54	0.122	0.192	0.192	0.073	54

Appendix D-1: VOC Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	cis-1,2-Dichloroethene					Ethylene dibromide				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.103	0.052	0.789	0.195	58	0.057	0.038	0.223	0.053	58
International Falls	Sa	1996-1997	6703	0.065	0.040	0.741	0.134	57	0.046	0.038	0.161	0.033	57
Leon Township	S	1996-1997	942	0.080	0.040	0.960	0.165	54	0.054	0.038	0.215	0.047	54
Little Falls	S	1996-1997	7719	0.074	0.060	0.793	0.145	56	0.072	0.038	0.453	0.075	56
Pipestone	S	1996-1997	4280	0.114	0.063	0.789	0.196	47	0.069	0.054	0.215	0.050	47
Plymouth	S	1996-1997	65894	0.065	0.024	0.900	0.154	55	0.051	0.038	0.238	0.047	55
Wagner Township	S	1996-1997	320	0.044	0.032	0.226	0.047	51	0.071	0.031	0.538	0.107	51
Elk River	S	1997-1998	16447	0.017	0.017	0.075	0.010	58	0.028	0.023	0.123	0.024	58
Fergus Falls	S	1997-1998	13471	0.024	0.017	0.424	0.059	48	0.026	0.023	0.138	0.023	48
Granite Falls	S	1997-1998	3070	0.015	0.017	0.067	0.010	43	0.026	0.016	0.077	0.018	43
Hibbing	S	1997-1998	17071	0.016	0.017	0.040	0.005	59	0.027	0.016	0.123	0.021	59
Minneapolis	S	1997-1998	382618	0.015	0.017	0.036	0.007	55	0.028	0.023	0.115	0.024	55
Rochester	S	1997-1998	85806	0.015	0.017	0.044	0.007	56	0.022	0.015	0.108	0.017	56
Warroad	Sa	1997-1998	1722	0.016	0.017	0.060	0.009	47	0.021	0.015	0.054	0.012	47
Bemidji	Sa	1998-1999	11917	0.057	0.071	0.071	0.024	55	0.082	0.105	0.238	0.058	55
Duluth 7550	S	1998-1999	86918	0.056	0.071	0.071	0.025	60	0.090	0.105	0.353	0.077	60
St. Paul	S	1998-1999	287151	0.057	0.071	0.071	0.024	56	0.092	0.105	0.384	0.075	56
Holloway	S	1998-1999	112	0.059	0.071	0.071	0.023	54	0.082	0.105	0.246	0.050	54
Moorhead	S	1998-1999	32177	0.056	0.071	0.071	0.025	52	0.079	0.105	0.507	0.078	52
St. Cloud	S	1998-1999	59107	0.055	0.071	0.071	0.025	52	0.083	0.105	0.323	0.063	52
Winona	S	1998-1999	27069	0.059	0.071	0.071	0.023	51	0.078	0.105	0.238	0.051	51
Albert Lea	S	1999-2000	18356	0.087	0.071	0.157	0.034	54	0.070	0.078	0.246	0.042	54
Hutchinson	S	1999-2000	13080	0.086	0.071	0.157	0.033	57	0.076	0.078	0.300	0.052	57
Perham	S	1999-2000	2559	0.082	0.071	0.157	0.029	54	0.078	0.078	0.254	0.050	54
Silver Bay	Sa	1999-2000	2068	0.080	0.071	0.157	0.027	46	0.084	0.078	0.238	0.044	46
St. Michael	S	1999-2000	9099	0.085	0.071	0.157	0.032	60	0.076	0.078	0.261	0.049	60
Virginia	S	1999-2000	9157	0.086	0.071	0.157	0.033	58	0.079	0.078	0.254	0.050	58
West Lakeland	S	1999-2000	3547	0.085	0.071	0.157	0.032	59	0.076	0.078	0.300	0.051	59
Apple Valley	S	2000-2001	45527	0.183	0.201	0.201	0.022	42	0.186	0.264	0.264	0.097	43
Brandon Township	S	2000-2001	450	0.180	0.201	0.201	0.022	53	0.172	0.264	0.264	0.098	53
Duluth 7551	S	2000-2001	86918	0.180	0.201	0.201	0.022	55	0.171	0.264	0.264	0.099	55
Fort Ripley	S	2000-2001	74	0.181	0.201	0.201	0.022	49	0.177	0.264	0.264	0.097	49
Grand Rapids	Sa	2000-2001	7764	0.182	0.201	0.201	0.022	41	0.179	0.264	0.264	0.097	41
North Mankato	S	2000-2001	11798	0.193	0.201	0.201	0.018	32	0.227	0.264	0.264	0.077	32
Willmar	S	2000-2001	18351	0.180	0.201	0.201	0.022	54	0.169	0.264	0.264	0.100	54

Appendix D-1: VOC Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Hexachlorobutadiene					Vinyl chloride				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.232	0.192	0.907	0.173	58	0.016	0.014	0.035	0.005	58
International Falls	Sa	1996-1997	6703	0.255	0.192	1.088	0.201	57	0.019	0.014	0.171	0.021	57
Leon Township	S	1996-1997	942	0.250	0.181	1.205	0.240	54	0.016	0.014	0.035	0.005	54
Little Falls	S	1996-1997	7719	0.310	0.181	2.901	0.411	56	0.018	0.014	0.087	0.012	56
Pipestone	S	1996-1997	4280	0.281	0.181	0.949	0.216	47	0.016	0.014	0.035	0.006	47
Plymouth	S	1996-1997	65894	0.246	0.160	1.813	0.321	55	0.016	0.014	0.035	0.005	55
Wagner Township	S	1996-1997	320	0.402	0.160	2.730	0.624	51	0.016	0.014	0.035	0.005	51
Elk River	S	1997-1998	16447	0.189	0.139	0.853	0.156	58	0.025	0.035	0.035	0.012	58
Fergus Falls	S	1997-1998	13471	0.189	0.149	0.917	0.145	48	0.026	0.035	0.036	0.012	48
Granite Falls	S	1997-1998	3070	0.174	0.139	0.405	0.087	43	0.026	0.035	0.038	0.013	43
Hibbing	S	1997-1998	17071	0.176	0.128	0.981	0.151	59	0.026	0.035	0.035	0.012	59
Minneapolis	S	1997-1998	382618	0.195	0.149	0.832	0.156	55	0.026	0.035	0.035	0.012	55
Rochester	S	1997-1998	85806	0.170	0.139	0.971	0.131	56	0.027	0.035	0.035	0.013	56
Warroad	Sa	1997-1998	1722	0.161	0.128	0.416	0.082	47	0.028	0.035	0.035	0.010	47
Bemidji	Sa	1998-1999	11917	0.390	0.169	2.272	0.448	55	0.064	0.075	0.075	0.019	55
Duluth 7550	S	1998-1999	86918	0.432	0.169	2.122	0.529	60	0.063	0.075	0.075	0.020	60
St. Paul	S	1998-1999	287151	0.405	0.169	2.549	0.529	56	0.064	0.075	0.075	0.019	56
Holloway	S	1998-1999	112	0.257	0.169	2.016	0.350	54	0.066	0.075	0.075	0.017	54
Moorhead	S	1998-1999	32177	0.225	0.169	1.131	0.215	52	0.063	0.075	0.075	0.020	52
St. Cloud	S	1998-1999	59107	0.339	0.169	1.781	0.407	52	0.064	0.075	0.075	0.018	52
Winona	S	1998-1999	27069	0.249	0.169	1.472	0.252	51	0.065	0.075	0.075	0.019	51
Albert Lea	S	1999-2000	18356	0.313	0.139	2.090	0.445	54	0.087	0.088	0.092	0.011	54
Hutchinson	S	1999-2000	13080	0.287	0.128	2.080	0.400	57	0.089	0.088	0.092	0.001	57
Perham	S	1999-2000	2559	0.316	0.181	1.664	0.355	54	0.088	0.088	0.092	0.001	54
Silver Bay	Sa	1999-2000	2068	0.343	0.090	2.016	0.478	46	0.087	0.088	0.092	0.012	46
St. Michael	S	1999-2000	9099	0.366	0.171	2.261	0.502	60	0.088	0.088	0.092	0.001	60
Virginia	S	1999-2000	9157	0.410	0.224	2.208	0.443	58	0.089	0.088	0.092	0.001	58
West Lakeland	S	1999-2000	3547	0.310	0.171	1.888	0.398	59	0.089	0.088	0.092	0.001	59
Apple Valley	S	2000-2001	45527	0.300	0.412	0.459	0.151	43	0.131	0.157	0.157	0.032	43
Brandon Township	S	2000-2001	450	0.266	0.412	0.412	0.152	51	0.126	0.157	0.157	0.033	53
Duluth 7551	S	2000-2001	86918	0.276	0.412	0.544	0.156	55	0.126	0.157	0.157	0.033	55
Fort Ripley	S	2000-2001	74	0.273	0.412	0.412	0.155	49	0.128	0.157	0.157	0.033	49
Grand Rapids	Sa	2000-2001	7764	0.273	0.412	0.412	0.155	40	0.128	0.157	0.157	0.033	41
North Mankato	S	2000-2001	11798	0.354	0.412	0.412	0.122	32	0.145	0.157	0.157	0.026	32
Willmar	S	2000-2001	18351	0.292	0.412	1.045	0.183	54	0.126	0.157	0.157	0.033	54

Appendix D-1: VOC Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	(p&m)-Xylene					Benzene				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	1.364	1.324	3.352	0.576	58	1.220	1.016	3.000	0.570	58
International Falls	Sa	1996-1997	6703	1.709	1.290	8.098	1.327	57	1.366	0.978	6.437	1.147	57
Leon Township	S	1996-1997	942	0.564	0.530	1.359	0.190	54	0.649	0.601	1.527	0.304	54
Little Falls	S	1996-1997	7719	0.968	0.903	2.297	0.437	56	0.903	0.780	2.240	0.450	56
Pipestone	S	1996-1997	4280	0.973	0.786	2.605	0.532	47	0.822	0.764	1.971	0.353	47
Plymouth	S	1996-1997	65894	1.679	1.529	6.848	1.117	55	1.309	1.163	5.591	0.745	55
Wagner Township	S	1996-1997	320	0.598	0.486	1.746	0.380	51	0.681	0.642	1.565	0.327	51
Elk River	S	1997-1998	16447	1.037	0.860	3.526	0.752	58	0.947	0.821	2.891	0.537	58
Fergus Falls	S	1997-1998	13471	1.370	1.246	7.078	1.049	48	1.189	1.105	2.757	0.449	48
Granite Falls	S	1997-1998	3070	0.627	0.552	2.084	0.330	43	0.933	0.732	6.661	1.014	43
Hibbing	S	1997-1998	17071	1.132	0.899	4.342	0.818	59	1.016	0.866	2.933	0.510	59
Minneapolis	S	1997-1998	382618	2.433	1.689	11.607	2.223	55	1.390	1.204	3.696	0.632	55
Rochester	S	1997-1998	85806	1.232	0.990	3.708	0.754	56	1.108	0.952	2.297	0.462	56
Warroad	Sa	1997-1998	1722	0.603	0.504	2.440	0.425	47	0.640	0.620	1.949	0.321	47
Bemidji	Sa	1998-1999	11917	1.373	1.246	4.069	0.770	55	1.229	0.920	4.498	0.775	55
Duluth 7550	S	1998-1999	86918	0.865	0.686	2.536	0.480	60	0.864	0.764	2.406	0.469	60
St. Paul	S	1998-1999	287151	2.068	1.659	6.027	1.415	56	1.698	1.383	5.712	1.109	56
Holloway	S	1998-1999	112	0.287	0.235	1.516	0.232	54	0.467	0.409	1.192	0.218	54
Moorhead	S	1998-1999	32177	0.867	0.725	2.905	0.577	52	0.978	0.917	2.747	0.466	52
St. Cloud	S	1998-1999	59107	1.254	1.029	4.208	0.907	52	1.101	0.958	4.006	0.784	52
Winona	S	1998-1999	27069	1.547	1.281	7.273	1.029	51	1.360	1.038	6.869	1.048	51
Albert Lea	S	1999-2000	18356	1.350	1.177	3.639	0.706	54	1.063	0.949	5.332	0.696	54
Hutchinson	S	1999-2000	13080	1.037	0.882	3.235	0.569	57	0.849	0.722	2.083	0.418	57
Perham	S	1999-2000	2559	0.509	0.447	1.785	0.310	54	0.581	0.537	1.265	0.269	54
Silver Bay	Sa	1999-2000	2068	0.609	0.578	1.702	0.311	46	0.546	0.508	1.272	0.261	46
St. Michael	S	1999-2000	9099	0.907	0.690	2.601	0.582	60	0.710	0.626	1.949	0.372	60
Virginia	S	1999-2000	9157	1.139	0.925	4.060	0.681	58	0.872	0.757	2.259	0.456	58
West Lakeland	S	1999-2000	3547	0.711	0.638	2.076	0.387	59	0.697	0.649	1.489	0.308	59
Apple Valley	S	2000-2001	45527	0.858	0.795	2.024	0.448	43	1.033	0.942	2.208	0.449	40
Brandon Township	S	2000-2001	450	0.279	0.204	1.177	0.224	53	0.520	0.511	1.335	0.228	48
Duluth 7551	S	2000-2001	86918	1.172	0.934	4.408	0.786	55	1.132	1.016	3.329	0.590	53
Fort Ripley	S	2000-2001	74	0.366	0.200	2.419	0.444	49	0.635	0.534	2.712	0.472	48
Grand Rapids	Sa	2000-2001	7764	1.049	0.821	3.027	0.698	41	1.087	0.923	3.313	0.635	38
North Mankato	S	2000-2001	11798	0.595	0.569	1.824	0.341	32	0.572	0.524	1.313	0.274	28
Willmar	S	2000-2001	18351	0.779	0.647	3.213	0.567	54	0.872	0.741	2.763	0.543	52

Appendix D-1: VOC Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Toluene					Ethylbenzene				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	2.083	1.963	4.933	0.960	58	0.442	0.417	1.073	0.188	58
International Falls	Sa	1996-1997	6703	2.345	1.794	11.788	1.958	57	0.523	0.404	2.545	0.406	57
Leon Township	S	1996-1997	942	0.881	0.859	2.061	0.360	54	0.197	0.182	0.478	0.073	54
Little Falls	S	1996-1997	7719	1.631	1.345	4.812	0.878	56	0.319	0.282	0.682	0.133	56
Pipestone	S	1996-1997	4280	1.626	1.315	5.860	1.018	47	0.343	0.287	0.929	0.185	47
Plymouth	S	1996-1997	65894	2.720	2.220	14.241	2.129	55	0.523	0.482	2.102	0.332	55
Wagner Township	S	1996-1997	320	0.817	0.675	2.012	0.431	51	0.207	0.161	0.721	0.139	51
Elk River	S	1997-1998	16447	1.714	1.376	5.675	1.139	58	0.331	0.269	1.233	0.233	58
Fergus Falls	S	1997-1998	13471	2.391	2.276	7.337	1.171	48	0.425	0.378	2.362	0.344	48
Granite Falls	S	1997-1998	3070	1.115	1.018	2.337	0.407	43	0.226	0.208	0.630	0.102	43
Hibbing	S	1997-1998	17071	2.090	1.560	10.552	1.607	59	0.357	0.274	1.303	0.247	59
Minneapolis	S	1997-1998	382618	3.176	2.589	10.993	2.009	55	0.737	0.508	3.717	0.699	55
Rochester	S	1997-1998	85806	2.301	1.790	7.028	1.374	56	0.387	0.326	1.077	0.220	56
Warroad	Sa	1997-1998	1722	1.066	0.799	4.258	0.704	47	0.200	0.174	0.699	0.122	47
Bemidji	Sa	1998-1999	11917	2.030	1.677	8.347	1.366	55	0.446	0.365	2.458	0.343	55
Duluth 7550	S	1998-1999	86918	1.192	1.002	3.761	0.720	60	0.254	0.213	0.764	0.146	60
St. Paul	S	1998-1999	287151	3.915	2.962	12.063	2.923	56	0.584	0.495	1.754	0.394	56
Holloway	S	1998-1999	112	0.398	0.362	0.969	0.222	54	0.097	0.083	0.604	0.089	54
Moorhead	S	1998-1999	32177	1.342	1.232	4.711	0.872	52	0.256	0.226	0.834	0.162	52
St. Cloud	S	1998-1999	59107	1.829	1.443	6.407	1.440	52	0.362	0.313	1.129	0.255	52
Winona	S	1998-1999	27069	2.600	2.190	12.007	1.758	51	0.441	0.373	2.089	0.293	51
Albert Lea	S	1999-2000	18356	2.304	2.012	7.937	1.584	54	0.416	0.369	1.155	0.221	54
Hutchinson	S	1999-2000	13080	2.578	2.227	7.526	1.778	57	0.318	0.265	0.934	0.170	57
Perham	S	1999-2000	2559	0.813	0.554	3.490	0.702	54	0.171	0.156	0.538	0.100	54
Silver Bay	Sa	1999-2000	2068	0.838	0.727	2.291	0.551	46	0.182	0.169	0.495	0.091	46
St. Michael	S	1999-2000	9099	1.314	0.961	4.526	0.967	60	0.282	0.222	0.725	0.170	60
Virginia	S	1999-2000	9157	1.783	1.402	6.964	1.299	58	0.336	0.278	1.112	0.191	58
West Lakeland	S	1999-2000	3547	1.144	0.871	5.408	0.807	59	0.227	0.200	0.621	0.121	59
Apple Valley	S	2000-2001	45527	1.711	1.440	6.863	1.128	43	0.257	0.243	0.621	0.140	44
Brandon Township	S	2000-2001	450	0.570	0.490	2.088	0.396	53	0.087	0.070	0.356	0.068	53
Duluth 7551	S	2000-2001	86918	2.064	1.477	9.561	1.687	55	0.315	0.248	1.216	0.217	55
Fort Ripley	S	2000-2001	74	0.684	0.460	3.667	0.672	49	0.116	0.065	0.782	0.146	49
Grand Rapids	Sa	2000-2001	7764	2.078	1.538	9.904	1.756	42	0.288	0.222	0.812	0.190	41
North Mankato	S	2000-2001	11798	1.095	0.931	4.767	0.839	32	0.180	0.156	0.612	0.115	32
Willmar	S	2000-2001	18351	1.373	1.165	6.851	1.021	54	0.237	0.178	0.955	0.175	54

