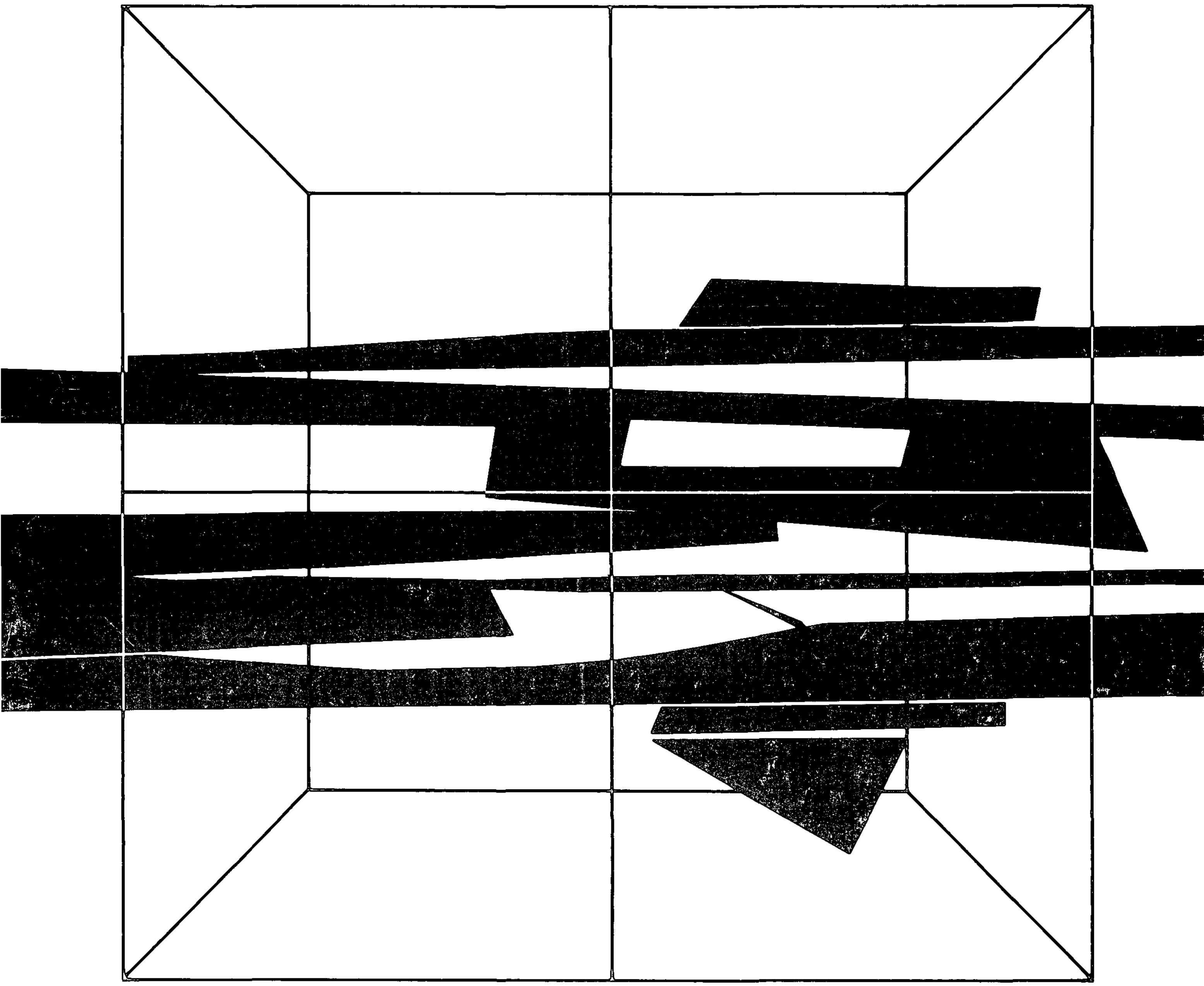
Ambient Air Particulate Lead Concentrations in Canada 1975-1983

Report EPS 7/AP/15
September 1985



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Environmental Protection Service
Environment Canada

EPS 7/AP/15
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ABSTRACT

Data for airborne lead concentrations in Canada between 1975 and 1983 show that annual average lead levels decreased by 55 percent in this period. A lower lead content in gasoline and lower demand for gasoline account for this decrease in airborne lead concentration. A comparison with U.S. data confirms this conclusion and shows that further reductions in ambient lead levels can be accomplished by decreasing the lead content in gasoline.

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1 INTRODUCTION

Human exposure to ambient airborne lead occurs through direct inhalation of lead-containing particles and through ingestion of lead that has been transported through the atmosphere to vegetation, soil and water. Knowledge of environmental concentrations of lead is essential to assess its effects on human populations and to design appropriate control strategies. Data for airborne lead concentrations in Canada are obtained primarily from the National Air Pollution Surveillance (NAPS) network, which is a cooperative federal/provincial urban monitoring system with 105 sampling sites in 52 cities in Canada. The NAPS network is designed to serve national monitoring needs, including assessment of national ambient air quality trends.

Airborne lead is predominantly inorganic particulate matter. Sampling for lead at all NAPS sites is carried out using the standard hi-vol sampler (1) which collects suspended particulate matter of up to 25-45 μm in diameter. The collected particles are deposited on a filter which is usually analyzed gravimetrically to determine total suspended particulate (TSP) loadings. Filter cuttings are then taken and analyzed for lead using atomic absorption spectrophotometry (2) or x-ray fluorescence techniques. Samples are collected over a 24-hour period every six days at all sites.

Environment Canada administers a quality assurance program for the NAPS network which ensures a consistent sampling and analytical approach for all monitoring agencies providing lead data. Current methods were in use prior to 1975; the trend data presented in this report have not been influenced by changes in sampling or analytical procedures.

1.1 Monitoring Objectives

Urban monitoring networks should be designed (a) to determine the highest levels expected to occur in the areas covered by the network, and (b) to determine representative concentrations in areas of high population density. In urban areas, the majority of lead emissions result from the use of leaded gasoline in motor vehicles (3). Accordingly, the highest concentrations of lead would be expected in areas with high population densities and accompanying high traffic densities.

1.2 Siting Criteria for Lead Monitoring Stations

Because no national ambient air quality objectives exist for lead in Canada, most monitoring sites have been selected to satisfy monitoring objectives for total suspended particulate matter (4). Most TSP sites are specifically located so that they are not unduly influenced by roadway sources or individual point sources.

Studies have indicated that lead levels decrease exponentially with increasing distance from the roadway (5,6). Measured concentrations will be directly related to distance from roadways and the traffic volume on the roadway. Although optimal placement of sampler inlets for lead monitoring would be at the breathing height level, practical factors such as prevention of vandalism and pedestrian safety must also be considered. Lead gradients in the vertical in the vicinity of roadways are not large within the first 7 m from the ground, but the highest concentrations would typically be measured at lower sampler heights.

Detailed site selection and probe siting criteria for lead monitoring have been published by the United States Environmental Protection Agency (7). Because of the lack of Canadian criteria, 67 sites in the NAPS network located in the major census metropolitan areas (CMAs) were examined to determine conformity with U.S. EPA recommended siting criteria as outlined in Appendix A. Except in British Columbia and Alberta, the distribution of monitoring sites in the network was adequate to determine representative concentrations in areas of high population density and to determine maximum exposure levels due to roadway sources. In British Columbia and Alberta, no sites were found that were close to major roadways (>30 000 vehicles per day). Few sites in the network appear to be representative of maximum exposures due to industrial point sources.

1.3 Monitoring Sites Showing Highest Lead Concentrations in 1983

Measured concentrations at NAPS sites in 1983 were compared using three averaging time statistics:

(a) annual geometric mean,
(b) quarterly arithmetic mean, and
(c) 24-h daily mean.

Sites with the highest lead concentrations for one or more of these periods are presented in Table 1 along with their locations and specific characteristics.

Sampling heights were within 5 m of the ground at all but one of the eastern Canadian stations with high measured lead concentrations. Four out of the six were close to major roadways with traffic volumes ranging from 56 000 to 225 000 vehicles per day. The Rouyn site was probably influenced by lead emissions from the Noranda copper

TABLE 1 MONITORING SITES* WITH HIGHEST MEASURED LEAD CONCENTRATIONS (1983)