Appendix D-1: VOC Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	o-Xylene					1,3,5-Trimethylbenzene				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.497	0.495	1.073	0.201	58	0.227	0.211	0.501	0.081	58
International Falls	Sa	1996-1997	6703	0.637	0.473	3.179	0.508	57	0.315	0.246	1.598	0.261	57
Leon Township	S	1996-1997	942	0.248	0.239	0.677	0.090	54	0.114	0.108	0.329	0.059	54
Little Falls	S	1996-1997	7719	0.374	0.365	1.107	0.175	56	0.171	0.157	0.457	0.080	56
Pipestone	S	1996-1997	4280	0.357	0.313	0.816	0.180	47	0.199	0.177	0.398	0.092	47
Plymouth	S	1996-1997	65894	0.611	0.538	2.536	0.402	55	0.279	0.231	1.008	0.184	55
Wagner Township	S	1996-1997	320	0.241	0.187	0.773	0.162	51	0.148	0.118	0.497	0.098	51
Elk River	S	1997-1998	16447	0.346	0.287	1.129	0.241	58	0.162	0.138	0.570	0.109	58
Fergus Falls	S	1997-1998	13471	0.456	0.408	1.450	0.266	48	0.213	0.187	0.595	0.105	48
Granite Falls	S	1997-1998	3070	0.214	0.195	0.530	0.091	43	0.113	0.108	0.211	0.038	43
Hibbing	S	1997-1998	17071	0.396	0.313	1.737	0.289	59	0.347	0.241	2.040	0.363	59
Minneapolis	S	1997-1998	382618	0.707	0.512	3.235	0.555	55	0.273	0.226	0.959	0.154	55
Rochester	S	1997-1998	85806	0.422	0.339	1.311	0.270	56	0.196	0.172	0.560	0.119	56
Warroad	Sa	1997-1998	1722	0.194	0.169	0.608	0.114	47	0.094	0.084	0.310	0.046	47
Bemidji	Sa	1998-1999	11917	0.540	0.521	1.494	0.291	55	0.383	0.324	1.445	0.263	55
Duluth 7550	S	1998-1999	86918	0.327	0.269	0.803	0.182	60	0.288	0.221	0.841	0.196	60
St. Paul	S	1998-1999	287151	0.760	0.604	2.315	0.487	56	0.441	0.408	1.175	0.259	56
Holloway	S	1998-1999	112	0.125	0.096	0.851	0.125	54	0.139	0.108	0.875	0.157	54
Moorhead	S	1998-1999	32177	0.306	0.274	0.960	0.196	52	0.210	0.187	0.634	0.140	52
St. Cloud	S	1998-1999	59107	0.463	0.417	1.446	0.313	52	0.329	0.285	1.145	0.239	52
Winona	S	1998-1999	27069	0.566	0.465	2.545	0.357	51	0.319	0.280	0.934	0.190	51
Albert Lea	S	1999-2000	18356	0.498	0.465	1.359	0.256	54	0.339	0.270	0.998	0.207	54
Hutchinson	S	1999-2000	13080	0.387	0.339	1.155	0.200	57	0.277	0.256	0.855	0.143	57
Perham	S	1999-2000	2559	0.203	0.178	0.690	0.126	54	0.217	0.177	0.644	0.142	54
Silver Bay	Sa	1999-2000	2068	0.240	0.239	0.621	0.123	46	0.245	0.182	0.737	0.154	46
St. Michael	S	1999-2000	9099	0.338	0.278	0.934	0.206	60	0.266	0.207	0.959	0.183	60
Virginia	S	1999-2000	9157	0.427	0.360	1.416	0.243	58	0.333	0.300	0.988	0.154	58
West Lakeland	S	1999-2000	3547	0.267	0.239	0.730	0.144	59	0.230	0.197	0.688	0.127	59
Apple Valley	S	2000-2001	45527	0.300	0.278	0.777	0.173	43	0.123	0.113	0.408	0.083	43
Brandon Township	S	2000-2001	450	0.106	0.087	0.443	0.085	53	0.046	0.044	0.138	0.033	51
Duluth 7551	S	2000-2001	86918	0.412	0.317	1.472	0.270	55	0.188	0.148	0.732	0.138	55
Fort Ripley	S	2000-2001	74	0.143	0.090	0.903	0.169	49	0.057	0.034	0.256	0.055	49
Grand Rapids	Sa	2000-2001	7764	0.372	0.304	1.042	0.244	41	0.171	0.133	0.492	0.110	40
North Mankato	S	2000-2001	11798	0.202	0.187	0.656	0.124	32	0.123	0.089	0.413	0.093	32
Willmar	S	2000-2001	18351	0.285	0.230	1.090	0.202	54	0.126	0.093	0.531	0.106	54

Appendix D-1: VOC Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	1,2,4-Trimethylbenzene					Styrene				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.632	0.575	1.902	0.305	58	0.168	0.158	0.332	0.056	58
International Falls	Sa	1996-1997	6703	0.694	0.521	3.761	0.602	57	0.240	0.205	0.758	0.142	57
Leon Township	S	1996-1997	942	0.262	0.241	0.610	0.115	54	0.133	0.119	0.324	0.061	54
Little Falls	S	1996-1997	7719	0.392	0.354	1.549	0.218	56	1.528	0.251	24.251	3.756	56
Pipestone	S	1996-1997	4280	0.527	0.462	1.416	0.277	47	0.853	0.192	12.754	2.178	47
Plymouth	S	1996-1997	65894	0.794	0.605	3.220	0.581	55	0.251	0.183	0.852	0.161	55
Wagner Township	S	1996-1997	320	0.275	0.241	0.968	0.186	51	0.168	0.136	0.788	0.140	51
Elk River	S	1997-1998	16447	0.375	0.324	1.421	0.283	58	0.199	0.124	1.184	0.231	58
Fergus Falls	S	1997-1998	13471	0.484	0.428	1.298	0.246	48	0.118	0.085	0.477	0.090	48
Granite Falls	S	1997-1998	3070	0.233	0.207	0.600	0.092	43	0.107	0.081	0.362	0.070	43
Hibbing	S	1997-1998	17071	0.866	0.556	5.766	1.060	59	0.116	0.102	0.426	0.075	59
Minneapolis	S	1997-1998	382618	0.700	0.575	3.269	0.495	55	0.206	0.162	0.656	0.137	55
Rochester	S	1997-1998	85806	0.473	0.403	1.426	0.321	56	0.125	0.102	0.784	0.112	56
Warroad	Sa	1997-1998	1722	0.178	0.162	0.447	0.073	47	0.075	0.068	0.166	0.040	47
Bemidji	Sa	1998-1999	11917	0.709	0.708	1.902	0.403	55	0.189	0.145	0.571	0.129	55
Duluth 7550	S	1998-1999	86918	0.513	0.433	1.273	0.301	60	0.173	0.124	0.609	0.151	60
St. Paul	S	1998-1999	287151	0.994	0.880	2.792	0.594	56	0.280	0.256	0.886	0.183	56
Holloway	S	1998-1999	112	0.229	0.202	1.023	0.192	54	0.118	0.078	0.520	0.128	54
Moorhead	S	1998-1999	32177	0.419	0.388	1.273	0.271	52	0.206	0.085	1.065	0.243	52
St. Cloud	S	1998-1999	59107	0.641	0.536	1.696	0.409	52	0.193	0.132	0.954	0.171	52
Winona	S	1998-1999	27069	0.751	0.693	2.620	0.416	51	0.180	0.153	0.481	0.109	51
Albert Lea	S	1999-2000	18356	0.777	0.654	2.020	0.457	54	1.088	0.149	48.348	6.557	54
Hutchinson	S	1999-2000	13080	0.565	0.482	1.490	0.262	57	0.169	0.132	0.754	0.144	57
Perham	S	1999-2000	2559	0.344	0.295	1.008	0.190	54	0.144	0.115	0.490	0.106	54
Silver Bay	Sa	1999-2000	2068	0.420	0.320	1.126	0.234	46	0.156	0.136	0.503	0.107	46
St. Michael	S	1999-2000	9099	0.483	0.398	1.367	0.271	60	0.216	0.162	0.916	0.188	60
Virginia	S	1999-2000	9157	0.669	0.654	1.843	0.332	58	0.197	0.166	0.648	0.112	58
West Lakeland	S	1999-2000	3547	0.401	0.364	0.909	0.185	59	0.164	0.132	0.745	0.128	59
Apple Valley	S	2000-2001	45527	0.350	0.354	0.870	0.175	43	0.102	0.117	0.328	0.062	43
Brandon Township	S	2000-2001	450	0.138	0.128	0.492	0.104	51	0.079	0.085	0.128	0.040	53
Duluth 7551	S	2000-2001	86918	0.537	0.428	2.104	0.366	55	0.099	0.107	0.230	0.058	55
Fort Ripley	S	2000-2001	74	0.152	0.093	0.777	0.161	49	0.133	0.117	0.967	0.166	49
Grand Rapids	Sa	2000-2001	7764	0.464	0.388	1.332	0.295	40	0.139	0.117	0.418	0.091	41
North Mankato	S	2000-2001	11798	0.342	0.315	0.841	0.176	30	0.106	0.117	0.418	0.067	32
Willmar	S	2000-2001	18351	0.340	0.266	1.342	0.232	54	0.104	0.117	0.464	0.065	54

Appendix D-1: VOC Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	4-Ethyltoluene					Chlorobenzene				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	.	.	.	.	0	0.090	0.083	0.387	0.065	58
International Falls	Sa	1996-1997	6703	.	.	.	.	0	0.080	0.078	0.166	0.031	57
Leon Township	S	1996-1997	942	.	.	.	.	0	0.138	0.115	0.359	0.087	54
Little Falls	S	1996-1997	7719	.	.	.	.	0	0.127	0.097	0.649	0.107	56
Pipestone	S	1996-1997	4280	.	.	.	.	0	0.112	0.092	0.391	0.075	47
Plymouth	S	1996-1997	65894	.	.	.	.	0	0.096	0.088	0.401	0.059	55
Wagner Township	S	1996-1997	320	.	.	.	.	0	0.102	0.069	0.566	0.118	51
Elk River	S	1997-1998	16447	.	.	.	.	0	0.092	0.092	0.216	0.036	58
Fergus Falls	S	1997-1998	13471	.	.	.	.	0	0.086	0.083	0.161	0.031	48
Granite Falls	S	1997-1998	3070	.	.	.	.	0	0.081	0.078	0.152	0.027	43
Hibbing	S	1997-1998	17071	.	.	.	.	0	0.058	0.051	0.157	0.027	59
Minneapolis	S	1997-1998	382618	.	.	.	.	0	0.090	0.083	0.207	0.036	55
Rochester	S	1997-1998	85806	.	.	.	.	0	0.118	0.120	0.244	0.050	56
Warroad	Sa	1997-1998	1722	.	.	.	.	0	0.076	0.065	0.235	0.039	47
Bemidji	Sa	1998-1999	11917	0.395	0.398	1.131	0.296	22	0.077	0.067	0.281	0.056	55
Duluth 7550	S	1998-1999	86918	0.294	0.266	0.688	0.185	25	0.096	0.067	0.382	0.082	60
St. Paul	S	1998-1999	287151	0.500	0.521	1.150	0.291	22	0.115	0.074	0.451	0.093	56
Holloway	S	1998-1999	112	0.138	0.082	0.541	0.127	23	0.068	0.067	0.276	0.045	54
Moorhead	S	1998-1999	32177	0.210	0.182	0.575	0.158	19	0.072	0.067	0.281	0.042	52
St. Cloud	S	1998-1999	59107	0.320	0.202	0.885	0.258	24	0.089	0.067	0.327	0.076	52
Winona	S	1998-1999	27069	0.322	0.270	0.998	0.228	25	0.085	0.067	0.281	0.056	51
Albert Lea	S	1999-2000	18356	0.389	0.295	1.244	0.299	54	0.073	0.064	0.295	0.053	54
Hutchinson	S	1999-2000	13080	0.263	0.231	0.929	0.191	57	0.080	0.064	0.364	0.060	57
Perham	S	1999-2000	2559	0.164	0.133	0.723	0.120	54	0.103	0.074	0.308	0.064	54
Silver Bay	Sa	1999-2000	2068	0.205	0.148	0.590	0.142	46	0.115	0.101	0.304	0.061	46
St. Michael	S	1999-2000	9099	0.243	0.192	0.846	0.169	60	0.091	0.065	0.327	0.062	60
Virginia	S	1999-2000	9157	0.338	0.280	1.165	0.228	58	0.094	0.069	0.336	0.065	58
West Lakeland	S	1999-2000	3547	0.189	0.152	0.560	0.123	59	0.132	0.115	0.442	0.078	59
Apple Valley	S	2000-2001	45527	0.216	0.202	0.580	0.130	44	0.082	0.100	0.157	0.030	43
Brandon Township	S	2000-2001	450	0.078	0.064	0.310	0.074	51	0.074	0.069	0.175	0.034	53
Duluth 7551	S	2000-2001	86918	0.339	0.266	1.327	0.259	55	0.076	0.100	0.106	0.028	55
Fort Ripley	S	2000-2001	74	0.101	0.049	0.624	0.128	49	0.076	0.100	0.100	0.027	48
Grand Rapids	Sa	2000-2001	7764	0.296	0.231	0.939	0.236	40	0.076	0.100	0.100	0.028	41
North Mankato	S	2000-2001	11798	0.264	0.236	0.934	0.209	32	0.086	0.100	0.100	0.024	32
Willmar	S	2000-2001	18351	0.232	0.162	1.101	0.198	54	0.080	0.100	0.295	0.041	54

Appendix D-1: VOC Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	1,2-Dichlorobenzene (o)					1,3-Dichlorobenzene (m)				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.191	0.156	0.439	0.106	58	0.204	0.168	0.517	0.122	58
International Falls	Sa	1996-1997	6703	0.206	0.186	0.535	0.111	57	0.238	0.186	0.697	0.144	57
Leon Township	S	1996-1997	942	0.213	0.168	0.896	0.158	54	0.228	0.180	0.992	0.179	54
Little Falls	S	1996-1997	7719	0.252	0.168	2.104	0.301	56	0.278	0.174	2.459	0.346	56
Pipestone	S	1996-1997	4280	0.236	0.180	0.776	0.143	47	0.263	0.204	0.770	0.166	47
Plymouth	S	1996-1997	65894	0.180	0.150	0.535	0.108	55	0.198	0.174	0.559	0.116	55
Wagner Township	S	1996-1997	320	0.310	0.150	1.894	0.418	51	0.354	0.186	2.273	0.473	51
Elk River	S	1997-1998	16447	0.141	0.090	0.643	0.121	58	0.144	0.090	0.709	0.140	58
Fergus Falls	S	1997-1998	13471	0.130	0.108	0.673	0.106	48	0.128	0.090	0.709	0.116	48
Granite Falls	S	1997-1998	3070	0.135	0.114	0.337	0.074	43	0.139	0.096	0.403	0.094	43
Hibbing	S	1997-1998	17071	0.132	0.096	0.673	0.106	59	0.146	0.084	0.818	0.145	59
Minneapolis	S	1997-1998	382618	0.149	0.108	0.589	0.115	55	0.161	0.102	0.679	0.145	55
Rochester	S	1997-1998	85806	0.118	0.096	0.511	0.079	56	0.122	0.090	0.709	0.107	56
Warroad	Sa	1997-1998	1722	0.122	0.108	0.325	0.054	47	0.131	0.108	0.385	0.072	47
Bemidji	Sa	1998-1999	11917	0.231	0.108	1.118	0.240	55	0.310	0.186	1.269	0.296	55
Duluth 7550	S	1998-1999	86918	0.265	0.107	1.365	0.334	60	0.331	0.192	1.467	0.352	60
St. Paul	S	1998-1999	287151	0.274	0.114	1.551	0.345	56	0.323	0.192	1.647	0.349	56
Holloway	S	1998-1999	112	0.162	0.107	1.136	0.212	54	0.206	0.150	1.335	0.242	54
Moorhead	S	1998-1999	32177	0.141	0.107	0.902	0.154	52	0.192	0.144	1.196	0.198	52
St. Cloud	S	1998-1999	59107	0.211	0.107	1.196	0.263	52	0.268	0.156	1.281	0.293	52
Winona	S	1998-1999	27069	0.155	0.107	0.896	0.177	51	0.237	0.168	1.233	0.225	51
Albert Lea	S	1999-2000	18356	0.232	0.144	1.251	0.232	54	0.258	0.174	1.215	0.232	54
Hutchinson	S	1999-2000	13080	0.224	0.144	1.251	0.239	57	0.252	0.174	1.299	0.248	57
Perham	S	1999-2000	2559	0.250	0.162	1.052	0.226	54	0.284	0.198	1.148	0.241	54
Silver Bay	Sa	1999-2000	2068	0.239	0.114	1.142	0.257	46	0.277	0.174	1.227	0.272	46
St. Michael	S	1999-2000	9099	0.255	0.168	1.311	0.266	60	0.296	0.180	1.347	0.277	60
Virginia	S	1999-2000	9157	0.286	0.204	1.269	0.239	58	0.315	0.229	1.329	0.252	58
West Lakeland	S	1999-2000	3547	0.223	0.144	1.070	0.217	59	0.255	0.180	1.130	0.225	59
Apple Valley	S	2000-2001	45527	0.127	0.152	0.421	0.072	43	0.138	0.162	0.481	0.085	43
Brandon Township	S	2000-2001	450	0.103	0.152	0.186	0.055	51	0.112	0.162	0.180	0.059	51
Duluth 7551	S	2000-2001	86918	0.109	0.152	0.295	0.057	55	0.118	0.162	0.367	0.065	55
Fort Ripley	S	2000-2001	74	0.106	0.152	0.152	0.052	49	0.112	0.162	0.162	0.059	49
Grand Rapids	Sa	2000-2001	7764	0.104	0.152	0.152	0.053	40	0.105	0.162	0.162	0.062	40
North Mankato	S	2000-2001	11798	0.132	0.152	0.152	0.042	32	0.136	0.162	0.162	0.047	32
Willmar	S	2000-2001	18351	0.123	0.152	0.619	0.094	54	0.136	0.162	0.643	0.100	54

Appendix D-1: VOC Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	1,4-Dichlorobenzene (p)					Xylenes				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.350	0.307	1.317	0.199	58	1.861	1.833	4.425	0.774	58
International Falls	Sa	1996-1997	6703	0.345	0.295	0.896	0.175	57	2.345	1.789	11.277	1.834	57
Leon Township	S	1996-1997	942	0.403	0.349	1.142	0.232	54	0.812	0.769	2.037	0.277	54
Little Falls	S	1996-1997	7719	0.374	0.271	2.537	0.352	56	1.342	1.264	3.404	0.607	56
Pipestone	S	1996-1997	4280	0.564	0.487	3.319	0.482	47	1.330	1.094	3.265	0.706	47
Plymouth	S	1996-1997	65894	0.400	0.355	1.148	0.209	55	2.291	2.037	9.384	1.517	55
Wagner Township	S	1996-1997	320	0.455	0.253	2.291	0.497	51	0.839	0.673	2.519	0.537	51
Elk River	S	1997-1998	16447	0.208	0.144	0.848	0.155	58	1.384	1.155	4.655	0.991	58
Fergus Falls	S	1997-1998	13471	0.317	0.283	1.148	0.192	48	1.826	1.646	8.528	1.302	48
Granite Falls	S	1997-1998	3070	0.221	0.192	0.463	0.107	43	0.841	0.751	2.614	0.416	43
Hibbing	S	1997-1998	17071	0.352	0.235	1.659	0.326	59	1.528	1.229	6.079	1.102	59
Minneapolis	S	1997-1998	382618	0.686	0.517	2.068	0.476	55	3.140	2.189	14.126	2.759	55
Rochester	S	1997-1998	85806	0.196	0.174	0.679	0.099	56	1.653	1.285	5.020	1.022	56
Warroad	Sa	1997-1998	1722	0.180	0.168	0.463	0.071	47	0.797	0.673	3.048	0.537	47
Bemidji	Sa	1998-1999	11917	0.310	0.204	1.407	0.306	55	1.913	1.733	5.428	1.054	55
Duluth 7550	S	1998-1999	86918	0.346	0.174	1.611	0.382	60	1.191	0.977	3.339	0.656	60
St. Paul	S	1998-1999	287151	0.394	0.253	1.900	0.416	56	2.828	2.202	8.342	1.898	56
Holloway	S	1998-1999	112	0.216	0.156	1.485	0.264	54	0.412	0.330	2.367	0.353	54
Moorhead	S	1998-1999	32177	0.200	0.144	1.215	0.209	52	1.173	0.981	3.865	0.749	52
St. Cloud	S	1998-1999	59107	0.303	0.186	1.401	0.322	52	1.717	1.446	5.654	1.217	52
Winona	S	1998-1999	27069	0.276	0.216	1.275	0.236	51	2.114	1.806	9.818	1.381	51
Albert Lea	S	1999-2000	18356	0.340	0.235	1.473	0.266	54	1.847	1.620	4.998	0.961	54
Hutchinson	S	1999-2000	13080	0.316	0.229	1.485	0.272	57	1.424	1.198	4.390	0.768	57
Perham	S	1999-2000	2559	0.331	0.241	1.257	0.264	54	0.712	0.630	2.475	0.434	54
Silver Bay	Sa	1999-2000	2068	0.332	0.216	1.371	0.295	46	0.849	0.829	2.310	0.431	46
St. Michael	S	1999-2000	9099	0.351	0.235	1.485	0.303	60	1.246	0.964	3.530	0.780	60
Virginia	S	1999-2000	9157	0.406	0.307	1.665	0.291	58	1.566	1.272	5.476	0.923	58
West Lakeland	S	1999-2000	3547	0.310	0.216	1.359	0.253	59	0.978	0.877	2.805	0.528	59
Apple Valley	S	2000-2001	45527	0.136	0.158	0.499	0.094	44	1.158	1.077	2.766	0.619	43
Brandon Township	S	2000-2001	450	0.109	0.158	0.271	0.065	51	0.385	0.282	1.620	0.306	53
Duluth 7551	S	2000-2001	86918	0.122	0.144	0.403	0.086	55	1.584	1.251	5.880	1.055	55
Fort Ripley	S	2000-2001	74	0.108	0.144	0.158	0.057	49	0.509	0.277	3.322	0.612	49
Grand Rapids	Sa	2000-2001	7764	0.116	0.158	0.235	0.056	40	1.422	1.125	4.069	0.941	41
North Mankato	S	2000-2001	11798	0.120	0.158	0.168	0.052	32	0.796	0.756	2.480	0.459	32
Willmar	S	2000-2001	18351	0.142	0.158	0.716	0.109	54	1.064	0.868	4.303	0.768	54