Station No.	City	Address	Annual Geometric Mean (μg/m^3)	Maximum Quarterly Mean (μg/m^3)	Maximum 24-h Conc. (μg/m^3)	Sampler Height (m)	Distance to Nearest Roadway (m)	Nearest Major Roadway Traffic Volume (veh/day)
50109	Montreal	Duncan/Décarie	0.72	0.93	1.8	4	20	100 000
50601	Rouyn	Hotel de Ville	0.41	1.20	7.7	8	--	--
60403	Toronto	Evans/Arnold	0.46	0.77	1.7	2	120	150 000
60412	Toronto	Bathurst/Wilson	0.45	0.90	1.6	2	50	225 800
60501	Hamilton	Barton/Sanford	0.40	0.67	2.5	4	18	18 650
61501	Kitchener	Edna/Frederick	0.52	0.83	2.2	4.5	20	56 000
90204	Calgary	316-7th Avenue	0.43	0.93	2.2	9	25	16 150
00104	Vancouver	27th/Ontario	0.50	0.77	1.8	18	200	10 800
00106	Vancouver	2294 W. 10th	0.41	0.67	1.3	17	100	30 000
00109	Vancouver	970 Burrard	0.56	0.77	1.9	4	20	21 200
00114	Vancouver	Mun. Hall (Richmond)	0.46	0.83	2.1	15	100	29 000
00117	Vancouver	BCIT Burnaby	0.51	0.87	2.2	18	200	35 000
00303	Victoria	1250 Quadra	0.45	1.0	2.3	12	18	12 000

* Only NAPS stations with complete data record included.

smelter complex; the Hamilton site may also have been influenced by industrial lead emissions.

Of the western Canadian sites, five out of seven were located in Vancouver. None of these sites was close to a major roadway; four of them were in residential neighbourhoods with sampler heights in the 15 to 18 m range. The Calgary and Victoria sites also had relatively high sampler heights, 9 and 12 m, respectively, and were not close to major roadways (>30 000 vehicles/day). The apparent regional differences in the characteristics of sites with high lead concentrations are discussed in Section 2.5.

2 AMBIENT LEAD CONCENTRATIONS IN CANADA

2.1 Data Base

In 1983, 105 TSP sites in the NAPS network reported particulate lead data (8). Of these, 81 sites provided data that satisfied the completeness criteria (40 samples in the year with at least 8 for each quarter) for calculation of a valid annual geometric mean. The total number of sites meeting completeness criteria varied from 58 to 84 over the period 1975 to 1983. Table B1 of Appendix B shows annual geometric mean lead concentrations for all sites in the network with valid annual means during 1975 to 1983. It should be noted that lead monitoring data were not available from the province of Alberta during the years 1979 to 1982.

2.2 Trends in Annual Geometric Mean Lead Concentrations

A composite national annual geometric mean was calculated for each year by averaging the annual geometric means for all sites (Table BI). A composite mean was also calculated for the subset of sites located in major census metropolitan areas (CMAs) of Canada. The trend lines for the composite annual geometric mean for NAPS sites and major CMA sites are given in Figure 1. The composite annual geometric mean for all NAPS sites decreased by 55 percent from 0.55 $\mu g/m^3$ to 0.25 $\mu g/m^3$ during the period 1975-1983. Application of the Wilcoxon Matched Pairs test (9) to the data showed that there was a statistically significant decrease in the ambient lead concentration during each year from 1975 to 1983 except for 1980-1981. The composite annual geometric mean for sites in the major CMAs decreased by 60 percent, from 0.65 to 0.29 $\mu g/m^3$ during the same period.

A box plot comparison of trends in the annual geometric mean lead concentrations for all NAPS sites is given in Figure 2 (10). The percentiles indicate the percentage of stations with annual averages less than the specific levels identified. As shown in Figure 2, the pattern of decrease in the upper percentile concentrations (75th and 90th) is similar to that of the composite means. The lower percentile concentrations (10th and 25th) showed little change.

2.3 Trends in Composite 24-h Maxima and Maximum Quarterly Mean Lead Concentrations

Based on lead criteria established in other countries, both 24-h and quarterly mean averaging time concentrations may be relevant to the assessment of lead exposure.

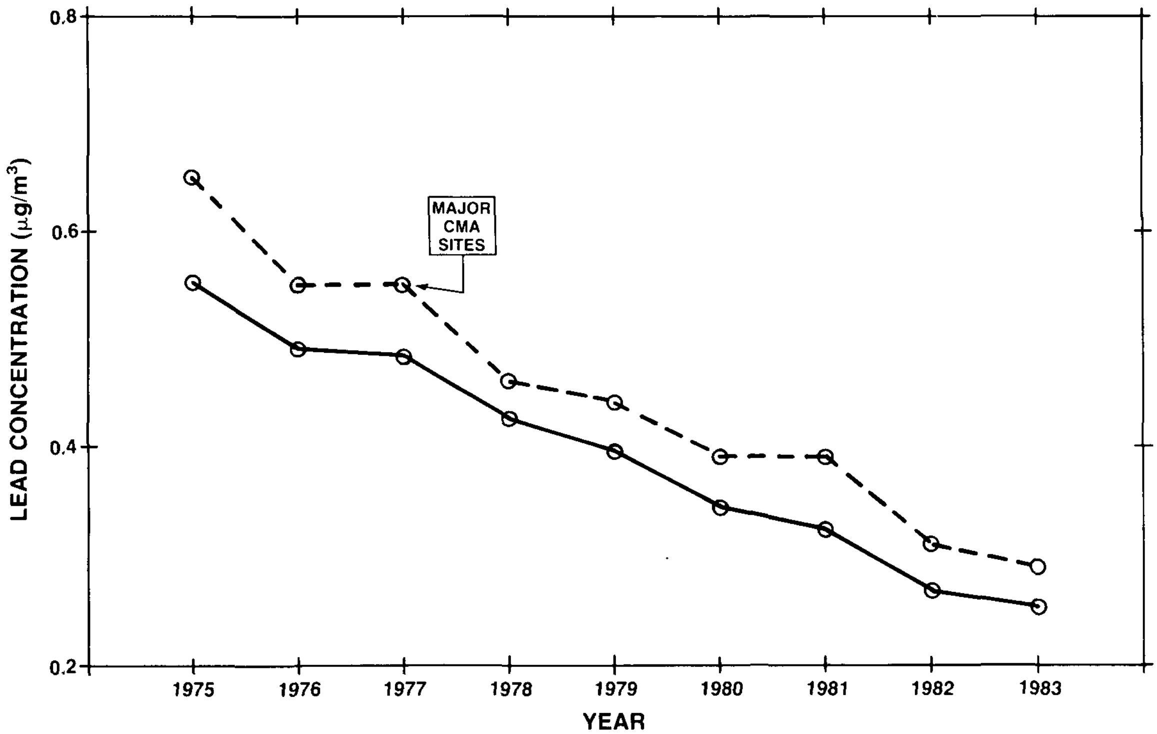


FIGURE 1 TRENDS IN ANNUAL GEOMETRIC MEAN LEAD CONCENTRATIONS 1975-1983 (All NAPS and Major CMA Sites)