Appendix D-2: Carbonyl Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Formaldehyde					Acetaldehyde				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	1.44	1.41	3.54	0.87	55	0.85	0.85	1.92	0.34	55
International Falls	Sa	1996-1997	6703	1.28	1.05	3.79	0.85	57	0.69	0.68	2.47	0.43	57
Leon Township	S	1996-1997	942	1.16	1.04	3.21	0.78	53	0.63	0.63	1.65	0.30	53
Little Falls	S	1996-1997	7719	1.14	1.03	2.90	0.69	56	0.60	0.56	1.62	0.29	56
Pipestone	S	1996-1997	4280	1.27	1.24	3.39	0.83	54	0.75	0.72	1.61	0.36	54
Plymouth	S	1996-1997	65894	1.24	1.04	5.48	0.97	50	0.95	0.89	2.67	0.50	50
Wagner Township	S	1996-1997	320	1.22	0.92	3.60	0.87	45	0.65	0.66	1.17	0.29	45
Elk River	S	1997-1998	16447	1.43	1.23	4.18	0.83	61	0.99	0.87	2.85	0.55	61
Fergus Falls	S	1997-1998	13471	1.66	1.42	3.53	0.80	59	1.81	1.16	5.41	1.27	59
Granite Falls	S	1997-1998	3070	1.97	1.45	20.20	2.83	50	1.00	0.94	2.75	0.42	50
Hibbing	S	1997-1998	17071	1.56	1.22	5.29	1.04	60	0.89	0.82	2.29	0.42	60
Minneapolis	S	1997-1998	382618	2.48	2.06	10.85	1.96	56	1.38	1.34	3.57	0.64	56
Rochester	S	1997-1998	85806	1.36	1.33	2.86	0.67	60	0.91	0.82	1.81	0.38	60
Warroad	Sa	1997-1998	1722	1.22	1.00	5.49	0.88	59	0.57	0.55	1.65	0.24	59
Bemidji	Sa	1998-1999	11917	1.38	1.25	2.92	0.56	55	0.98	0.96	2.11	0.37	55
Duluth 7550	S	1998-1999	86918	1.40	1.05	5.03	0.96	61	0.86	0.79	2.29	0.38	61
St. Paul	S	1998-1999	287151	2.23	1.73	8.29	1.44	60	1.42	1.30	3.17	0.64	60
Holloway	S	1998-1999	112	0.85	0.85	2.63	0.52	57	0.73	0.63	1.55	0.33	57
Moorhead	S	1998-1999	32177	1.71	1.40	5.24	0.89	58	1.49	1.45	2.97	0.58	58
St. Cloud	S	1998-1999	59107	1.50	1.15	12.74	1.68	56	1.09	0.92	8.40	1.07	56
Winona	S	1998-1999	27069	2.16	1.97	6.10	1.23	59	1.46	1.36	4.26	0.62	59
Albert Lea	S	1999-2000	18356	1.57	1.41	3.91	1.06	60	1.19	1.04	3.67	0.76	60
Hutchinson	S	1999-2000	13080	1.62	1.46	3.48	0.79	61	1.22	1.08	3.79	0.66	61
Perham	S	1999-2000	2559	1.18	1.02	2.99	0.63	55	0.87	0.79	3.10	0.46	55
Silver Bay	Sa	1999-2000	2068	1.24	0.96	3.18	0.77	54	0.72	0.64	2.58	0.35	54
St. Michael	S	1999-2000	9099	1.40	1.31	3.81	0.96	60	0.90	0.86	2.04	0.48	60
Virginia	S	1999-2000	9157	1.61	1.34	4.26	1.00	57	0.95	0.92	2.64	0.48	57
West Lakeland	S	1999-2000	3547	1.37	1.13	5.51	0.95	60	0.90	0.83	2.28	0.45	60
Apple Valley	S	2000-2001	45527	1.28	1.24	3.54	0.61	55	0.87	0.78	2.09	0.45	49
Brandon Township	S	2000-2001	450	1.24	1.01	3.36	0.88	57	0.82	0.77	1.41	0.37	51
Duluth 7551	S	2000-2001	86918	1.94	1.81	4.52	1.00	56	1.20	1.06	3.43	0.64	52
Fort Ripley	S	2000-2001	74	1.45	1.25	4.21	0.89	54	0.87	0.73	2.24	0.45	51
Grand Rapids	Sa	2000-2001	7764	2.25	1.99	6.62	1.20	56	1.16	1.06	2.27	0.49	48
North Mankato	S	2000-2001	11798	1.68	1.56	3.91	1.08	60	1.03	1.01	3.36	0.62	54
Willmar	S	2000-2001	18351	1.80	1.86	3.72	0.91	56	1.16	1.12	2.47	0.49	47

Appendix D-2: Carbonyl Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Propionaldehyde					Butyraldehyde				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.19	0.16	0.40	0.09	55	0.30	0.27	0.61	0.14	55
International Falls	Sa	1996-1997	6703	0.12	0.11	0.43	0.08	57	0.17	0.18	0.44	0.09	57
Leon Township	S	1996-1997	942	0.19	0.18	0.62	0.15	53	0.20	0.19	0.61	0.10	53
Little Falls	S	1996-1997	7719	0.12	0.11	0.42	0.08	56	0.21	0.20	0.57	0.10	56
Pipestone	S	1996-1997	4280	0.15	0.15	0.41	0.09	54	0.24	0.23	0.65	0.11	54
Plymouth	S	1996-1997	65894	0.19	0.17	0.52	0.12	50	0.25	0.25	0.77	0.13	50
Wagner Township	S	1996-1997	320	0.14	0.15	0.36	0.08	45	0.22	0.22	0.58	0.12	45
Elk River	S	1997-1998	16447	0.17	0.15	0.48	0.09	61	0.23	0.19	0.86	0.17	61
Fergus Falls	S	1997-1998	13471	0.18	0.16	0.53	0.11	59	0.27	0.23	1.21	0.20	59
Granite Falls	S	1997-1998	3070	0.15	0.14	0.33	0.06	50	0.21	0.19	0.59	0.09	50
Hibbing	S	1997-1998	17071	0.12	0.12	0.45	0.07	60	0.23	0.19	0.50	0.12	60
Minneapolis	S	1997-1998	382618	0.24	0.23	0.74	0.13	56	0.37	0.31	1.50	0.25	56
Rochester	S	1997-1998	85806	0.16	0.14	0.41	0.08	60	0.23	0.20	0.79	0.14	60
Warroad	Sa	1997-1998	1722	0.08	0.07	0.24	0.04	59	0.14	0.13	0.41	0.07	59
Bemidji	Sa	1998-1999	11917	0.13	0.12	0.36	0.06	55	0.27	0.17	3.14	0.42	55
Duluth 7550	S	1998-1999	86918	0.14	0.13	0.40	0.07	61	0.23	0.16	2.65	0.34	61
St. Paul	S	1998-1999	287151	0.26	0.23	0.66	0.13	60	0.35	0.33	0.90	0.18	60
Holloway	S	1998-1999	112	0.12	0.10	0.36	0.07	57	0.19	0.18	0.58	0.12	57
Moorhead	S	1998-1999	32177	0.23	0.19	0.67	0.12	58	0.44	0.31	2.38	0.48	58
St. Cloud	S	1998-1999	59107	0.17	0.14	1.32	0.17	56	0.26	0.19	2.73	0.36	56
Winona	S	1998-1999	27069	0.23	0.22	0.75	0.12	59	0.29	0.29	1.00	0.16	59
Albert Lea	S	1999-2000	18356	0.17	0.16	0.49	0.12	60	0.30	0.24	1.08	0.23	60
Hutchinson	S	1999-2000	13080	0.19	0.17	0.60	0.11	61	0.67	0.30	4.36	0.89	61
Perham	S	1999-2000	2559	0.15	0.14	0.91	0.12	55	0.20	0.17	0.39	0.10	55
Silver Bay	Sa	1999-2000	2068	0.12	0.11	0.40	0.07	54	0.15	0.14	0.35	0.07	54
St. Michael	S	1999-2000	9099	0.16	0.15	0.35	0.09	60	0.20	0.16	0.75	0.13	60
Virginia	S	1999-2000	9157	0.12	0.11	0.35	0.07	57	0.20	0.14	2.02	0.27	57
West Lakeland	S	1999-2000	3547	0.16	0.15	0.53	0.09	60	0.15	0.14	0.35	0.08	60
Apple Valley	S	2000-2001	45527	0.15	0.12	0.63	0.12	53	0.18	0.17	0.68	0.12	53
Brandon Township	S	2000-2001	450	0.14	0.10	0.41	0.11	57	0.15	0.13	0.36	0.08	55
Duluth 7551	S	2000-2001	86918	0.16	0.14	0.58	0.12	54	0.20	0.18	0.50	0.10	52
Fort Ripley	S	2000-2001	74	0.13	0.10	0.64	0.12	54	0.17	0.15	0.60	0.12	52
Grand Rapids	Sa	2000-2001	7764	0.16	0.14	0.48	0.12	56	0.18	0.15	0.62	0.12	54
North Mankato	S	2000-2001	11798	0.18	0.14	1.02	0.17	60	0.21	0.20	0.60	0.13	58
Willmar	S	2000-2001	18351	0.16	0.15	0.50	0.10	56	0.24	0.21	0.66	0.14	55

Appendix D-2: Carbonyl Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Crotonaldehyde					Acetone				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.04	0.01	0.56	0.09	55	1.43	1.38	2.69	0.47	51
International Falls	Sa	1996-1997	6703	0.06	0.01	0.40	0.08	57	1.25	1.28	2.57	0.35	53
Leon Township	S	1996-1997	942	0.07	0.01	0.50	0.13	53	1.04	1.07	2.69	0.46	49
Little Falls	S	1996-1997	7719	0.06	0.01	0.55	0.10	56	1.31	1.22	2.63	0.47	52
Pipestone	S	1996-1997	4280	0.02	0.01	0.14	0.03	54	1.20	1.22	2.38	0.44	50
Plymouth	S	1996-1997	65894	0.02	0.01	0.11	0.02	50	1.03	1.13	1.62	0.34	45
Wagner Township	S	1996-1997	320	0.11	0.01	0.60	0.16	45	1.45	1.22	3.09	0.60	41
Elk River	S	1997-1998	16447	0.04	0.02	0.37	0.07	61	1.60	1.49	3.83	0.70	61
Fergus Falls	S	1997-1998	13471	0.02	0.02	0.12	0.02	59	1.70	1.56	3.60	0.72	59
Granite Falls	S	1997-1998	3070	0.02	0.02	0.02	0.00	50	1.58	1.52	3.57	0.60	50
Hibbing	S	1997-1998	17071	0.04	0.02	0.25	0.06	60	2.03	1.95	5.00	0.85	60
Minneapolis	S	1997-1998	382618	0.03	0.02	0.22	0.04	56	1.77	1.61	5.10	0.90	56
Rochester	S	1997-1998	85806	0.02	0.02	0.02	0.00	60	1.18	1.14	2.58	0.44	60
Warroad	Sa	1997-1998	1722	0.02	0.02	0.19	0.03	59	1.08	1.09	2.58	0.41	59
Bemidji	Sa	1998-1999	11917	0.04	0.03	0.25	0.04	55	1.76	1.66	3.50	0.69	55
Duluth 7550	S	1998-1999	86918	0.05	0.03	0.37	0.07	61	1.50	1.37	3.72	0.72	61
St. Paul	S	1998-1999	287151	0.03	0.03	0.03	0.00	60	1.40	1.31	3.55	0.78	60
Holloway	S	1998-1999	112	0.03	0.03	0.22	0.03	57	1.30	1.21	3.65	0.68	57
Moorhead	S	1998-1999	32177	0.03	0.03	0.05	0.00	58	1.82	1.65	3.94	0.87	58
St. Cloud	S	1998-1999	59107	0.03	0.03	0.15	0.02	56	1.41	1.34	5.50	0.80	56
Winona	S	1998-1999	27069	0.03	0.03	0.15	0.02	59	1.76	1.49	4.64	1.18	59
Albert Lea	S	1999-2000	18356	0.03	0.03	0.05	0.00	60	1.54	1.59	3.92	0.89	60
Hutchinson	S	1999-2000	13080	0.03	0.03	0.10	0.01	61	1.09	1.07	3.09	0.64	61
Perham	S	1999-2000	2559	0.03	0.03	0.15	0.02	55	1.20	1.19	2.26	0.59	55
Silver Bay	Sa	1999-2000	2068	0.03	0.03	0.13	0.01	54	0.67	0.67	1.57	0.33	54
St. Michael	S	1999-2000	9099	0.03	0.03	0.09	0.01	60	1.16	1.07	4.28	0.77	60
Virginia	S	1999-2000	9157	0.05	0.03	0.22	0.05	57	1.46	1.32	4.11	0.71	57
West Lakeland	S	1999-2000	3547	0.03	0.03	0.18	0.02	60	0.88	0.79	2.40	0.48	60
Apple Valley	S	2000-2001	45527	0.02	0.02	0.07	0.01	55	1.08	0.92	3.11	0.64	55
Brandon Township	S	2000-2001	450	0.02	0.02	0.04	0.00	55	1.04	0.92	3.44	0.62	55
Duluth 7551	S	2000-2001	86918	0.03	0.02	0.28	0.04	54	1.35	1.39	2.93	0.83	54
Fort Ripley	S	2000-2001	74	0.03	0.02	0.16	0.02	53	1.12	1.00	3.30	0.68	53
Grand Rapids	Sa	2000-2001	7764	0.04	0.02	0.22	0.04	54	1.17	1.04	3.49	0.77	54
North Mankato	S	2000-2001	11798	0.02	0.02	0.03	0.00	58	1.29	1.11	3.24	0.82	58
Willmar	S	2000-2001	18351	0.02	0.02	0.03	0.00	54	1.45	1.39	3.69	0.84	54

Appendix D-2: Carbonyl Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Benzaldehyde				
				Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.05	0.02	0.18	0.05	55
International Falls	Sa	1996-1997	6703	0.07	0.02	0.31	0.07	57
Leon Township	S	1996-1997	942	0.03	0.02	0.11	0.02	53
Little Falls	S	1996-1997	7719	0.05	0.02	0.82	0.12	56
Pipestone	S	1996-1997	4280	0.09	0.02	0.84	0.13	54
Plymouth	S	1996-1997	65894	0.03	0.02	0.18	0.04	50
Wagner Township	S	1996-1997	320	0.04	0.02	0.14	0.04	45
Elk River	S	1997-1998	16447	0.03	0.02	0.12	0.02	61
Fergus Falls	S	1997-1998	13471	0.05	0.02	0.23	0.05	59
Granite Falls	S	1997-1998	3070	0.04	0.02	0.47	0.07	50
Hibbing	S	1997-1998	17071	0.05	0.02	0.18	0.04	60
Minneapolis	S	1997-1998	382618	0.05	0.02	0.21	0.05	56
Rochester	S	1997-1998	85806	0.04	0.02	0.19	0.04	60
Warroad	Sa	1997-1998	1722	0.04	0.02	0.22	0.04	59
Bemidji	Sa	1998-1999	11917	0.05	0.03	0.17	0.04	55
Duluth 7550	S	1998-1999	86918	0.04	0.03	0.28	0.04	61
St. Paul	S	1998-1999	287151	0.04	0.03	0.24	0.04	60
Holloway	S	1998-1999	112	0.07	0.03	1.90	0.25	57
Moorhead	S	1998-1999	32177	0.06	0.03	0.63	0.10	58
St. Cloud	S	1998-1999	59107	0.05	0.03	0.71	0.09	56
Winona	S	1998-1999	27069	0.08	0.03	0.28	0.07	59
Albert Lea	S	1999-2000	18356	0.05	0.06	0.06	0.01	60
Hutchinson	S	1999-2000	13080	0.05	0.06	0.10	0.01	61
Perham	S	1999-2000	2559	0.06	0.06	0.15	0.02	55
Silver Bay	Sa	1999-2000	2068	0.06	0.06	0.39	0.05	54
St. Michael	S	1999-2000	9099	0.05	0.06	0.06	0.01	60
Virginia	S	1999-2000	9157	0.05	0.06	0.06	0.01	57
West Lakeland	S	1999-2000	3547	0.05	0.06	0.06	0.01	60
Apple Valley	S	2000-2001	45527	0.03	0.03	0.09	0.01	52
Brandon Township	S	2000-2001	450	0.03	0.03	0.19	0.03	55
Duluth 7551	S	2000-2001	86918	0.05	0.03	0.27	0.05	54
Fort Ripley	S	2000-2001	74	0.03	0.03	0.11	0.02	52
Grand Rapids	Sa	2000-2001	7764	0.04	0.03	0.22	0.03	52
North Mankato	S	2000-2001	11798	0.03	0.03	0.12	0.01	58
Willmar	S	2000-2001	18351	0.03	0.03	0.10	0.02	54