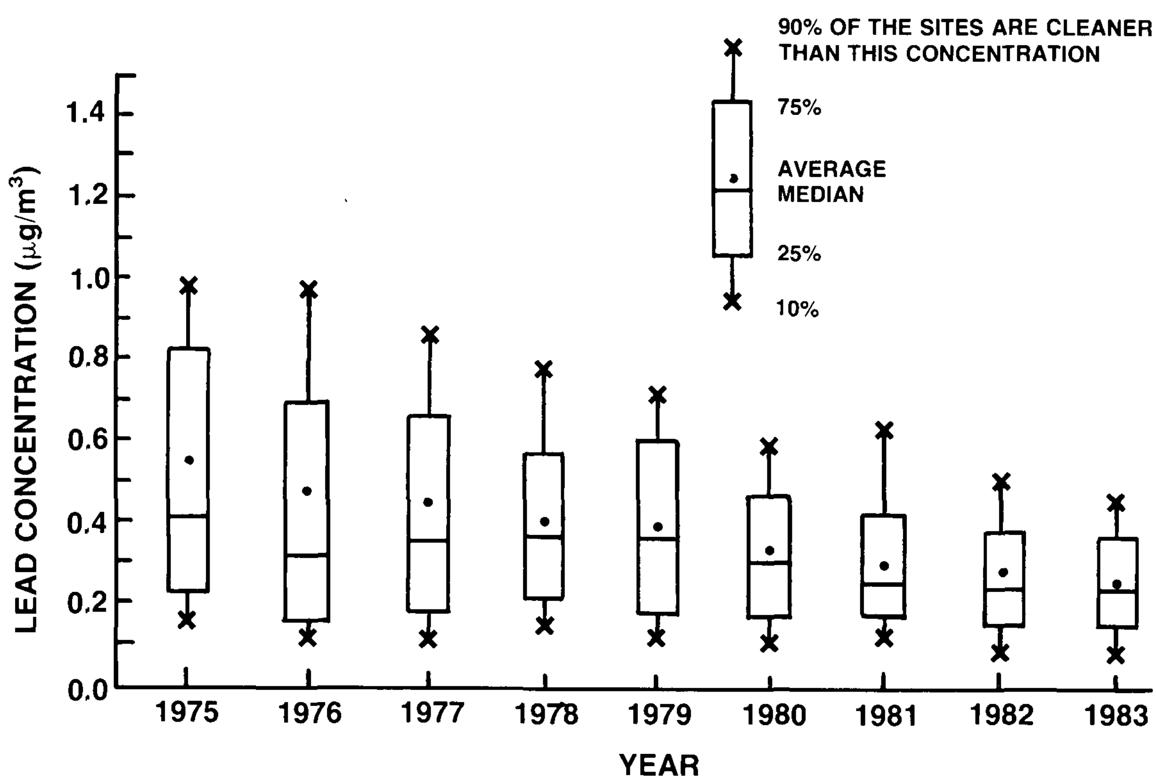


FIGURE 2 ANNUAL AMBIENT LEAD CONCENTRATION TRENDS 1975-1983 (BOX PLOT ANALYSIS)

The composite average of (a) 24-h maximum and (b) maximum quarterly means has been calculated for all network sites during the years 1975 to 1983 as shown in Table 2.

TABLE 2 TRENDS IN COMPOSITE 24-h MAXIMA AND MAXIMUM QUARTERLY MEANS AT NAPS NETWORK SITES 1975-1983

Year	Composite 24-h Maxima ($\mu g/m^3$)	Composite Maximum Quarterly Mean ($\mu g/m^3$)
1975	2.5	0.90
1976	2.0	0.83
1977	2.1	0.71
1978	1.8	0.77
1979	1.6	0.66
1980	1.4	0.62
1981	1.1	0.55
1982	1.3	0.50
1983	1.1	0.42

2.4 Comparison of Lead Consumption in Gasoline and Ambient Lead Concentrations

Because most of the lead in urban air is emitted by motor vehicles using leaded gasoline (3), ambient lead concentrations are related to total lead consumption in gasoline. The amount of lead consumed in gasoline has decreased as a result of the decline in the market share of leaded gasoline (and corresponding increase in use of unleaded gasoline). This was compounded in the early 1980s by the decrease in the total demand for gasoline (11). In Figure 3, lead consumption in gasoline is plotted against the composite annual geometric mean lead concentrations for all NAPS sites during the period 1975-1983. The linear correlation between lead consumed in gasoline and the composite mean is excellent with $r2 = 0.97$. Between 1975 and 1983, lead consumed in gasoline decreased by 45 percent (from 15 800 tonnes to 8 700 tonnes) (12), while the corresponding composite ambient annual geometric mean for lead at all NAPS sites decreased by 55 percent. This indicates that decreased use of lead in gasoline has effected a direct decrease in annual geometric mean lead concentrations at NAPS monitoring sites.