Appendix D-3: Metal Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Antimony					Arsenic				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.011	0.008	0.039	0.008	23	0.002	0.001	0.003	0.001	27
International Falls	Sa	1996-1997	6703	0.016	0.014	0.046	0.012	26	0.002	0.002	0.004	0.001	32
Leon Township	S	1996-1997	942	0.013	0.009	0.044	0.010	24	0.002	0.002	0.004	0.001	30
Little Falls	S	1996-1997	7719	0.011	0.008	0.034	0.007	23	0.002	0.001	0.004	0.001	28
Pipestone	S	1996-1997	4280	0.018	0.013	0.049	0.012	30	0.002	0.001	0.003	0.001	26
Plymouth	S	1996-1997	65894	0.020	0.013	0.074	0.018	33	0.002	0.002	0.006	0.001	31
Wagner Township	S	1996-1997	320	0.011	0.008	0.055	0.013	32	0.002	0.002	0.003	0.001	28
Elk River	S	1997-1998	16447	0.012	0.008	0.037	0.009	33	0.003	0.002	0.015	0.003	40
Fergus Falls	S	1997-1998	13471	0.010	0.008	0.034	0.008	32	0.003	0.003	0.007	0.001	39
Granite Falls	S	1997-1998	3070	0.016	0.008	0.058	0.015	26	0.002	0.002	0.003	0.001	35
Hibbing	S	1997-1998	17071	0.010	0.008	0.047	0.009	35	0.003	0.003	0.008	0.001	40
Minneapolis	S	1997-1998	382618	0.012	0.008	0.051	0.011	29	0.002	0.003	0.004	0.001	46
Rochester	S	1997-1998	85806	0.011	0.008	0.042	0.010	33	0.002	0.003	0.004	0.001	39
Warroad	Sa	1997-1998	1722	0.019	0.008	0.078	0.019	23	0.002	0.002	0.005	0.001	39
Bemidji	Sa	1998-1999	11917	0.010	0.008	0.032	0.008	30	0.002	0.002	0.003	0.001	25
Duluth 7550	S	1998-1999	86918	0.011	0.008	0.029	0.007	39	0.003	0.003	0.013	0.002	35
St. Paul	S	1998-1999	287151	0.013	0.008	0.059	0.012	38	0.003	0.003	0.009	0.002	40
Holloway	S	1998-1999	112	0.015	0.009	0.043	0.012	27	0.002	0.002	0.003	0.001	23
Moorhead	S	1998-1999	32177	0.014	0.008	0.032	0.010	23	0.002	0.002	0.005	0.001	26
St. Cloud	S	1998-1999	59107	0.013	0.008	0.061	0.011	31	0.002	0.002	0.004	0.001	31
Winona	S	1998-1999	27069	0.012	0.008	0.036	0.009	31	0.002	0.002	0.005	0.001	27
Albert Lea	S	1999-2000	18356	0.008	0.008	0.019	0.004	9	0.002	0.002	0.005	0.001	26
Hutchinson	S	1999-2000	13080	0.010	0.008	0.033	0.010	11	0.002	0.002	0.006	0.001	19
Perham	S	1999-2000	2559	0.011	0.008	0.028	0.009	9	0.002	0.002	0.005	0.001	20
Silver Bay	Sa	1999-2000	2068	0.011	0.010	0.021	0.005	10	0.003	0.003	0.007	0.002	27
St. Michael	S	1999-2000	9099	0.008	0.008	0.028	0.007	11	0.005	0.003	0.102	0.017	36
Virginia	S	1999-2000	9157	0.004	0.006	0.008	0.003	7	0.003	0.003	0.007	0.001	24
West Lakeland	S	1999-2000	3547	0.019	0.017	0.044	0.012	12	0.003	0.003	0.006	0.001	30
Apple Valley	S	2000-2001	45527	0.014	0.012	0.038	0.012	8	0.002	0.002	0.008	0.002	19
Brandon Township	S	2000-2001	450	0.015	0.012	0.028	0.006	11	0.002	0.001	0.007	0.002	16
Duluth 7551	S	2000-2001	86918	0.019	0.019	0.041	0.011	8	0.002	0.003	0.004	0.001	18
Fort Ripley	S	2000-2001	74	0.010	0.008	0.023	0.008	11	0.002	0.003	0.004	0.001	16
Grand Rapids	Sa	2000-2001	7764	0.018	0.017	0.042	0.014	7	0.002	0.002	0.004	0.001	16
North Mankato	S	2000-2001	11798	0.012	0.011	0.027	0.009	12	0.002	0.002	0.004	0.001	19
Willmar	S	2000-2001	18351	0.014	0.012	0.019	0.004	3	0.002	0.002	0.003	0.001	6

Appendix D-3: Metal Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Barium					Bromine				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.041	0.017	0.176	0.047	48	0.003	0.003	0.007	0.001	46
International Falls	Sa	1996-1997	6703	0.042	0.017	0.279	0.056	58	0.002	0.002	0.008	0.001	55
Leon Township	S	1996-1997	942	0.044	0.017	0.191	0.048	48	0.002	0.002	0.013	0.002	47
Little Falls	S	1996-1997	7719	0.059	0.019	0.276	0.065	49	0.002	0.002	0.006	0.001	45
Pipestone	S	1996-1997	4280	0.031	0.017	0.153	0.032	57	0.002	0.002	0.005	0.001	52
Plymouth	S	1996-1997	65894	0.036	0.017	0.173	0.041	55	0.002	0.002	0.006	0.001	51
Wagner Township	S	1996-1997	320	0.047	0.017	0.305	0.070	59	0.002	0.002	0.004	0.001	53
Elk River	S	1997-1998	16447	0.035	0.017	0.168	0.039	54	0.002	0.002	0.007	0.001	48
Fergus Falls	S	1997-1998	13471	0.044	0.017	0.300	0.057	57	0.003	0.002	0.015	0.002	54
Granite Falls	S	1997-1998	3070	0.030	0.017	0.184	0.037	57	0.002	0.002	0.005	0.001	52
Hibbing	S	1997-1998	17071	0.052	0.023	0.200	0.049	54	0.002	0.002	0.012	0.002	48
Minneapolis	S	1997-1998	382618	0.040	0.017	0.225	0.045	56	0.003	0.002	0.008	0.002	56
Rochester	S	1997-1998	85806	0.032	0.017	0.109	0.030	51	0.003	0.003	0.012	0.002	51
Warroad	Sa	1997-1998	1722	0.034	0.017	0.170	0.037	57	0.002	0.002	0.004	0.001	54
Bemidji	Sa	1998-1999	11917	0.043	0.017	0.198	0.044	57	0.002	0.002	0.005	0.001	50
Duluth 7550	S	1998-1999	86918	0.046	0.017	0.244	0.052	61	0.002	0.002	0.010	0.002	53
St. Paul	S	1998-1999	287151	0.044	0.017	0.229	0.050	60	0.003	0.002	0.009	0.002	58
Holloway	S	1998-1999	112	0.038	0.017	0.190	0.039	51	0.003	0.002	0.022	0.003	49
Moorhead	S	1998-1999	32177	0.055	0.017	0.193	0.053	52	0.002	0.002	0.006	0.001	51
St. Cloud	S	1998-1999	59107	0.042	0.017	0.237	0.047	58	0.003	0.002	0.008	0.002	56
Winona	S	1998-1999	27069	0.044	0.017	0.167	0.044	47	0.003	0.002	0.009	0.002	46
Albert Lea	S	1999-2000	18356	0.073	0.062	0.267	0.062	40	0.002	0.002	0.006	0.002	49
Hutchinson	S	1999-2000	13080	0.068	0.059	0.179	0.048	31	0.003	0.002	0.009	0.002	42
Perham	S	1999-2000	2559	0.076	0.076	0.262	0.056	40	0.002	0.002	0.008	0.001	43
Silver Bay	Sa	1999-2000	2068	0.085	0.059	0.268	0.073	28	0.002	0.002	0.005	0.001	35
St. Michael	S	1999-2000	9099	0.083	0.078	0.218	0.058	40	0.003	0.002	0.010	0.002	44
Virginia	S	1999-2000	9157	0.077	0.064	0.205	0.053	33	0.002	0.002	0.006	0.001	36
West Lakeland	S	1999-2000	3547	0.091	0.072	0.276	0.083	34	0.002	0.002	0.009	0.002	46
Apple Valley	S	2000-2001	45527	0.067	0.064	0.208	0.050	30	0.002	0.002	0.004	0.001	41
Brandon Township	S	2000-2001	450	0.080	0.051	0.219	0.065	27	0.002	0.002	0.014	0.002	38
Duluth 7551	S	2000-2001	86918	0.052	0.046	0.147	0.044	37	0.002	0.002	0.004	0.001	35
Fort Ripley	S	2000-2001	74	0.083	0.086	0.186	0.055	29	0.002	0.002	0.004	0.001	32
Grand Rapids	Sa	2000-2001	7764	0.089	0.081	0.278	0.068	31	0.002	0.002	0.008	0.001	48
North Mankato	S	2000-2001	11798	0.072	0.049	0.283	0.060	29	0.002	0.002	0.004	0.001	39
Willmar	S	2000-2001	18351	0.102	0.060	0.295	0.094	14	0.002	0.002	0.002	0.000	20

Appendix D-3: Metal Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Cadmium					Calcium				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.007	0.008	0.008	0.002	25	0.254	0.202	1.174	0.250	48
International Falls	Sa	1996-1997	6703	0.006	0.008	0.010	0.003	32	0.103	0.081	0.526	0.106	58
Leon Township	S	1996-1997	942	0.007	0.008	0.013	0.003	25	0.633	0.243	8.906	1.364	48
Little Falls	S	1996-1997	7719	0.007	0.008	0.017	0.003	20	0.160	0.063	1.474	0.244	49
Pipestone	S	1996-1997	4280	0.006	0.008	0.013	0.003	26	0.386	0.262	2.235	0.414	57
Plymouth	S	1996-1997	65894	0.007	0.008	0.011	0.003	24	0.308	0.163	2.213	0.452	55
Wagner Township	S	1996-1997	320	0.006	0.008	0.010	0.003	30	0.111	0.033	1.067	0.204	59
Elk River	S	1997-1998	16447	0.007	0.008	0.016	0.003	34	0.288	0.155	2.557	0.461	54
Fergus Falls	S	1997-1998	13471	0.007	0.008	0.013	0.003	27	0.662	0.494	4.304	0.754	57
Granite Falls	S	1997-1998	3070	0.006	0.008	0.015	0.003	32	0.384	0.269	1.743	0.419	57
Hibbing	S	1997-1998	17071	0.005	0.007	0.008	0.003	26	0.085	0.046	0.981	0.145	54
Minneapolis	S	1997-1998	382618	0.006	0.008	0.017	0.004	32	0.344	0.219	1.769	0.407	56
Rochester	S	1997-1998	85806	0.006	0.007	0.012	0.003	23	0.632	0.383	2.515	0.676	51
Warroad	Sa	1997-1998	1722	0.007	0.008	0.013	0.003	33	0.382	0.211	3.311	0.518	57
Bemidji	Sa	1998-1999	11917	0.007	0.008	0.014	0.003	30	0.391	0.232	1.995	0.436	57
Duluth 7550	S	1998-1999	86918	0.006	0.008	0.013	0.003	32	0.115	0.084	0.867	0.141	61
St. Paul	S	1998-1999	287151	0.006	0.008	0.013	0.003	30	0.346	0.295	1.842	0.302	60
Holloway	S	1998-1999	112	0.007	0.008	0.013	0.003	28	0.284	0.174	1.747	0.361	51
Moorhead	S	1998-1999	32177	0.007	0.008	0.015	0.004	26	0.678	0.576	2.476	0.518	52
St. Cloud	S	1998-1999	59107	0.007	0.008	0.014	0.003	28	0.249	0.180	0.922	0.222	58
Winona	S	1998-1999	27069	0.005	0.005	0.010	0.003	29	0.338	0.245	1.253	0.309	47
Albert Lea	S	1999-2000	18356	0.006	0.005	0.011	0.003	25	1.406	0.989	8.641	1.455	53
Hutchinson	S	1999-2000	13080	0.006	0.005	0.018	0.004	23	0.514	0.404	3.780	0.649	41
Perham	S	1999-2000	2559	0.006	0.007	0.014	0.003	23	0.562	0.365	3.267	0.604	48
Silver Bay	Sa	1999-2000	2068	0.006	0.006	0.021	0.005	18	0.247	0.154	2.014	0.319	43
St. Michael	S	1999-2000	9099	0.007	0.006	0.014	0.004	22	0.422	0.233	3.755	0.609	50
Virginia	S	1999-2000	9157	0.006	0.005	0.015	0.004	19	0.314	0.214	1.507	0.291	47
West Lakeland	S	1999-2000	3547	0.005	0.005	0.013	0.003	19	0.412	0.180	3.050	0.608	47
Apple Valley	S	2000-2001	45527	0.005	0.005	0.010	0.002	24	0.449	0.235	2.298	0.528	50
Brandon Township	S	2000-2001	450	0.005	0.005	0.012	0.003	17	0.535	0.222	2.106	0.618	37
Duluth 7551	S	2000-2001	86918	0.006	0.005	0.012	0.003	20	0.248	0.162	0.844	0.249	51
Fort Ripley	S	2000-2001	74	0.005	0.004	0.014	0.004	15	0.272	0.122	1.446	0.325	42
Grand Rapids	Sa	2000-2001	7764	0.006	0.005	0.016	0.004	22	0.204	0.141	1.135	0.211	53
North Mankato	S	2000-2001	11798	0.006	0.007	0.016	0.004	18	0.881	0.554	3.491	0.845	47
Willmar	S	2000-2001	18351	0.005	0.005	0.010	0.003	12	0.291	0.247	0.726	0.202	25

Appendix D-3: Metal Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Chromium					Cobalt				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.001	0.001	0.005	0.001	26	0.000	0.000	0.001	0.000	24
International Falls	Sa	1996-1997	6703	0.001	0.001	0.003	0.001	43	0.001	0.001	0.003	0.001	33
Leon Township	S	1996-1997	942	0.001	0.001	0.003	0.001	32	0.001	0.001	0.002	0.001	29
Little Falls	S	1996-1997	7719	0.002	0.001	0.003	0.001	34	0.001	0.000	0.004	0.001	34
Pipestone	S	1996-1997	4280	0.002	0.001	0.006	0.001	25	0.001	0.000	0.003	0.001	39
Plymouth	S	1996-1997	65894	0.001	0.001	0.003	0.001	44	0.000	0.000	0.002	0.001	35
Wagner Township	S	1996-1997	320	0.002	0.001	0.005	0.001	36	0.000	0.000	0.002	0.001	37
Elk River	S	1997-1998	16447	0.002	0.001	0.005	0.001	46	0.001	0.000	0.005	0.001	33
Fergus Falls	S	1997-1998	13471	0.002	0.001	0.004	0.001	50	0.001	0.001	0.005	0.001	38
Granite Falls	S	1997-1998	3070	0.001	0.001	0.003	0.001	44	0.001	0.001	0.003	0.001	35
Hibbing	S	1997-1998	17071	0.001	0.001	0.004	0.001	41	0.001	0.001	0.007	0.001	43
Minneapolis	S	1997-1998	382618	0.002	0.001	0.005	0.001	46	0.001	0.001	0.003	0.001	43
Rochester	S	1997-1998	85806	0.001	0.001	0.003	0.001	41	0.001	0.001	0.003	0.001	30
Warroad	Sa	1997-1998	1722	0.001	0.001	0.003	0.001	45	0.001	0.001	0.002	0.001	38
Bemidji	Sa	1998-1999	11917	0.001	0.001	0.004	0.001	45	0.001	0.001	0.002	0.001	40
Duluth 7550	S	1998-1999	86918	0.001	0.001	0.004	0.001	47	0.001	0.000	0.003	0.001	41
St. Paul	S	1998-1999	287151	0.002	0.001	0.004	0.001	53	0.000	0.000	0.003	0.001	39
Holloway	S	1998-1999	112	0.001	0.001	0.004	0.001	38	0.000	0.000	0.002	0.001	29
Moorhead	S	1998-1999	32177	0.001	0.001	0.004	0.001	44	0.001	0.000	0.003	0.001	36
St. Cloud	S	1998-1999	59107	0.001	0.001	0.003	0.001	51	0.001	0.000	0.003	0.001	41
Winona	S	1998-1999	27069	0.002	0.001	0.004	0.001	42	0.001	0.001	0.004	0.001	32
Albert Lea	S	1999-2000	18356	0.001	0.001	0.004	0.001	28	0.001	0.001	0.004	0.001	30
Hutchinson	S	1999-2000	13080	0.001	0.001	0.005	0.001	30	0.001	0.001	0.003	0.001	26
Perham	S	1999-2000	2559	0.001	0.001	0.003	0.001	30	0.001	0.001	0.004	0.001	32
Silver Bay	Sa	1999-2000	2068	0.002	0.001	0.005	0.001	28	0.003	0.002	0.019	0.004	30
St. Michael	S	1999-2000	9099	0.002	0.001	0.007	0.001	30	0.001	0.001	0.003	0.001	25
Virginia	S	1999-2000	9157	0.002	0.001	0.006	0.001	37	0.003	0.003	0.014	0.003	42
West Lakeland	S	1999-2000	3547	0.001	0.001	0.003	0.001	24	0.001	0.001	0.002	0.001	29
Apple Valley	S	2000-2001	45527	0.001	0.001	0.002	0.000	21	0.001	0.001	0.003	0.001	24
Brandon Township	S	2000-2001	450	0.001	0.001	0.005	0.001	20	0.002	0.001	0.004	0.001	18
Duluth 7551	S	2000-2001	86918	0.001	0.001	0.004	0.001	29	0.001	0.001	0.003	0.001	33
Fort Ripley	S	2000-2001	74	0.001	0.001	0.004	0.001	16	0.002	0.002	0.004	0.001	21
Grand Rapids	Sa	2000-2001	7764	0.002	0.001	0.004	0.001	23	0.001	0.001	0.003	0.001	32
North Mankato	S	2000-2001	11798	0.001	0.001	0.002	0.000	21	0.001	0.001	0.004	0.001	31
Willmar	S	2000-2001	18351	0.001	0.001	0.002	0.000	11	0.001	0.000	0.002	0.001	12

Appendix D-3: Metal Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Chlorine					Gallium				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.008	0.002	0.112	0.020	34	.	.	.	.	0
International Falls	Sa	1996-1997	6703	0.019	0.001	0.611	0.093	43	.	.	.	.	0
Leon Township	S	1996-1997	942	0.003	0.001	0.021	0.004	33	.	.	.	.	0
Little Falls	S	1996-1997	7719	0.004	0.002	0.022	0.004	38	.	.	.	.	0
Pipestone	S	1996-1997	4280	0.002	0.001	0.011	0.002	42	.	.	.	.	0
Plymouth	S	1996-1997	65894	0.031	0.002	0.673	0.114	49	.	.	.	.	0
Wagner Township	S	1996-1997	320	0.003	0.001	0.017	0.003	45	.	.	.	.	0
Elk River	S	1997-1998	16447	0.006	0.004	0.039	0.006	44	.	.	.	.	0
Fergus Falls	S	1997-1998	13471	0.012	0.009	0.051	0.011	55	.	.	.	.	0
Granite Falls	S	1997-1998	3070	0.012	0.003	0.083	0.021	41	.	.	.	.	0
Hibbing	S	1997-1998	17071	0.007	0.001	0.083	0.015	46	.	.	.	.	0
Minneapolis	S	1997-1998	382618	0.008	0.005	0.047	0.009	51	.	.	.	.	0
Rochester	S	1997-1998	85806	0.006	0.004	0.065	0.010	44	.	.	.	.	0
Warroad	Sa	1997-1998	1722	0.008	0.005	0.081	0.012	55	.	.	.	.	0
Bemidji	Sa	1998-1999	11917	0.012	0.004	0.158	0.029	51	.	.	.	.	0
Duluth 7550	S	1998-1999	86918	0.020	0.005	0.259	0.045	53	.	.	.	.	0
St. Paul	S	1998-1999	287151	0.018	0.006	0.149	0.033	56	.	.	.	.	0
Holloway	S	1998-1999	112	0.015	0.002	0.418	0.068	37	.	.	.	.	0
Moorhead	S	1998-1999	32177	0.015	0.005	0.093	0.023	47	.	.	.	.	0
St. Cloud	S	1998-1999	59107	0.008	0.002	0.124	0.018	51	.	.	.	.	0
Winona	S	1998-1999	27069	0.065	0.005	0.937	0.190	38	.	.	.	.	0
Albert Lea	S	1999-2000	18356	0.007	0.003	0.042	0.010	34	0.002	0.001	0.003	0.001	18
Hutchinson	S	1999-2000	13080	0.018	0.004	0.238	0.050	23	0.001	0.001	0.003	0.001	10
Perham	S	1999-2000	2559	0.005	0.003	0.023	0.005	33	0.002	0.001	0.006	0.002	10
Silver Bay	Sa	1999-2000	2068	0.014	0.002	0.241	0.045	29	0.002	0.002	0.003	0.001	12
St. Michael	S	1999-2000	9099	0.030	0.003	0.658	0.120	30	0.002	0.002	0.003	0.001	17
Virginia	S	1999-2000	9157	0.017	0.007	0.196	0.034	34	0.002	0.001	0.003	0.001	15
West Lakeland	S	1999-2000	3547	0.021	0.007	0.183	0.039	23	0.002	0.002	0.003	0.001	16
Apple Valley	S	2000-2001	45527	0.010	0.004	0.185	0.029	38	0.002	0.002	0.004	0.001	25
Brandon Township	S	2000-2001	450	0.006	0.005	0.017	0.004	34	0.002	0.003	0.003	0.001	20
Duluth 7551	S	2000-2001	86918	0.025	0.006	0.477	0.077	38	0.002	0.002	0.003	0.001	18
Fort Ripley	S	2000-2001	74	0.034	0.004	0.486	0.102	30	0.002	0.001	0.003	0.001	21
Grand Rapids	Sa	2000-2001	7764	0.006	0.004	0.054	0.010	34	0.002	0.003	0.003	0.001	18
North Mankato	S	2000-2001	11798	0.005	0.003	0.012	0.003	37	0.002	0.002	0.003	0.001	22
Willmar	S	2000-2001	18351	0.003	0.002	0.011	0.003	16	0.002	0.003	0.003	0.001	13