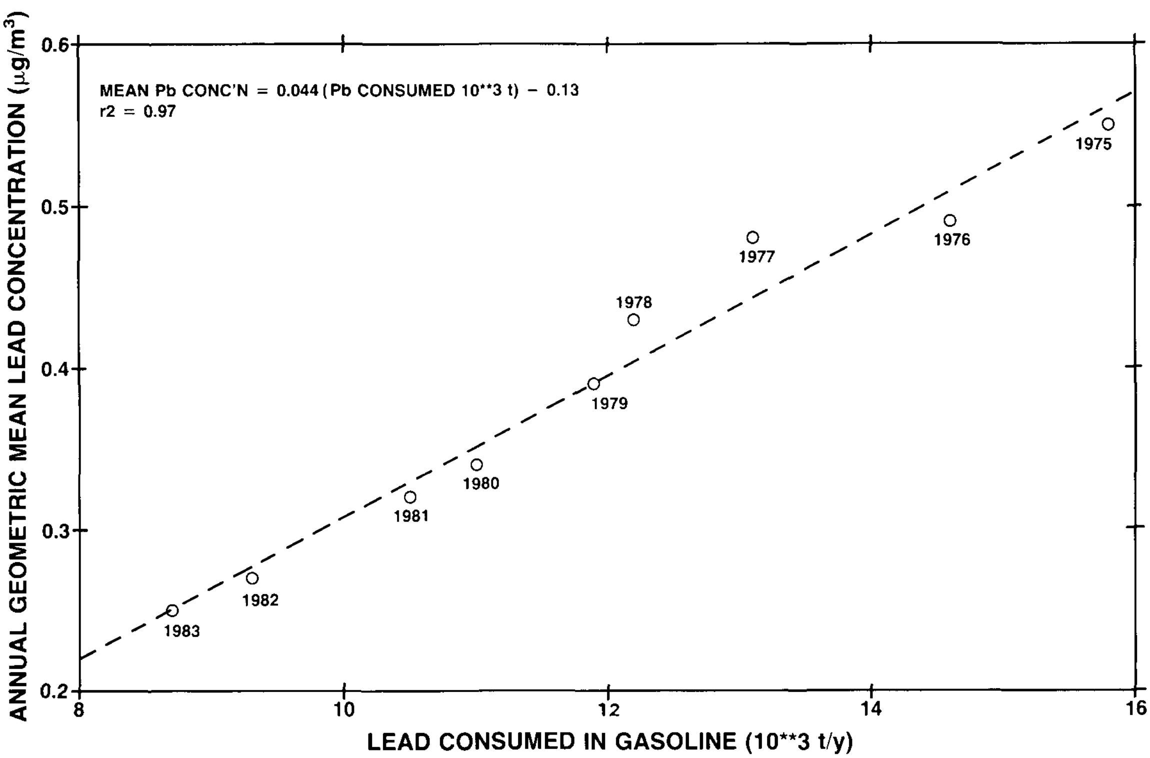


FIGURE 3 LEAD CONSUMED IN GASOLINE AND ANNUAL GEOMETRIC MEAN LEAD CONCENTRATIONS FOR ALL NAPS SITES 1975-1983

2.5 Regional Differences

As noted in Section 1, a number of sites in British Columbia exhibited higher than average concentrations of lead in 1983 even though sampling instruments were at a greater than average height and the stations were not near major roadways or known point sources of lead. Potential regional differences in Canadian ambient lead concentrations were examined by comparing a subset of sites in Ontario and British Columbia that were located in CMAs of more than 200 000 population. Sites in Ontario near major roadways were not included because no comparable sites existed in British Columbia. Data for 13 sites in British Columbia were used to calculate a composite provincial annual geometric mean; data for 18 sites in Ontario were available. Figures for lead consumption in gasoline and average lead content in gasoline data for each province during the period 1975-1983 (12,13) were also obtained (Table 3).

Figure 4 provides a plot of the average lead content of gasoline in each province versus the composite annual geometric lead concentrations. Some variability is

TABLE 3 LEAD CONSUMPTION IN GASOLINE, GASOLINE LEAD CONTENTS AND COMPOSITE ANNUAL GEOMETRIC MEAN LEAD CONCENTRATIONS - ONTARIO AND BRITISH COLUMBIA 1975-1983

	ONTARIO			BRITISH COLUMBIA		
Year	Gasoline Lead Consumption (10^3 t)	Average Lead Content of Gasoline (g/L)	Composite Annual Mean ($\mu g/m^3$)	Gasoline Lead Consumption (10^3 t)	Average Lead Content of Gasoline (g/L)	Composite Annual Mean ($\mu g/m^3$)
1975	4.31	0.38	0.68	1.48	0.44	0.79
1976	3.90	0.36	0.53	1.44	0.42	0.83
1977	3.61	0.315	0.45	1.35	0.38	0.73
1978	3.32	0.23	0.45	1.24	0.36	0.59
1979	2.61	0.22	0.32	1.27	0.32	0.57
1980	2.77	0.22	0.24	1.33	0.33	0.57
1981	2.63	0.225	0.27	1.43	0.35	0.60
1982	2.39	0.21	0.21	1.42	0.36	0.51
1983	2.47	0.22	0.20	1.19	0.30	0.41

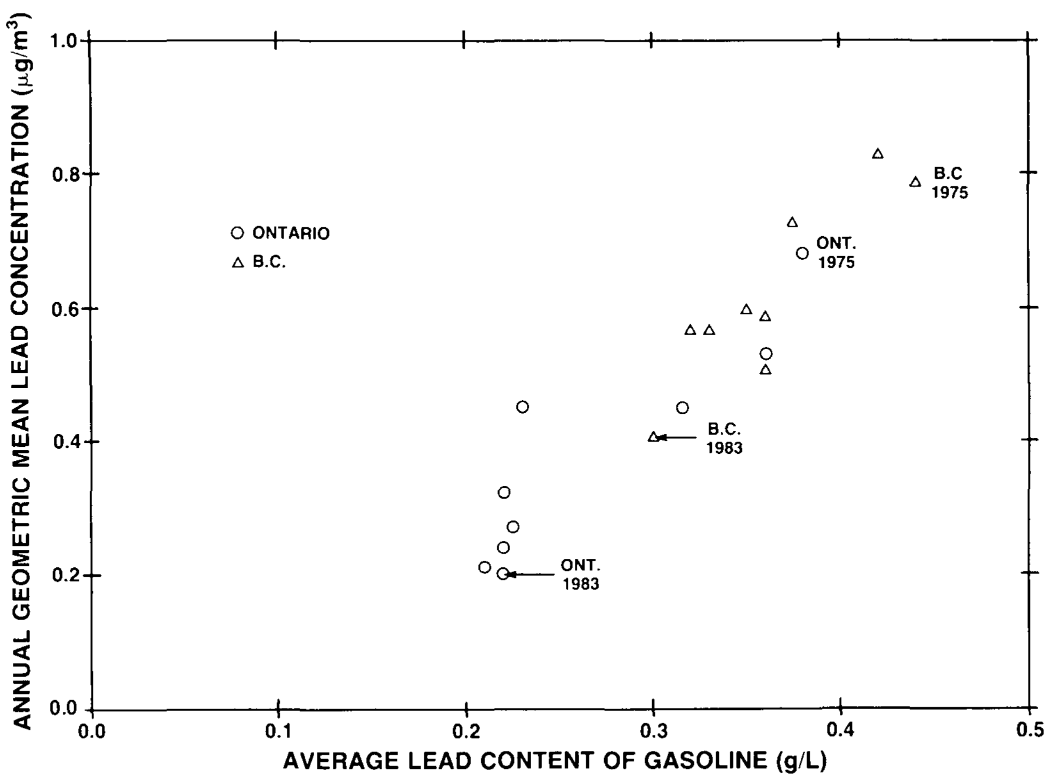


FIGURE 4 AVERAGE LEAD CONTENT OF GASOLINE AND ANNUAL GEOMETRIC MEAN LEAD CONCENTRATIONS, ONTARIO AND BRITISH COLUMBIA 1975-1983

introduced by the changes in numbers of stations with valid annual geometric means from year to year and by variability in the relationship between total lead consumption in gasoline and average lead content of gasoline. In general, however, decreases in annual geometric mean lead levels have paralleled decreases in the average lead content of gasoline. High lead levels at British Columbia stations can be attributed to a significantly higher average lead content in gasoline and correspondingly higher per-vehicle lead emissions.

3 CANADA - U.S.A. TRENDS IN AMBIENT LEAD CONCENTRATIONS

The United States Environmental Protection Agency (EPA) has adopted a primary standard for lead of 1.5 $\mu g/m^3$ averaged over a calendar quarter (14). To meet this objective in urban areas, the EPA has undertaken and planned a number of control actions aimed at reducing the lead content of gasoline. These actions resulted in an average lead content in gasoline of 0.14 g/L in 1982; the Canadian average lead content was 0.28 g/L in 1982. A comparison of trends in lead content of gasoline and ambient air concentrations of lead for the two countries may indicate the potential effectiveness of a further reduction in gasoline lead content in Canada in reducing ambient air lead levels.

3.1 Data Base

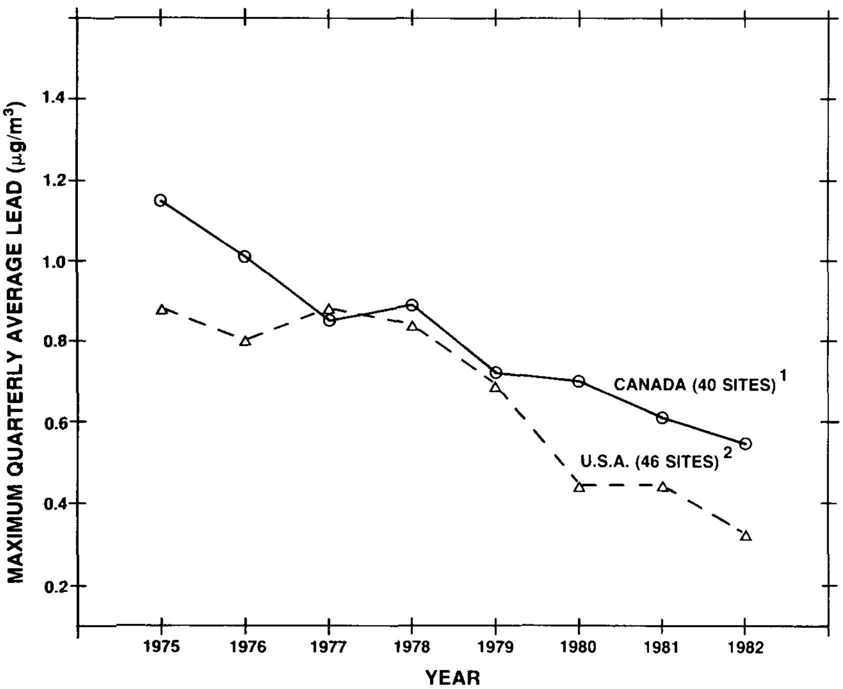
United States data is reported in accordance with their primary air quality standard, i.e., maximum quarterly average lead concentrations. This statistic was calculated for each NAPS site for the years 1975 to 1982 (the latest published U.S. trends data are for 1982). Quarterly maximum lead concentrations are reported for U.S. stations having three out of four valid quarterly means; for Canadian sites, no maximum quarterly average was reported unless all four quarterly means could be calculated.