Appendix D-3: Metal Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Iron					Palladium				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.109	0.091	0.360	0.083	48	0.004	0.003	0.008	0.003	22
International Falls	Sa	1996-1997	6703	0.137	0.104	0.825	0.142	58	0.005	0.005	0.008	0.003	34
Leon Township	S	1996-1997	942	0.126	0.077	0.688	0.128	48	0.006	0.008	0.009	0.003	20
Little Falls	S	1996-1997	7719	0.174	0.130	0.962	0.164	49	0.006	0.008	0.011	0.003	23
Pipestone	S	1996-1997	4280	0.176	0.122	0.824	0.159	57	0.005	0.005	0.011	0.003	30
Plymouth	S	1996-1997	65894	0.186	0.183	0.609	0.114	55	0.006	0.007	0.012	0.003	33
Wagner Township	S	1996-1997	320	0.124	0.078	0.647	0.120	59	0.005	0.008	0.010	0.003	30
Elk River	S	1997-1998	16447	0.226	0.132	1.447	0.267	54	0.006	0.007	0.008	0.002	31
Fergus Falls	S	1997-1998	13471	0.248	0.182	1.396	0.257	57	0.005	0.006	0.009	0.003	29
Granite Falls	S	1997-1998	3070	0.191	0.106	1.060	0.204	57	0.004	0.003	0.008	0.003	23
Hibbing	S	1997-1998	17071	0.385	0.291	2.057	0.349	54	0.005	0.004	0.009	0.003	30
Minneapolis	S	1997-1998	382618	0.215	0.159	0.965	0.185	56	0.005	0.005	0.010	0.003	30
Rochester	S	1997-1998	85806	0.153	0.135	0.540	0.114	51	0.005	0.005	0.015	0.003	27
Warroad	Sa	1997-1998	1722	0.144	0.095	0.746	0.139	57	0.005	0.005	0.010	0.003	30
Bemidji	Sa	1998-1999	11917	0.212	0.131	1.220	0.219	57	0.006	0.008	0.010	0.003	31
Duluth 7550	S	1998-1999	86918	0.195	0.149	0.626	0.133	61	0.005	0.007	0.009	0.003	39
St. Paul	S	1998-1999	287151	0.221	0.202	0.641	0.136	60	0.004	0.004	0.009	0.003	31
Holloway	S	1998-1999	112	0.120	0.084	0.550	0.116	51	0.004	0.004	0.008	0.003	28
Moorhead	S	1998-1999	32177	0.301	0.288	0.858	0.189	52	0.006	0.007	0.010	0.003	35
St. Cloud	S	1998-1999	59107	0.193	0.166	0.898	0.145	58	0.006	0.008	0.011	0.003	29
Winona	S	1998-1999	27069	0.169	0.151	0.488	0.111	47	0.006	0.008	0.010	0.002	26
Albert Lea	S	1999-2000	18356	0.320	0.247	1.325	0.246	51	0.005	0.005	0.010	0.002	27
Hutchinson	S	1999-2000	13080	0.178	0.145	0.853	0.148	47	0.005	0.007	0.009	0.003	24
Perham	S	1999-2000	2559	0.268	0.225	1.057	0.234	48	0.005	0.005	0.013	0.003	22
Silver Bay	Sa	1999-2000	2068	1.065	0.474	5.732	1.416	43	0.006	0.005	0.010	0.003	17
St. Michael	S	1999-2000	9099	0.184	0.134	0.797	0.148	53	0.005	0.008	0.011	0.003	21
Virginia	S	1999-2000	9157	1.223	0.928	5.178	1.043	45	0.005	0.004	0.016	0.003	24
West Lakeland	S	1999-2000	3547	0.152	0.128	0.535	0.112	48	0.005	0.006	0.010	0.003	24
Apple Valley	S	2000-2001	45527	0.172	0.146	0.540	0.132	54	0.005	0.004	0.012	0.003	17
Brandon Township	S	2000-2001	450	0.217	0.083	0.938	0.245	49	0.005	0.006	0.010	0.003	22
Duluth 7551	S	2000-2001	86918	0.293	0.204	1.927	0.309	53	0.003	0.003	0.007	0.002	13
Fort Ripley	S	2000-2001	74	0.239	0.130	1.077	0.262	46	0.004	0.005	0.008	0.003	20
Grand Rapids	Sa	2000-2001	7764	0.256	0.209	1.054	0.206	57	0.005	0.006	0.016	0.004	23
North Mankato	S	2000-2001	11798	0.269	0.213	1.047	0.217	56	0.004	0.004	0.008	0.003	16
Willmar	S	2000-2001	18351	0.140	0.141	0.322	0.086	27	0.004	0.004	0.010	0.003	8

Appendix D-3: Metal Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Lead					Indium				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.003	0.003	0.016	0.003	47	.	.	.	.	0
International Falls	Sa	1996-1997	6703	0.003	0.002	0.010	0.002	52	.	.	.	.	0
Leon Township	S	1996-1997	942	0.004	0.004	0.012	0.003	45	.	.	.	.	0
Little Falls	S	1996-1997	7719	0.004	0.004	0.008	0.002	49	.	.	.	.	0
Pipestone	S	1996-1997	4280	0.004	0.004	0.010	0.003	56	.	.	.	.	0
Plymouth	S	1996-1997	65894	0.005	0.005	0.015	0.004	54	.	.	.	.	0
Wagner Township	S	1996-1997	320	0.003	0.002	0.011	0.003	55	.	.	.	.	0
Elk River	S	1997-1998	16447	0.004	0.004	0.015	0.003	54	.	.	.	.	0
Fergus Falls	S	1997-1998	13471	0.005	0.005	0.026	0.005	56	.	.	.	.	0
Granite Falls	S	1997-1998	3070	0.003	0.003	0.009	0.002	56	.	.	.	.	0
Hibbing	S	1997-1998	17071	0.005	0.002	0.068	0.011	52	.	.	.	.	0
Minneapolis	S	1997-1998	382618	0.006	0.005	0.017	0.005	56	.	.	.	.	0
Rochester	S	1997-1998	85806	0.004	0.004	0.021	0.004	51	.	.	.	.	0
Warroad	Sa	1997-1998	1722	0.002	0.002	0.010	0.002	53	.	.	.	.	0
Bemidji	Sa	1998-1999	11917	0.003	0.002	0.014	0.003	52	.	.	.	.	0
Duluth 7550	S	1998-1999	86918	0.003	0.003	0.009	0.003	51	.	.	.	.	0
St. Paul	S	1998-1999	287151	0.007	0.005	0.028	0.005	60	.	.	.	.	0
Holloway	S	1998-1999	112	0.003	0.003	0.029	0.004	49	.	.	.	.	0
Moorhead	S	1998-1999	32177	0.003	0.003	0.022	0.003	50	.	.	.	.	0
St. Cloud	S	1998-1999	59107	0.003	0.003	0.014	0.003	55	.	.	.	.	0
Winona	S	1998-1999	27069	0.005	0.004	0.029	0.005	47	.	.	.	.	0
Albert Lea	S	1999-2000	18356	0.006	0.006	0.017	0.004	38	0.009	0.010	0.014	0.005	9
Hutchinson	S	1999-2000	13080	0.004	0.003	0.014	0.003	38	0.007	0.006	0.013	0.004	10
Perham	S	1999-2000	2559	0.003	0.003	0.007	0.002	32	0.009	0.006	0.030	0.008	13
Silver Bay	Sa	1999-2000	2068	0.003	0.002	0.011	0.003	39	0.009	0.008	0.018	0.005	12
St. Michael	S	1999-2000	9099	0.008	0.003	0.105	0.017	42	0.009	0.008	0.023	0.008	12
Virginia	S	1999-2000	9157	0.004	0.004	0.011	0.002	38	0.007	0.007	0.014	0.004	9
West Lakeland	S	1999-2000	3547	0.004	0.004	0.013	0.003	42	0.006	0.007	0.010	0.003	11
Apple Valley	S	2000-2001	45527	0.004	0.004	0.023	0.004	43	0.009	0.009	0.019	0.005	19
Brandon Township	S	2000-2001	450	0.004	0.003	0.023	0.004	39	0.006	0.004	0.023	0.005	19
Duluth 7551	S	2000-2001	86918	0.003	0.002	0.010	0.003	40	0.007	0.004	0.040	0.008	23
Fort Ripley	S	2000-2001	74	0.003	0.002	0.009	0.002	38	0.010	0.008	0.022	0.007	11
Grand Rapids	Sa	2000-2001	7764	0.003	0.003	0.011	0.002	38	0.014	0.013	0.043	0.010	21
North Mankato	S	2000-2001	11798	0.004	0.003	0.012	0.003	44	0.010	0.009	0.024	0.007	20
Willmar	S	2000-2001	18351	0.003	0.003	0.009	0.002	23	0.008	0.008	0.019	0.006	8

Appendix D-3: Metal Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Manganese					Molybdenum				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.004	0.003	0.019	0.004	48	0.008	0.007	0.026	0.005	48
International Falls	Sa	1996-1997	6703	0.003	0.002	0.009	0.002	58	0.007	0.007	0.020	0.004	58
Leon Township	S	1996-1997	942	0.004	0.003	0.027	0.005	48	0.008	0.007	0.022	0.004	48
Little Falls	S	1996-1997	7719	0.005	0.003	0.047	0.007	49	0.008	0.007	0.027	0.005	49
Pipestone	S	1996-1997	4280	0.009	0.007	0.050	0.011	57	0.009	0.007	0.030	0.006	57
Plymouth	S	1996-1997	65894	0.006	0.005	0.033	0.005	55	0.007	0.007	0.020	0.004	55
Wagner Township	S	1996-1997	320	0.004	0.002	0.032	0.005	59	0.008	0.007	0.029	0.005	59
Elk River	S	1997-1998	16447	0.009	0.004	0.071	0.013	54	0.007	0.007	0.020	0.003	54
Fergus Falls	S	1997-1998	13471	0.010	0.007	0.064	0.012	57	0.009	0.007	0.033	0.007	57
Granite Falls	S	1997-1998	3070	0.007	0.005	0.031	0.007	57	0.010	0.007	0.096	0.013	57
Hibbing	S	1997-1998	17071	0.008	0.006	0.063	0.011	54	0.009	0.007	0.029	0.006	54
Minneapolis	S	1997-1998	382618	0.007	0.005	0.034	0.007	56	0.008	0.007	0.031	0.005	56
Rochester	S	1997-1998	85806	0.005	0.005	0.021	0.005	51	0.009	0.007	0.035	0.006	51
Warroad	Sa	1997-1998	1722	0.005	0.003	0.026	0.005	57	0.008	0.007	0.018	0.004	57
Bemidji	Sa	1998-1999	11917	0.006	0.004	0.035	0.006	57	0.007	0.007	0.021	0.004	57
Duluth 7550	S	1998-1999	86918	0.004	0.003	0.014	0.003	61	0.008	0.007	0.027	0.005	61
St. Paul	S	1998-1999	287151	0.007	0.006	0.021	0.005	60	0.007	0.007	0.037	0.006	60
Holloway	S	1998-1999	112	0.005	0.004	0.029	0.006	51	0.007	0.007	0.018	0.003	51
Moorhead	S	1998-1999	32177	0.011	0.010	0.034	0.008	52	0.008	0.007	0.026	0.005	52
St. Cloud	S	1998-1999	59107	0.006	0.005	0.020	0.004	58	0.007	0.007	0.022	0.003	58
Winona	S	1998-1999	27069	0.006	0.004	0.028	0.006	47	0.007	0.007	0.023	0.004	47
Albert Lea	S	1999-2000	18356	0.014	0.011	0.050	0.010	46	0.017	0.013	0.045	0.011	35
Hutchinson	S	1999-2000	13080	0.009	0.008	0.045	0.008	46	0.016	0.013	0.038	0.010	34
Perham	S	1999-2000	2559	0.013	0.010	0.057	0.012	50	0.016	0.014	0.038	0.010	35
Silver Bay	Sa	1999-2000	2068	0.008	0.006	0.034	0.008	43	0.015	0.013	0.034	0.009	32
St. Michael	S	1999-2000	9099	0.008	0.005	0.041	0.008	45	0.017	0.016	0.035	0.009	41
Virginia	S	1999-2000	9157	0.029	0.022	0.176	0.029	46	0.017	0.015	0.054	0.013	31
West Lakeland	S	1999-2000	3547	0.006	0.005	0.023	0.005	45	0.015	0.013	0.051	0.012	41
Apple Valley	S	2000-2001	45527	0.007	0.005	0.024	0.006	52	0.009	0.008	0.025	0.006	40
Brandon Township	S	2000-2001	450	0.009	0.004	0.039	0.010	47	0.018	0.016	0.056	0.014	27
Duluth 7551	S	2000-2001	86918	0.005	0.005	0.017	0.004	51	0.010	0.008	0.025	0.006	31
Fort Ripley	S	2000-2001	74	0.010	0.005	0.044	0.011	46	0.010	0.010	0.020	0.006	21
Grand Rapids	Sa	2000-2001	7764	0.008	0.006	0.026	0.006	54	0.013	0.011	0.032	0.008	33
North Mankato	S	2000-2001	11798	0.013	0.010	0.048	0.012	56	0.008	0.007	0.022	0.006	31
Willmar	S	2000-2001	18351	0.007	0.007	0.014	0.003	26	0.008	0.006	0.020	0.006	15

Appendix D-3: Metal Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Nickel					Lanthanum				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.001	0.001	0.003	0.000	48	.	.	.	.	0
International Falls	Sa	1996-1997	6703	0.001	0.001	0.001	0.000	58	.	.	.	.	0
Leon Township	S	1996-1997	942	0.001	0.001	0.002	0.000	48	.	.	.	.	0
Little Falls	S	1996-1997	7719	0.001	0.001	0.002	0.000	49	.	.	.	.	0
Pipestone	S	1996-1997	4280	0.001	0.001	0.002	0.000	57	.	.	.	.	0
Plymouth	S	1996-1997	65894	0.001	0.001	0.002	0.000	55	.	.	.	.	0
Wagner Township	S	1996-1997	320	0.001	0.001	0.002	0.000	58	.	.	.	.	0
Elk River	S	1997-1998	16447	0.001	0.001	0.002	0.000	53	.	.	.	.	0
Fergus Falls	S	1997-1998	13471	0.001	0.001	0.002	0.000	56	.	.	.	.	0
Granite Falls	S	1997-1998	3070	0.001	0.001	0.002	0.000	56	.	.	.	.	0
Hibbing	S	1997-1998	17071	0.001	0.001	0.003	0.000	53	.	.	.	.	0
Minneapolis	S	1997-1998	382618	0.001	0.001	0.003	0.001	55	.	.	.	.	0
Rochester	S	1997-1998	85806	0.001	0.001	0.002	0.000	50	.	.	.	.	0
Warroad	Sa	1997-1998	1722	0.001	0.001	0.003	0.000	55	.	.	.	.	0
Bemidji	Sa	1998-1999	11917	0.001	0.001	0.002	0.000	57	.	.	.	.	0
Duluth 7550	S	1998-1999	86918	0.001	0.001	0.002	0.000	61	.	.	.	.	0
St. Paul	S	1998-1999	287151	0.001	0.001	0.003	0.001	60	.	.	.	.	0
Holloway	S	1998-1999	112	0.001	0.001	0.002	0.000	51	.	.	.	.	0
Moorhead	S	1998-1999	32177	0.001	0.001	0.004	0.000	52	.	.	.	.	0
St. Cloud	S	1998-1999	59107	0.001	0.001	0.002	0.000	58	.	.	.	.	0
Winona	S	1998-1999	27069	0.001	0.001	0.003	0.000	47	.	.	.	.	0
Albert Lea	S	1999-2000	18356	0.001	0.001	0.002	0.000	36	0.052	0.050	0.118	0.036	10
Hutchinson	S	1999-2000	13080	0.001	0.001	0.004	0.000	38	0.065	0.063	0.156	0.050	8
Perham	S	1999-2000	2559	0.001	0.001	0.001	0.000	34	0.072	0.084	0.132	0.043	8
Silver Bay	Sa	1999-2000	2068	0.001	0.001	0.002	0.000	29	0.075	0.073	0.156	0.053	11
St. Michael	S	1999-2000	9099	0.001	0.001	0.002	0.000	35	0.084	0.113	0.131	0.050	6
Virginia	S	1999-2000	9157	0.001	0.001	0.002	0.000	28	0.084	0.092	0.143	0.048	7
West Lakeland	S	1999-2000	3547	0.001	0.001	0.002	0.000	38	0.067	0.072	0.142	0.051	7
Apple Valley	S	2000-2001	45527	0.001	0.001	0.003	0.000	34	0.059	0.067	0.159	0.048	16
Brandon Township	S	2000-2001	450	0.001	0.001	0.003	0.000	29	0.038	0.029	0.111	0.033	9
Duluth 7551	S	2000-2001	86918	0.002	0.002	0.004	0.001	41	0.056	0.049	0.198	0.048	17
Fort Ripley	S	2000-2001	74	0.001	0.001	0.003	0.001	36	0.053	0.047	0.162	0.045	11
Grand Rapids	Sa	2000-2001	7764	0.002	0.001	0.004	0.001	33	0.058	0.048	0.211	0.055	14
North Mankato	S	2000-2001	11798	0.001	0.001	0.003	0.000	43	0.049	0.053	0.100	0.034	14
Willmar	S	2000-2001	18351	0.001	0.001	0.002	0.000	18	0.025	0.018	0.051	0.022	5

Appendix D-3: Metal Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Phosphorous						Selenium				
				Mean	Median	Maximum	Standard Deviation	Count	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	.	.	.	.	63	0	0.002	0.002	0.003	0.001	33
International Falls	Sa	1996-1997	6703	.	.	.	.	62	0	0.002	0.003	0.003	0.001	29
Leon Township	S	1996-1997	942	.	.	.	.	63	0	0.002	0.003	0.004	0.001	30
Little Falls	S	1996-1997	7719	.	.	.	.	64	0	0.002	0.003	0.003	0.001	28
Pipestone	S	1996-1997	4280	0.002	0.002	0.002	.	63	1	0.002	0.003	0.003	0.001	45
Plymouth	S	1996-1997	65894	.	.	.	.	63	0	0.002	0.003	0.003	0.001	38
Wagner Township	S	1996-1997	320	.	.	.	.	63	0	0.002	0.003	0.003	0.001	37
Elk River	S	1997-1998	16447	.	.	.	.	62	0	0.002	0.003	0.003	0.001	39
Fergus Falls	S	1997-1998	13471	.	.	.	.	62	0	0.002	0.002	0.003	0.001	36
Granite Falls	S	1997-1998	3070	.	.	.	.	62	0	0.002	0.002	0.003	0.001	39
Hibbing	S	1997-1998	17071	.	.	.	.	62	0	0.002	0.003	0.003	0.001	38
Minneapolis	S	1997-1998	382618	.	.	.	.	63	0	0.002	0.003	0.003	0.001	32
Rochester	S	1997-1998	85806	.	.	.	.	63	0	0.002	0.003	0.003	0.001	38
Warroad	Sa	1997-1998	1722	.	.	.	.	61	0	0.002	0.003	0.003	0.001	36
Bemidji	Sa	1998-1999	11917	.	.	.	.	62	0	0.002	0.003	0.003	0.001	32
Duluth 7550	S	1998-1999	86918	.	.	.	.	61	0	0.002	0.003	0.003	0.001	34
St. Paul	S	1998-1999	287151	.	.	.	.	61	0	0.002	0.003	0.003	0.001	41
Holloway	S	1998-1999	112	.	.	.	.	62	0	0.002	0.002	0.003	0.001	33
Moorhead	S	1998-1999	32177	.	.	.	.	61	0	0.002	0.002	0.003	0.001	37
St. Cloud	S	1998-1999	59107	.	.	.	.	61	0	0.002	0.003	0.003	0.001	38
Winona	S	1998-1999	27069	.	.	.	.	63	0	0.002	0.003	0.003	0.001	37
Albert Lea	S	1999-2000	18356	.	.	.	.	60	0	0.002	0.001	0.003	0.001	21
Hutchinson	S	1999-2000	13080	.	.	.	.	59	0	0.002	0.001	0.003	0.001	20
Perham	S	1999-2000	2559	.	.	.	.	60	0	0.002	0.003	0.003	0.001	17
Silver Bay	Sa	1999-2000	2068	.	.	.	.	55	0	0.002	0.003	0.003	0.001	18
St. Michael	S	1999-2000	9099	.	.	.	.	61	0	0.001	0.001	0.003	0.001	18
Virginia	S	1999-2000	9157	.	.	.	.	58	0	0.002	0.002	0.003	0.001	17
West Lakeland	S	1999-2000	3547	.	.	.	.	61	0	0.002	0.003	0.004	0.001	22
Apple Valley	S	2000-2001	45527	.	.	.	.	60	0	0.001	0.001	0.003	0.001	15
Brandon Township	S	2000-2001	450	.	.	.	.	58	0	0.002	0.002	0.003	0.001	14
Duluth 7551	S	2000-2001	86918	.	.	.	.	66	0	0.002	0.003	0.003	0.001	12
Fort Ripley	S	2000-2001	74	.	.	.	.	60	0	0.002	0.003	0.003	0.001	19
Grand Rapids	Sa	2000-2001	7764	.	.	.	.	61	0	0.002	0.002	0.003	0.001	17
North Mankato	S	2000-2001	11798	.	.	.	.	61	0	0.002	0.001	0.003	0.001	22
Willmar	S	2000-2001	18351	.	.	.	.	60	0	0.002	0.002	0.003	0.001	16

Appendix D-3: Metal Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Tin					Titanium				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.008	0.008	0.027	0.007	26	0.007	0.006	0.029	0.007	48
International Falls	Sa	1996-1997	6703	0.010	0.009	0.024	0.005	32	0.007	0.005	0.029	0.006	58
Leon Township	S	1996-1997	942	0.012	0.009	0.042	0.009	30	0.010	0.007	0.074	0.013	48
Little Falls	S	1996-1997	7719	0.011	0.009	0.030	0.007	27	0.011	0.007	0.071	0.013	49
Pipestone	S	1996-1997	4280	0.014	0.009	0.037	0.009	33	0.011	0.008	0.052	0.011	57
Plymouth	S	1996-1997	65894	0.015	0.012	0.048	0.011	31	0.012	0.010	0.044	0.009	55
Wagner Township	S	1996-1997	320	0.008	0.009	0.024	0.005	31	0.009	0.006	0.050	0.010	59
Elk River	S	1997-1998	16447	0.012	0.009	0.037	0.008	29	0.014	0.008	0.093	0.019	54
Fergus Falls	S	1997-1998	13471	0.010	0.009	0.027	0.006	42	0.017	0.012	0.102	0.022	57
Granite Falls	S	1997-1998	3070	0.011	0.009	0.039	0.009	32	0.010	0.007	0.052	0.011	57
Hibbing	S	1997-1998	17071	0.010	0.009	0.040	0.008	35	0.007	0.004	0.109	0.015	54
Minneapolis	S	1997-1998	382618	0.013	0.010	0.035	0.009	26	0.013	0.007	0.101	0.017	56
Rochester	S	1997-1998	85806	0.010	0.009	0.025	0.005	35	0.010	0.008	0.041	0.010	51
Warroad	Sa	1997-1998	1722	0.012	0.009	0.040	0.009	36	0.010	0.006	0.060	0.012	57
Bemidji	Sa	1998-1999	11917	0.010	0.009	0.034	0.007	38	0.015	0.009	0.085	0.016	57
Duluth 7550	S	1998-1999	86918	0.010	0.009	0.037	0.007	37	0.008	0.006	0.032	0.008	61
St. Paul	S	1998-1999	287151	0.013	0.009	0.035	0.008	42	0.013	0.011	0.046	0.009	60
Holloway	S	1998-1999	112	0.012	0.009	0.046	0.010	27	0.008	0.006	0.033	0.007	51
Moorhead	S	1998-1999	32177	0.009	0.008	0.031	0.007	31	0.019	0.016	0.077	0.014	52
St. Cloud	S	1998-1999	59107	0.012	0.009	0.041	0.009	46	0.013	0.009	0.055	0.010	58
Winona	S	1998-1999	27069	0.012	0.009	0.038	0.007	30	0.011	0.010	0.058	0.009	47
Albert Lea	S	1999-2000	18356	0.015	0.009	0.046	0.011	17	0.026	0.020	0.141	0.024	46
Hutchinson	S	1999-2000	13080	0.011	0.011	0.028	0.007	24	0.015	0.012	0.061	0.011	36
Perham	S	1999-2000	2559	0.011	0.009	0.028	0.009	17	0.020	0.014	0.074	0.017	53
Silver Bay	Sa	1999-2000	2068	0.014	0.009	0.045	0.012	15	0.012	0.010	0.054	0.010	41
St. Michael	S	1999-2000	9099	0.014	0.013	0.032	0.010	17	0.015	0.011	0.071	0.013	49
Virginia	S	1999-2000	9157	0.011	0.009	0.026	0.008	16	0.015	0.013	0.049	0.011	44
West Lakeland	S	1999-2000	3547	0.009	0.009	0.023	0.006	21	0.013	0.011	0.034	0.009	44
Apple Valley	S	2000-2001	45527	0.013	0.010	0.040	0.012	17	0.014	0.011	0.046	0.011	52
Brandon Township	S	2000-2001	450	0.010	0.006	0.031	0.008	13	0.018	0.009	0.078	0.018	43
Duluth 7551	S	2000-2001	86918	0.010	0.012	0.019	0.007	14	0.013	0.011	0.045	0.011	48
Fort Ripley	S	2000-2001	74	0.009	0.009	0.022	0.005	12	0.020	0.011	0.081	0.021	42
Grand Rapids	Sa	2000-2001	7764	0.011	0.008	0.035	0.008	21	0.016	0.013	0.060	0.013	51
North Mankato	S	2000-2001	11798	0.009	0.007	0.025	0.007	15	0.022	0.016	0.098	0.018	53
Willmar	S	2000-2001	18351	0.009	0.009	0.024	0.008	10	0.011	0.010	0.027	0.006	26

Appendix D-3: Metal Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Vanadium					Silver				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	.	.	.	.	0	0.006	0.008	0.009	0.002	23
International Falls	Sa	1996-1997	6703	.	.	.	.	0	0.006	0.008	0.015	0.004	35
Leon Township	S	1996-1997	942	.	.	.	.	0	0.007	0.008	0.014	0.003	31
Little Falls	S	1996-1997	7719	.	.	.	.	0	0.007	0.008	0.017	0.004	27
Pipestone	S	1996-1997	4280	.	.	.	.	0	0.007	0.008	0.015	0.003	38
Plymouth	S	1996-1997	65894	.	.	.	.	0	0.006	0.008	0.012	0.003	31
Wagner Township	S	1996-1997	320	.	.	.	.	0	0.006	0.008	0.024	0.004	30
Elk River	S	1997-1998	16447	.	.	.	.	0	0.006	0.008	0.012	0.003	33
Fergus Falls	S	1997-1998	13471	.	.	.	.	0	0.007	0.008	0.017	0.003	33
Granite Falls	S	1997-1998	3070	.	.	.	.	0	0.005	0.006	0.012	0.003	32
Hibbing	S	1997-1998	17071	.	.	.	.	0	0.006	0.008	0.011	0.003	30
Minneapolis	S	1997-1998	382618	.	.	.	.	0	0.006	0.008	0.013	0.003	25
Rochester	S	1997-1998	85806	.	.	.	.	0	0.006	0.008	0.012	0.003	36
Warroad	Sa	1997-1998	1722	.	.	.	.	0	0.006	0.008	0.015	0.003	36
Bemidji	Sa	1998-1999	11917	.	.	.	.	0	0.006	0.008	0.013	0.003	38
Duluth 7550	S	1998-1999	86918	.	.	.	.	0	0.007	0.008	0.017	0.003	31
St. Paul	S	1998-1999	287151	.	.	.	.	0	0.007	0.008	0.015	0.003	37
Holloway	S	1998-1999	112	.	.	.	.	0	0.005	0.005	0.010	0.003	21
Moorhead	S	1998-1999	32177	.	.	.	.	0	0.006	0.006	0.011	0.003	32
St. Cloud	S	1998-1999	59107	.	.	.	.	0	0.007	0.008	0.013	0.003	31
Winona	S	1998-1999	27069	.	.	.	.	0	0.006	0.007	0.015	0.003	27
Albert Lea	S	1999-2000	18356	.	.	.	.	0	0.005	0.004	0.010	0.003	14
Hutchinson	S	1999-2000	13080	.	.	.	.	0	0.007	0.008	0.015	0.004	14
Perham	S	1999-2000	2559	.	.	.	.	0	0.005	0.005	0.008	0.003	22
Silver Bay	Sa	1999-2000	2068	.	.	.	.	0	0.005	0.006	0.009	0.003	10
St. Michael	S	1999-2000	9099	.	.	.	.	0	0.006	0.005	0.014	0.003	19
Virginia	S	1999-2000	9157	.	.	.	.	0	0.006	0.005	0.011	0.004	13
West Lakeland	S	1999-2000	3547	.	.	.	.	0	0.006	0.008	0.018	0.004	26
Apple Valley	S	2000-2001	45527	.	.	.	.	0	0.004	0.003	0.008	0.002	13
Brandon Township	S	2000-2001	450	.	.	.	.	0	0.005	0.004	0.017	0.006	6
Duluth 7551	S	2000-2001	86918	.	.	.	.	0	0.004	0.002	0.012	0.004	11
Fort Ripley	S	2000-2001	74	.	.	.	.	0	0.009	0.008	0.016	0.007	3
Grand Rapids	Sa	2000-2001	7764	.	.	.	.	0	0.007	0.007	0.016	0.005	9
North Mankato	S	2000-2001	11798	.	.	.	.	0	0.005	0.005	0.011	0.004	10
Willmar	S	2000-2001	18351	.	.	.	.	0	0.003	0.002	0.010	0.004	5

Appendix D-3: Metal Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Zinc					Strontium				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.008	0.008	0.020	0.005	48	0.002	0.001	0.005	0.001	48
International Falls	Sa	1996-1997	6703	0.007	0.006	0.021	0.005	58	0.002	0.001	0.007	0.001	58
Leon Township	S	1996-1997	942	0.011	0.010	0.026	0.006	48	0.002	0.001	0.006	0.001	48
Little Falls	S	1996-1997	7719	0.011	0.011	0.038	0.007	49	0.002	0.001	0.005	0.001	49
Pipestone	S	1996-1997	4280	0.012	0.011	0.077	0.011	57	0.002	0.002	0.009	0.002	57
Plymouth	S	1996-1997	65894	0.013	0.012	0.031	0.007	55	0.002	0.001	0.007	0.001	55
Wagner Township	S	1996-1997	320	0.007	0.005	0.029	0.007	59	0.002	0.001	0.005	0.001	59
Elk River	S	1997-1998	16447	0.017	0.018	0.034	0.008	54	0.002	0.001	0.006	0.001	54
Fergus Falls	S	1997-1998	13471	0.018	0.013	0.085	0.018	57	0.003	0.002	0.014	0.002	57
Granite Falls	S	1997-1998	3070	0.010	0.010	0.021	0.005	57	0.002	0.001	0.006	0.001	57
Hibbing	S	1997-1998	17071	0.010	0.009	0.045	0.008	54	0.002	0.001	0.009	0.002	54
Minneapolis	S	1997-1998	382618	0.016	0.016	0.036	0.008	56	0.002	0.001	0.006	0.001	56
Rochester	S	1997-1998	85806	0.015	0.013	0.056	0.009	51	0.002	0.002	0.007	0.001	51
Warroad	Sa	1997-1998	1722	0.008	0.007	0.026	0.006	57	0.002	0.001	0.007	0.001	57
Bemidji	Sa	1998-1999	11917	0.008	0.008	0.023	0.006	57	0.002	0.001	0.009	0.002	57
Duluth 7550	S	1998-1999	86918	0.007	0.007	0.024	0.006	61	0.002	0.001	0.005	0.001	61
St. Paul	S	1998-1999	287151	0.022	0.016	0.101	0.020	60	0.002	0.001	0.005	0.001	59
Holloway	S	1998-1999	112	0.007	0.007	0.019	0.006	51	0.002	0.001	0.006	0.001	51
Moorhead	S	1998-1999	32177	0.014	0.013	0.037	0.009	52	0.003	0.002	0.007	0.002	52
St. Cloud	S	1998-1999	59107	0.014	0.015	0.034	0.008	58	0.002	0.001	0.008	0.001	58
Winona	S	1998-1999	27069	0.019	0.015	0.095	0.016	47	0.002	0.001	0.007	0.001	47
Albert Lea	S	1999-2000	18356	0.017	0.011	0.066	0.015	48	0.003	0.002	0.009	0.002	46
Hutchinson	S	1999-2000	13080	0.012	0.011	0.046	0.008	43	0.002	0.002	0.006	0.002	36
Perham	S	1999-2000	2559	0.009	0.007	0.030	0.007	41	0.003	0.002	0.012	0.003	37
Silver Bay	Sa	1999-2000	2068	0.014	0.010	0.054	0.012	31	0.002	0.001	0.009	0.002	33
St. Michael	S	1999-2000	9099	0.014	0.010	0.127	0.018	48	0.003	0.002	0.007	0.002	38
Virginia	S	1999-2000	9157	0.009	0.007	0.026	0.007	39	0.003	0.002	0.007	0.002	38
West Lakeland	S	1999-2000	3547	0.014	0.013	0.033	0.008	47	0.003	0.003	0.007	0.002	38
Apple Valley	S	2000-2001	45527	0.010	0.009	0.023	0.005	52	0.002	0.002	0.007	0.001	37
Brandon Township	S	2000-2001	450	0.007	0.007	0.015	0.003	47	0.003	0.001	0.007	0.002	35
Duluth 7551	S	2000-2001	86918	0.009	0.008	0.021	0.004	53	0.002	0.002	0.007	0.002	41
Fort Ripley	S	2000-2001	74	0.008	0.007	0.020	0.005	45	0.003	0.002	0.007	0.002	32
Grand Rapids	Sa	2000-2001	7764	0.010	0.008	0.048	0.007	56	0.003	0.002	0.009	0.002	45
North Mankato	S	2000-2001	11798	0.014	0.012	0.055	0.010	56	0.003	0.003	0.011	0.002	50
Willmar	S	2000-2001	18351	0.008	0.007	0.018	0.005	27	0.002	0.002	0.004	0.001	18

Appendix D-3: Metal Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Rubidium					Potassium				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.001	0.001	0.003	0.000	46	0.060	0.051	0.172	0.038	48
International Falls	Sa	1996-1997	6703	0.001	0.001	0.004	0.001	48	0.060	0.054	0.203	0.036	58
Leon Township	S	1996-1997	942	0.001	0.001	0.004	0.001	44	0.110	0.067	1.066	0.165	48
Little Falls	S	1996-1997	7719	0.001	0.001	0.003	0.001	40	0.084	0.067	0.453	0.071	49
Pipestone	S	1996-1997	4280	0.001	0.001	0.003	0.000	54	0.074	0.061	0.382	0.063	57
Plymouth	S	1996-1997	65894	0.001	0.001	0.004	0.001	47	0.085	0.075	0.337	0.060	55
Wagner Township	S	1996-1997	320	0.001	0.001	0.003	0.001	52	0.061	0.044	0.333	0.055	59
Elk River	S	1997-1998	16447	0.002	0.001	0.006	0.001	47	0.104	0.073	0.513	0.105	54
Fergus Falls	S	1997-1998	13471	0.002	0.001	0.004	0.001	49	0.121	0.094	0.540	0.104	57
Granite Falls	S	1997-1998	3070	0.001	0.001	0.004	0.001	51	0.090	0.068	0.365	0.076	57
Hibbing	S	1997-1998	17071	0.001	0.001	0.003	0.000	46	0.058	0.048	0.521	0.070	54
Minneapolis	S	1997-1998	382618	0.001	0.001	0.004	0.001	47	0.103	0.072	0.457	0.091	56
Rochester	S	1997-1998	85806	0.001	0.001	0.003	0.001	45	0.107	0.083	0.381	0.083	51
Warroad	Sa	1997-1998	1722	0.001	0.001	0.003	0.001	52	0.092	0.077	0.355	0.075	57
Bemidji	Sa	1998-1999	11917	0.001	0.001	0.004	0.001	49	0.102	0.069	0.440	0.087	57
Duluth 7550	S	1998-1999	86918	0.001	0.001	0.004	0.001	57	0.048	0.044	0.172	0.032	61
St. Paul	S	1998-1999	287151	0.001	0.001	0.003	0.001	54	0.090	0.078	0.243	0.055	60
Holloway	S	1998-1999	112	0.001	0.001	0.003	0.001	41	0.061	0.051	0.231	0.051	51
Moorhead	S	1998-1999	32177	0.002	0.001	0.005	0.001	47	0.131	0.116	0.414	0.093	52
St. Cloud	S	1998-1999	59107	0.001	0.001	0.004	0.001	51	0.090	0.077	0.313	0.060	58
Winona	S	1998-1999	27069	0.001	0.001	0.004	0.001	42	0.081	0.070	0.252	0.047	47
Albert Lea	S	1999-2000	18356	0.002	0.001	0.004	0.001	36	0.162	0.120	0.708	0.121	47
Hutchinson	S	1999-2000	13080	0.002	0.001	0.005	0.001	25	0.097	0.072	0.568	0.092	49
Perham	S	1999-2000	2559	0.002	0.001	0.004	0.001	34	0.144	0.111	0.608	0.123	48
Silver Bay	Sa	1999-2000	2068	0.002	0.001	0.005	0.001	28	0.072	0.061	0.355	0.055	42
St. Michael	S	1999-2000	9099	0.001	0.001	0.003	0.001	33	0.112	0.082	0.567	0.095	51
Virginia	S	1999-2000	9157	0.002	0.001	0.004	0.001	28	0.107	0.095	0.329	0.060	46
West Lakeland	S	1999-2000	3547	0.001	0.001	0.003	0.001	31	0.098	0.071	0.391	0.076	47
Apple Valley	S	2000-2001	45527	0.002	0.001	0.004	0.001	25	0.090	0.070	0.283	0.067	52
Brandon Township	S	2000-2001	450	0.002	0.001	0.004	0.001	27	0.102	0.059	0.393	0.095	48
Duluth 7551	S	2000-2001	86918	0.001	0.001	0.003	0.001	37	0.067	0.053	0.207	0.048	53
Fort Ripley	S	2000-2001	74	0.001	0.001	0.003	0.001	28	0.108	0.067	0.386	0.098	46
Grand Rapids	Sa	2000-2001	7764	0.001	0.001	0.003	0.001	30	0.096	0.086	0.335	0.070	56
North Mankato	S	2000-2001	11798	0.002	0.001	0.004	0.001	30	0.141	0.094	0.552	0.119	56
Willmar	S	2000-2001	18351	0.002	0.002	0.003	0.001	15	0.065	0.058	0.134	0.038	27

Appendix D-3: Metal Concentration Summary Page

(Concentrations in ug/m^3)

Site	Site Type	Monitoring Year	2000 Population	Yttrium					Zirconium				
				Mean	Median	Maximum	Standard Deviation	Valid N	Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	0.001	0.001	0.003	0.001	36	0.005	0.007	0.008	0.002	48
International Falls	Sa	1996-1997	6703	0.001	0.001	0.003	0.000	41	0.005	0.007	0.009	0.002	58
Leon Township	S	1996-1997	942	0.001	0.001	0.004	0.001	39	0.005	0.007	0.008	0.002	48
Little Falls	S	1996-1997	7719	0.002	0.001	0.005	0.001	47	0.005	0.007	0.008	0.002	49
Pipestone	S	1996-1997	4280	0.001	0.001	0.003	0.000	43	0.005	0.007	0.009	0.002	57
Plymouth	S	1996-1997	65894	0.002	0.001	0.004	0.001	46	0.005	0.007	0.010	0.002	55
Wagner Township	S	1996-1997	320	0.002	0.001	0.004	0.001	51	0.005	0.007	0.007	0.002	59
Elk River	S	1997-1998	16447	0.002	0.001	0.006	0.001	40	0.006	0.007	0.016	0.003	54
Fergus Falls	S	1997-1998	13471	0.002	0.001	0.006	0.001	46	0.005	0.007	0.013	0.002	57
Granite Falls	S	1997-1998	3070	0.002	0.001	0.007	0.001	51	0.006	0.007	0.015	0.003	57
Hibbing	S	1997-1998	17071	0.002	0.001	0.011	0.002	44	0.006	0.007	0.014	0.003	54
Minneapolis	S	1997-1998	382618	0.002	0.001	0.006	0.001	51	0.006	0.007	0.015	0.003	56
Rochester	S	1997-1998	85806	0.002	0.001	0.008	0.002	42	0.006	0.007	0.012	0.003	51
Warroad	Sa	1997-1998	1722	0.002	0.001	0.005	0.001	50	0.006	0.007	0.014	0.003	57
Bemidji	Sa	1998-1999	11917	0.003	0.002	0.007	0.002	57	0.006	0.007	0.020	0.003	57
Duluth 7550	S	1998-1999	86918	0.003	0.002	0.008	0.002	61	0.006	0.007	0.015	0.003	61
St. Paul	S	1998-1999	287151	0.002	0.002	0.007	0.002	59	0.005	0.005	0.013	0.003	60
Holloway	S	1998-1999	112	0.003	0.002	0.008	0.002	51	0.006	0.007	0.012	0.002	51
Moorhead	S	1998-1999	32177	0.002	0.001	0.007	0.002	52	0.006	0.007	0.013	0.003	52
St. Cloud	S	1998-1999	59107	0.003	0.002	0.008	0.002	58	0.006	0.007	0.010	0.002	58
Winona	S	1998-1999	27069	0.002	0.001	0.007	0.001	47	0.005	0.006	0.011	0.003	47
Albert Lea	S	1999-2000	18356	0.002	0.001	0.007	0.001	27	0.007	0.007	0.013	0.002	37
Hutchinson	S	1999-2000	13080	0.002	0.001	0.005	0.001	18	0.007	0.007	0.013	0.003	38
Perham	S	1999-2000	2559	0.002	0.001	0.005	0.001	28	0.007	0.007	0.019	0.004	36
Silver Bay	Sa	1999-2000	2068	0.002	0.001	0.004	0.001	25	0.006	0.007	0.012	0.003	33
St. Michael	S	1999-2000	9099	0.002	0.001	0.007	0.001	24	0.007	0.007	0.014	0.003	36
Virginia	S	1999-2000	9157	0.003	0.001	0.010	0.002	22	0.008	0.007	0.022	0.004	32
West Lakeland	S	1999-2000	3547	0.001	0.001	0.003	0.001	21	0.006	0.007	0.011	0.003	35
Apple Valley	S	2000-2001	45527	0.002	0.002	0.004	0.001	27	0.004	0.004	0.009	0.003	28
Brandon Township	S	2000-2001	450	0.002	0.001	0.004	0.001	24	0.004	0.003	0.013	0.003	31
Duluth 7551	S	2000-2001	86918	0.002	0.002	0.005	0.001	21	0.004	0.004	0.009	0.002	31
Fort Ripley	S	2000-2001	74	0.003	0.002	0.006	0.002	21	0.006	0.006	0.016	0.003	32
Grand Rapids	Sa	2000-2001	7764	0.002	0.001	0.006	0.001	27	0.004	0.004	0.010	0.003	34
North Mankato	S	2000-2001	11798	0.002	0.002	0.006	0.001	28	0.005	0.005	0.011	0.003	39
Willmar	S	2000-2001	18351	0.002	0.002	0.008	0.002	16	0.004	0.004	0.008	0.002	10

Appendix D-3: Metal Concentration Summary Page

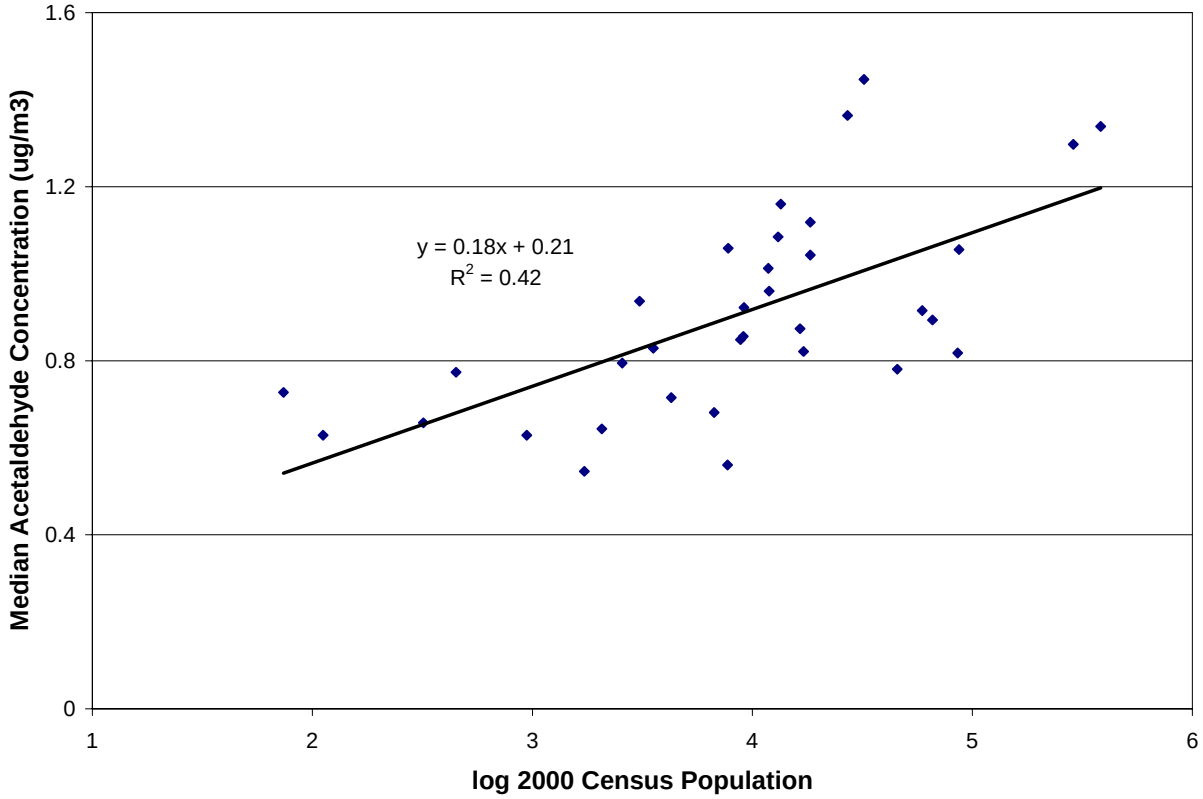
(Concentrations in ug/m^3)

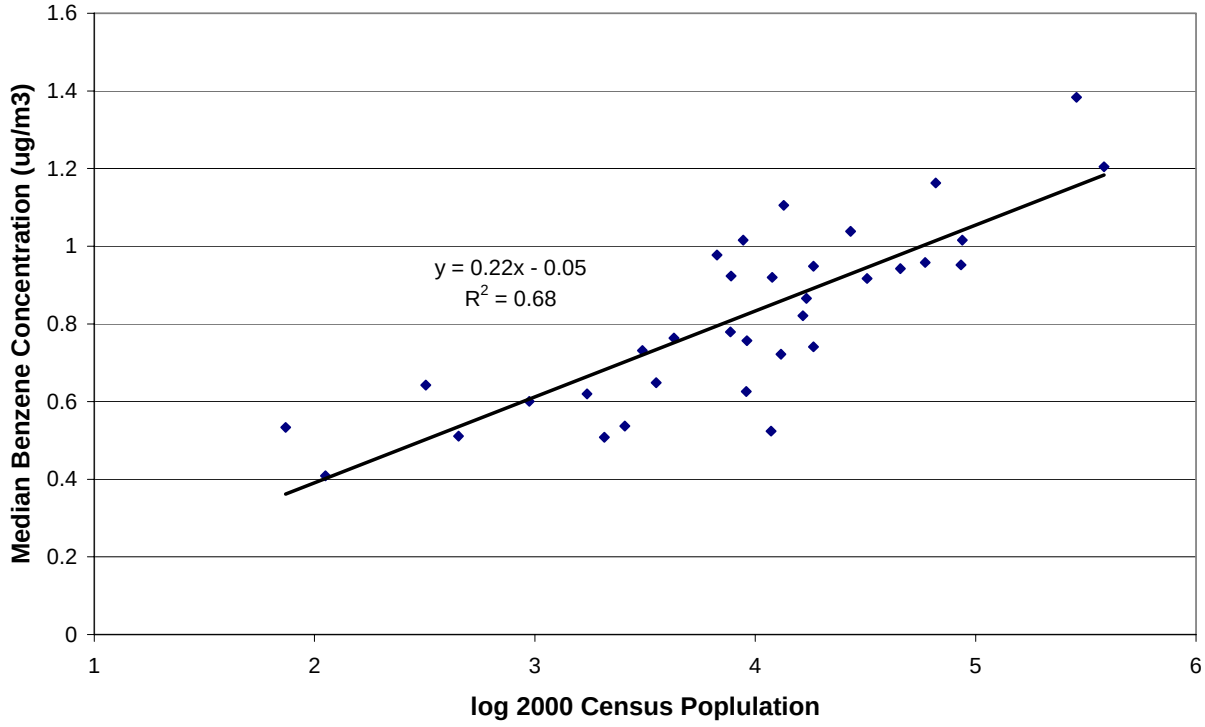
Site	Site Type	Monitoring Year	2000 Population	PM10				
				Mean	Median	Maximum	Standard Deviation	Valid N
Alexandria	S	1996-1997	8820	10.9	11.0	21.0	4.7	48
International Falls	Sa	1996-1997	6703	9.4	9.0	22.0	4.5	58
Leon Township	S	1996-1997	942	15.5	13.0	61.0	9.3	48
Little Falls	S	1996-1997	7719	13.2	12.0	43.0	7.5	50
Pipestone	S	1996-1997	4280	12.6	13.0	37.0	6.1	57
Plymouth	S	1996-1997	65894	15.1	14.0	35.0	7.2	55
Wagner Township	S	1996-1997	320	9.5	8.0	28.0	5.6	59
Elk River	S	1997-1998	16447	17.2	16.0	41.0	8.6	53
Fergus Falls	S	1997-1998	13471	18.3	17.0	55.0	9.9	56
Granite Falls	S	1997-1998	3070	16.3	16.0	41.0	7.7	57
Hibbing	S	1997-1998	17071	11.5	10.0	39.0	6.7	54
Minneapolis	S	1997-1998	382618	18.1	18.0	40.0	8.4	56
Rochester	S	1997-1998	85806	17.9	16.0	62.0	9.6	50
Warroad	Sa	1997-1998	1722	11.7	12.0	40.0	6.7	57
Bemidji	Sa	1998-1999	11917	14.8	13.0	40.0	7.9	57
Duluth 7550	S	1998-1999	86918	9.8	9.0	29.0	5.0	61
St. Paul	S	1998-1999	287151	15.6	15.0	33.0	6.9	60
Holloway	S	1998-1999	112	11.2	10.0	29.0	6.5	52
Moorhead	S	1998-1999	32177	17.3	15.0	39.0	7.7	52
St. Cloud	S	1998-1999	59107	13.2	12.0	39.0	7.0	58
Winona	S	1998-1999	27069	16.0	14.0	42.0	7.2	47
Albert Lea	S	1999-2000	18356	24.0	22.3	71.0	12.0	58
Hutchinson	S	1999-2000	13080	12.7	11.6	27.6	6.1	49
Perham	S	1999-2000	2559	15.9	14.0	40.0	9.0	56
Silver Bay	Sa	1999-2000	2068	13.9	12.9	75.3	11.6	47
St. Michael	S	1999-2000	9099	13.9	11.5	28.0	6.5	50
Virginia	S	1999-2000	9157	17.1	15.6	47.5	7.6	43
West Lakeland	S	1999-2000	3547	14.3	13.5	40.2	7.5	52
Apple Valley	S	2000-2001	45527	15.1	14.7	35.5	7.7	55
Brandon Township	S	2000-2001	450	14.6	11.9	40.5	9.0	49
Duluth 7551	S	2000-2001	86918	11.6	11.4	25.5	6.2	60
Fort Ripley	S	2000-2001	74	14.5	12.9	36.1	8.8	54
Grand Rapids	Sa	2000-2001	7764	13.6	12.9	31.9	6.7	57
North Mankato	S	2000-2001	11798	21.6	21.0	51.9	10.2	57
Willmar	S	2000-2001	18351	12.9	12.1	30.4	5.8	49

Appendix E: Risk Summaries

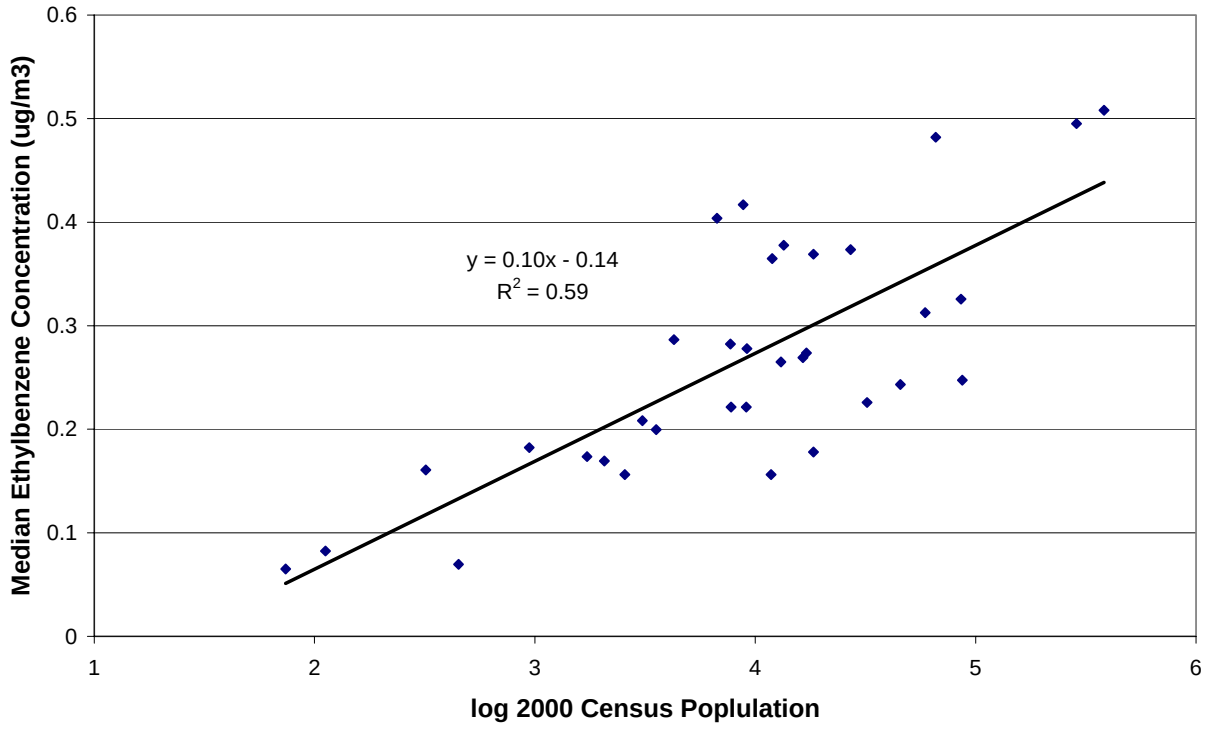
Site Name	Monitoring Year	2000 Population	Acute HI	Developmental	Eyes	Nervous	Reproductive	Respiratory System	10-5 Cancer Risk	Chronic Non-Cancer HI	Blood Cardiovascular	Developmental	Eyes	Hematopoietic	Kidney Urinary	Liver	Nervous	Reproductive	Upper Respiratory System	Lower Respiratory System	Respiratory System	Whole Body
Alexandria	1996-1997	8820	0.04	0.00	0.04	0.00	0.00	0.04	4.39	0.82	0.04	0.11	0.48	0.00	0.00	0.04	0.07	0.00	0.62	0.52	0.62	0.00
International Falls	1996-1997	6703	0.05	0.01	0.04	0.00	0.00	0.04	4.25	0.81	0.05	0.11	0.43	0.00	0.00	0.04	0.07	0.00	0.61	0.53	0.61	0.00
Leon Township	1996-1997	942	0.04	0.00	0.03	0.00	0.00	0.03	3.56	0.65	0.02	0.11	0.39	0.00	0.00	0.04	0.06	0.00	0.47	0.40	0.48	0.00
Little Falls	1996-1997	7719	0.03	0.00	0.03	0.00	0.00	0.03	3.69	0.70	0.03	0.14	0.38	0.00	0.00	0.04	0.07	0.00	0.47	0.40	0.47	0.00
Pipestone	1996-1997	4280	0.04	0.00	0.04	0.00	0.00	0.04	3.84	0.72	0.03	0.09	0.42	0.00	0.00	0.04	0.09	0.00	0.52	0.44	0.53	0.00
Plymouth	1996-1997	65894	0.07	0.01	0.06	0.00	0.00	0.06	4.22	0.89	0.04	0.10	0.41	0.00	0.00	0.04	0.08	0.00	0.68	0.57	0.69	0.00
Wagner Township	1996-1997	320	0.04	0.00	0.04	0.00	0.00	0.04	3.63	0.68	0.02	0.12	0.41	0.00	0.00	0.04	0.05	0.00	0.49	0.42	0.50	0.00
Elk River	1997-1998	16447	0.05	0.00	0.04	0.00	0.00	0.04	4.04	0.82	0.03	0.09	0.48	0.00	0.00	0.03	0.08	0.00	0.62	0.51	0.62	0.00
Fergus Falls	1997-1998	13471	0.04	0.00	0.04	0.00	0.00	0.04	4.65	1.06	0.04	0.11	0.55	0.00	0.00	0.03	0.10	0.00	0.82	0.62	0.82	0.00
Granite Falls	1997-1998	3070	0.22	0.01	0.22	0.00	0.00	0.22	4.69	1.00	0.03	0.08	0.66	0.00	0.00	0.03	0.07	0.00	0.83	0.72	0.83	0.00
Hibbing	1997-1998	17071	0.06	0.00	0.06	0.00	0.00	0.06	4.21	0.89	0.03	0.12	0.52	0.00	0.00	0.03	0.08	0.00	0.66	0.56	0.66	0.00
Minneapolis	1997-1998	382618	0.12	0.00	0.12	0.00	0.00	0.12	5.81	1.26	0.05	0.10	0.83	0.00	0.00	0.03	0.10	0.00	1.03	0.87	1.03	0.00
Rochester	1997-1998	85806	0.03	0.00	0.03	0.00	0.00	0.03	4.06	0.77	0.04	0.08	0.45	0.00	0.00	0.04	0.07	0.00	0.59	0.49	0.59	0.00
Warroad	1997-1998	1722	0.06	0.00	0.06	0.00	0.00	0.06	3.44	0.67	0.02	0.09	0.41	0.00	0.00	0.04	0.06	0.00	0.51	0.45	0.52	0.00
Bemidji	1998-1999	11917	0.04	0.01	0.03	0.00	0.00	0.03	3.83	0.84	0.04	0.10	0.46	0.00	0.00	0.03	0.07	0.00	0.63	0.52	0.63	0.00
Duluth 7550	1998-1999	86918	0.06	0.00	0.05	0.00	0.00	0.05	3.56	0.84	0.03	0.11	0.47	0.00	0.00	0.03	0.05	0.00	0.66	0.57	0.67	0.00
St. Paul	1998-1999	287151	0.10	0.01	0.09	0.00	0.00	0.09	5.45	1.24	0.06	0.10	0.74	0.00	0.00	0.03	0.09	0.00	1.00	0.84	1.01	0.00
Holloway	1998-1999	112	0.03	0.00	0.03	0.00	0.00	0.03	2.47	0.59	0.02	0.09	0.28	0.00	0.00	0.02	0.05	0.00	0.44	0.36	0.44	0.00
Moorhead	1998-1999	32177	0.06	0.00	0.06	0.00	0.00	0.06	4.17	1.05	0.03	0.12	0.57	0.00	0.00	0.03	0.08	0.00	0.81	0.64	0.81	0.00
St. Cloud	1998-1999	59107	0.14	0.00	0.14	0.00	0.00	0.14	3.95	0.86	0.04	0.10	0.50	0.00	0.00	0.03	0.06	0.00	0.67	0.54	0.67	0.00
Winona	1998-1999	27069	0.08	0.01	0.07	0.00	0.00	0.07	5.09	1.43	0.05	0.10	0.72	0.00	0.00	0.03	0.08	0.00	1.21	1.04	1.21	0.00
Albert Lea	1999-2000	18356	0.05	0.01	0.04	0.00	0.00	0.04	4.15	1.00	0.04	0.16	0.52	0.00	0.00	0.03	0.11	0.00	0.70	0.56	0.70	0.00
Hutchinson	1999-2000	13080	0.04	0.00	0.04	0.00	0.00	0.04	4.05	1.02	0.03	0.15	0.54	0.00	0.00	0.02	0.08	0.00	0.77	0.63	0.77	0.00
Perham	1999-2000	2559	0.03	0.00	0.03	0.00	0.00	0.03	3.20	0.79	0.02	0.17	0.39	0.00	0.00	0.03	0.09	0.00	0.52	0.42	0.52	0.00
Silver Bay	1999-2000	2068	0.04	0.00	0.03	0.00	0.00	0.03	3.21	0.83	0.02	0.19	0.41	0.00	0.00	0.03	0.07	0.00	0.56	0.48	0.57	0.00
St. Michael	1999-2000	9099	0.05	0.00	0.04	0.00	0.00	0.04	3.60	1.00	0.02	0.18	0.47	0.00	0.00	0.03	0.07	0.00	0.72	0.62	0.72	0.00
Virginia	1999-2000	9157	0.05	0.00	0.05	0.00	0.00	0.05	4.00	1.11	0.03	0.17	0.54	0.00	0.00	0.03	0.18	0.00	0.73	0.63	0.74	0.00
West Lakeland	1999-2000	3547	0.06	0.00	0.06	0.00	0.00	0.06	3.53	0.94	0.02	0.20	0.46	0.00	0.00	0.03	0.06	0.00	0.66	0.56	0.67	0.00
Apple Valley	2000-2001	45527	0.04	0.00	0.04	0.00	0.00	0.04	3.45	0.82	0.03	0.15	0.43	0.00	0.00	0.03	0.06	0.00	0.58	0.48	0.58	0.00
Brandon Township	2000-2001	450	0.04	0.00	0.04	0.00	0.00	0.04	3.07	0.79	0.02	0.17	0.41	0.00	0.00	0.03	0.06	0.00	0.53	0.44	0.54	0.00
Duluth 7551	2000-2001	86918	0.05	0.00	0.05	0.00	0.00	0.05	4.45	1.12	0.04	0.12	0.65	0.00	0.00	0.03	0.06	0.00	0.91	0.77	0.91	0.00
Fort Ripley	2000-2001	74	0.05	0.00	0.04	0.00	0.00	0.05	3.45	1.02	0.02	0.18	0.48	0.00	0.00	0.03	0.07	0.00	0.75	0.66	0.75	0.00
Grand Rapids	2000-2001	7764	0.08	0.00	0.07	0.00	0.00	0.07	5.07	1.22	0.04	0.20	0.75	0.00	0.00	0.03	0.07	0.00	0.92	0.78	0.92	0.00
North Mankato	2000-2001	11798	0.04	0.00	0.04	0.00	0.00	0.04	3.90	0.96	0.02	0.16	0.56	0.00	0.00	0.03	0.09	0.00	0.70	0.59	0.70	0.00
Willmar	2000-2001	18351	0.04	0.00	0.04	0.00	0.00	0.04	4.19	1.06	0.03	0.22	0.60	0.00	0.00	0.03	0.06	0.00	0.75	0.62	0.75	0.00

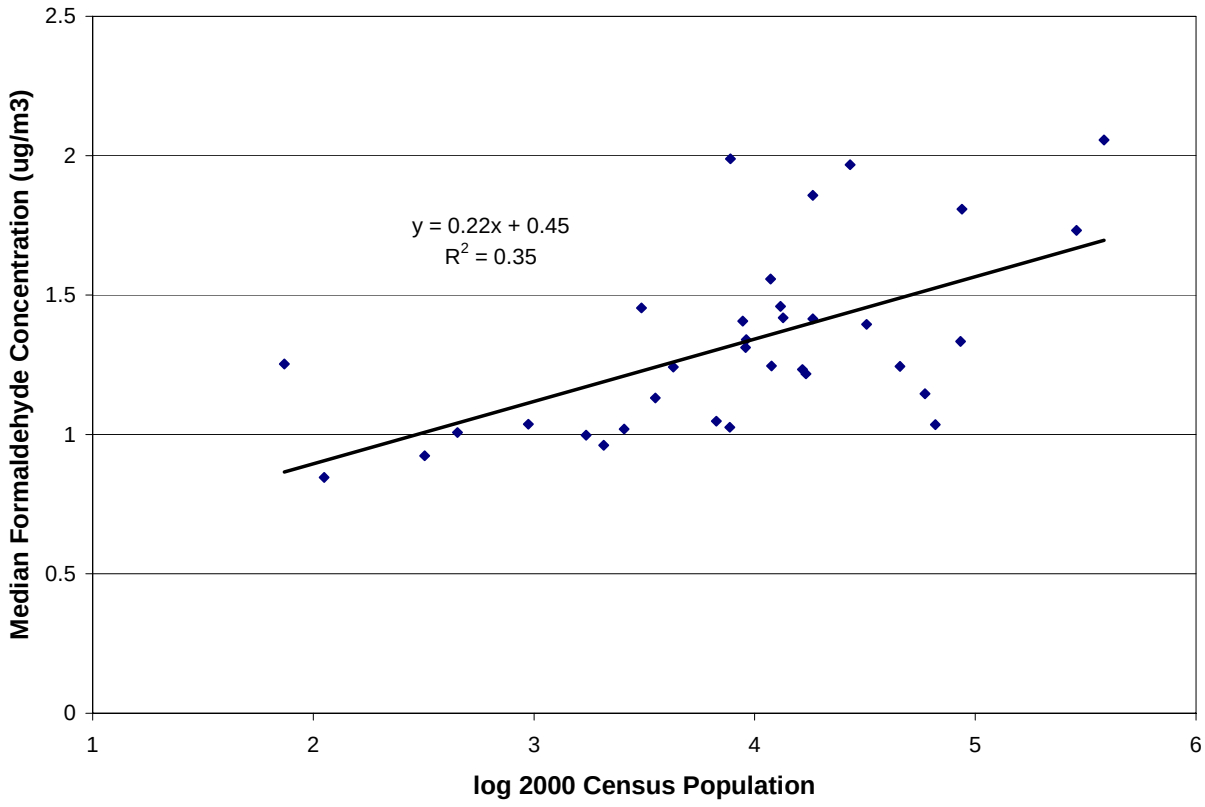
Appendix F: Mobile Source Air Toxic Concentrations Compared to Population



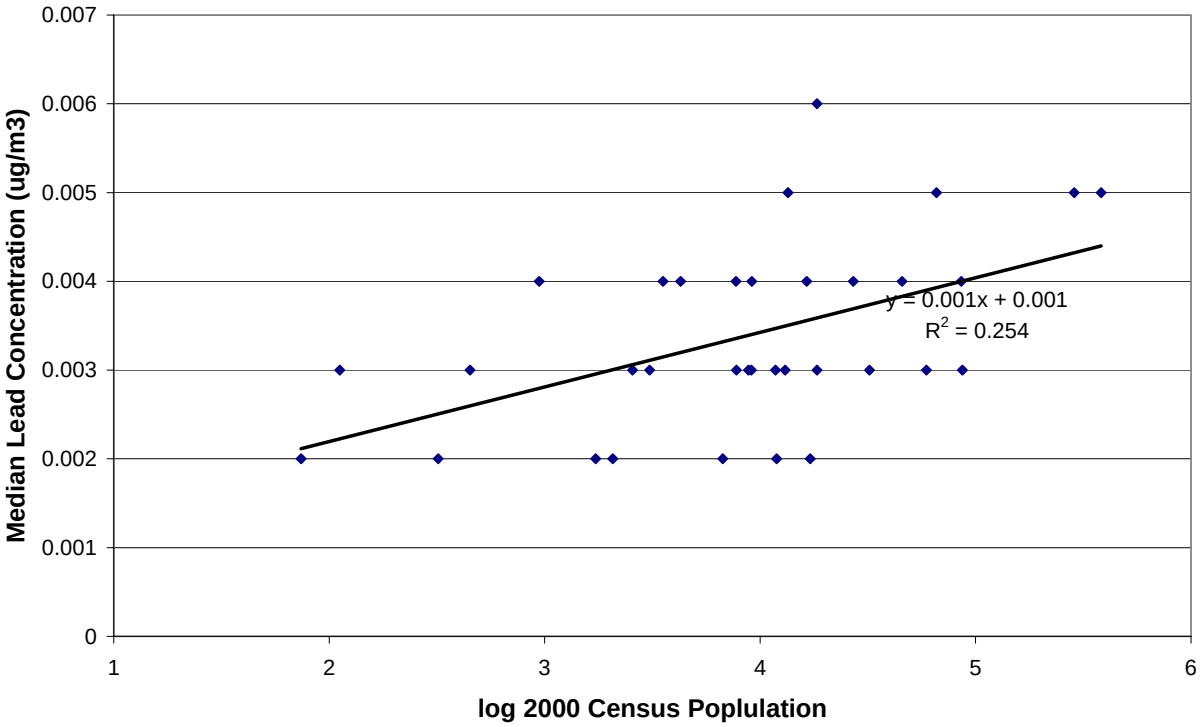


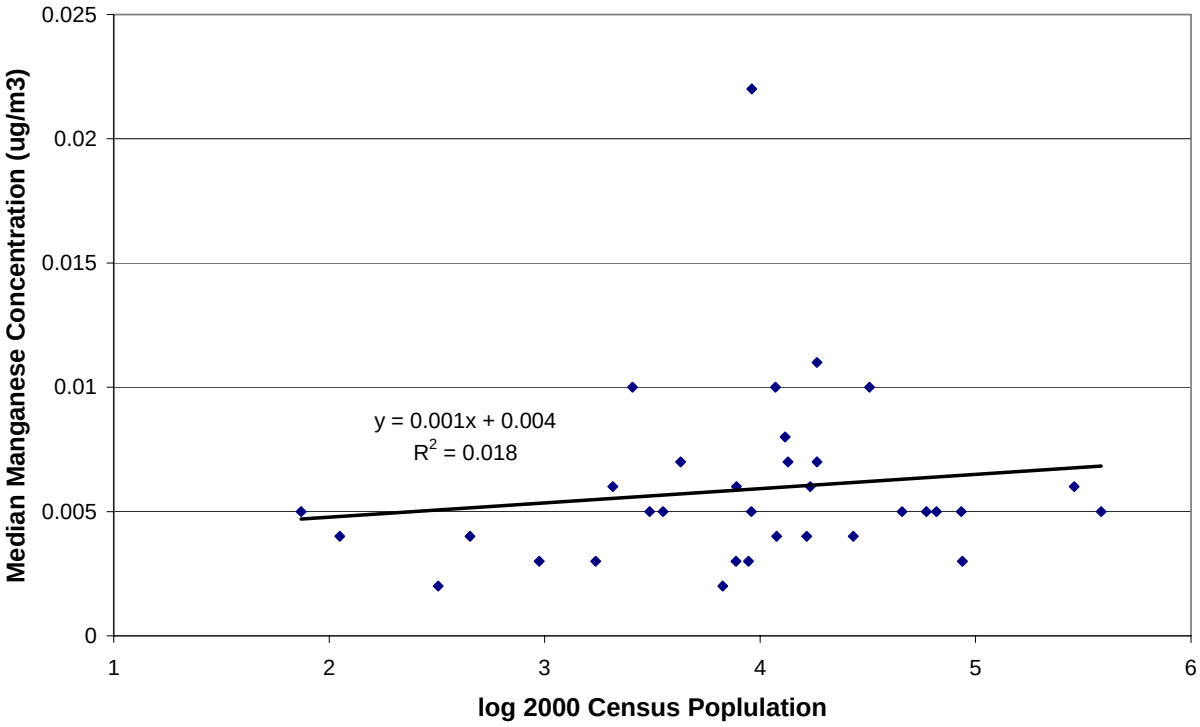
Appendix F: Mobile Source Air Toxic Concentrations Compared to Population



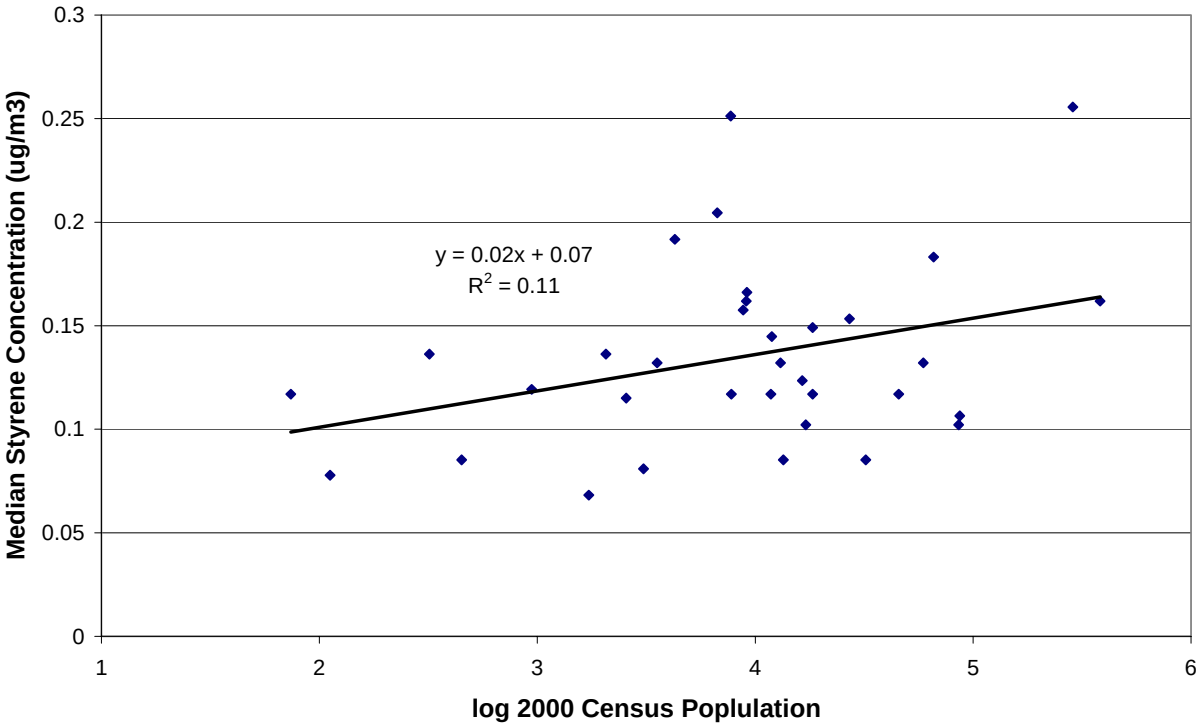


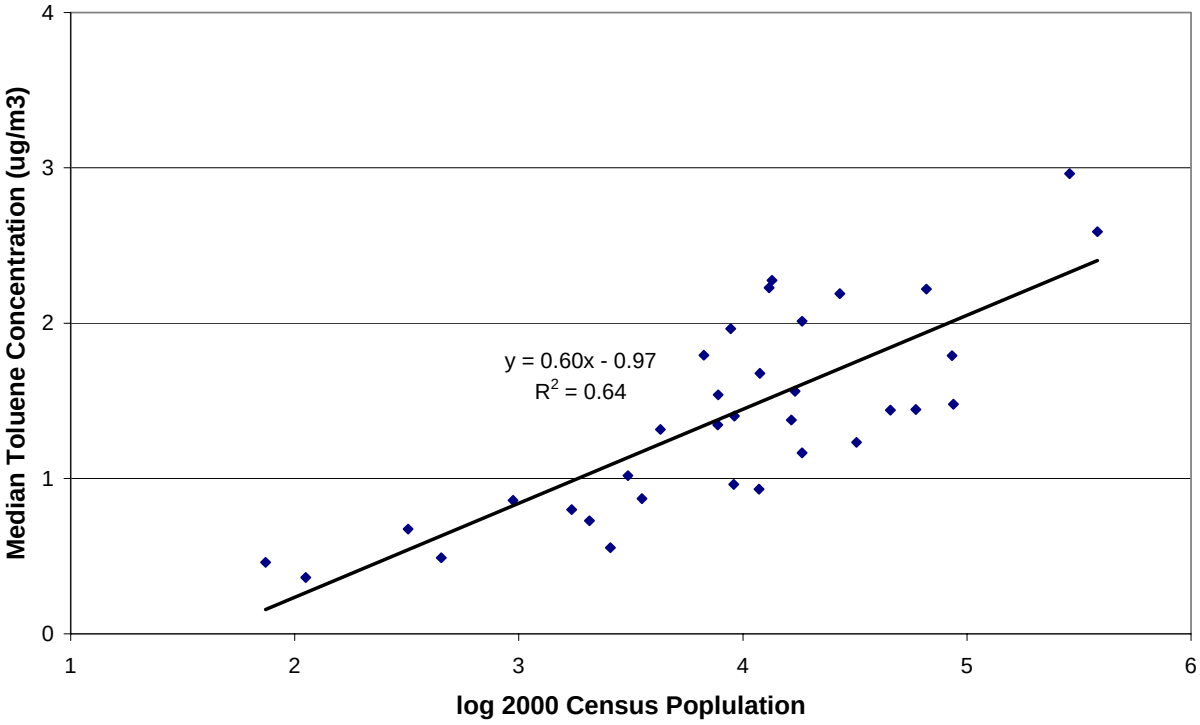
Appendix F: Mobile Source Air Toxic Concentrations Compared to Population





Appendix F: Mobile Source Air Toxic Concentrations Compared to Population





Appendix F: Mobile Source Air Toxic Concentrations Compared to Population