The U.S. sites were located predominantly in larger American cities (16); for trend determination, the sites had to report a valid maximum quarterly average in at least six of the eight years from 1975 to 1982. Data from 46 urban U.S. sites met the completeness criteria in 1982 (16). To ensure comparability, only data from Canadian sites in major CMAs were used; sites were also required to report a valid maximum quarterly average in at least five of the eight years from 1975 to 1982. Use of a six out of eight year completeness criteria resulted in a poor national distribution of sites. The Canadian sites and the maximum quarterly average lead concentrations for each year are provided in Table B2 of Appendix B. Forty sites in the NAPS network met the selection criteria.

3.2 Comparison of Canadian and U.S. Data for 1975-1982

Composite mean maximum quarterly average lead concentrations were calculated for the NAPS sites. Similar composite means for the U.S. stations were obtained (16) and the results for the two countries were plotted as shown in Figure 5.

For the U.S. sites, there was a 64 percent overall decrease in the composite maximum quarterly average from 1975 to 1982. For the Canadian sites, there was a



Notes
1) CANADIAN CMA'S > 200 000 WITH 5 OUT OF 8 YRS. DATA
2) U.S. NASN SITES WITH 6 OUT OF 8 YRS. DATA

FIGURE 5 CANADIAN AND U.S. MAXIMUM QUARTERLY AVERAGE LEAD LEVELS 1975-1982

52 percent overall decrease in the composite maximum quarterly average. Although composite maximum quarterly average lead concentrations in the two countries were essentially identical from 1977 to 1979, there was a statistically significant difference in the composite averages for the two countries in 1980 and 1982.

Table 4 presents a comparison of the highest quarterly average lead concentrations recorded in the largest urban areas of Canada and the United States during 1980, 1981 and 1982. Apart from measurements made at a Los Angeles site and at three other U.S. sites with industrial point source impacts, the Canadian sites recorded significantly higher maximum quarterly average lead concentrations during the period than did the United States sites.

3.3 Relationship Between Lead in Gasoline and Ambient Lead Concentrations in Canada and the U.S.

Composite average maximum quarterly lead levels were plotted versus the average lead content of gasoline for both Canada (11,12) and the United States (15,16)

TABLE 4 MAXIMUM QUARTERLY AVERAGE LEAD CONCENTRATIONS IN CANADIAN AND U.S. METROPOLITAN AREAS

City	Lead Concentration (µg/m^3) Highest Maximum Quarterly Average		
	1980	1981	1982
Canada CMAs >1 Million			
Montreal	1.85	1.30	1.13
Toronto	1.63	1.50	1.00
Vancouver	1.10	1.45	1.43
U.S. CMAs >2 Million			
New York, NY-NJ	0.51	0.37	0.62
Los Angeles-Long Beach, CA	2.56	1.58	1.68
Chicago, IL	1.95	0.89	0.81
Philadelphia, PA-NJ	1.26*	1.30*	1.57*
Detroit, MI	ND	0.34	ND
San Francisco-Oakland, CA	0.73	0.43	0.55
Washington, DC-MD-VA	0.69	0.48	0.71
Dallas-Fort Worth, TX	0.67	0.86	0.71
Houston, TX	0.63	0.75	0.25
Boston, MA	0.57	0.37	1.08
Nassau-Suffolk, NY	ND	ND	0.72
St. Louis, MO-IL	2.97*	7.27*	3.81*
Pittsburg, PA	0.58	0.41	0.41
Baltimore, MD	1.11	0.61	0.86
Minneapolis-St. Paul, MN-WI	3.04*	3.11*	7.97*
Atlanta, GA	0.68	0.40	0.59

* This level reflects the impact of industrial sources.
ND - No data

from 1975 to 1982 as shown in Figure 6. Gasoline lead consumption and average lead content of gasoline values for the two countries are given in Table 5.

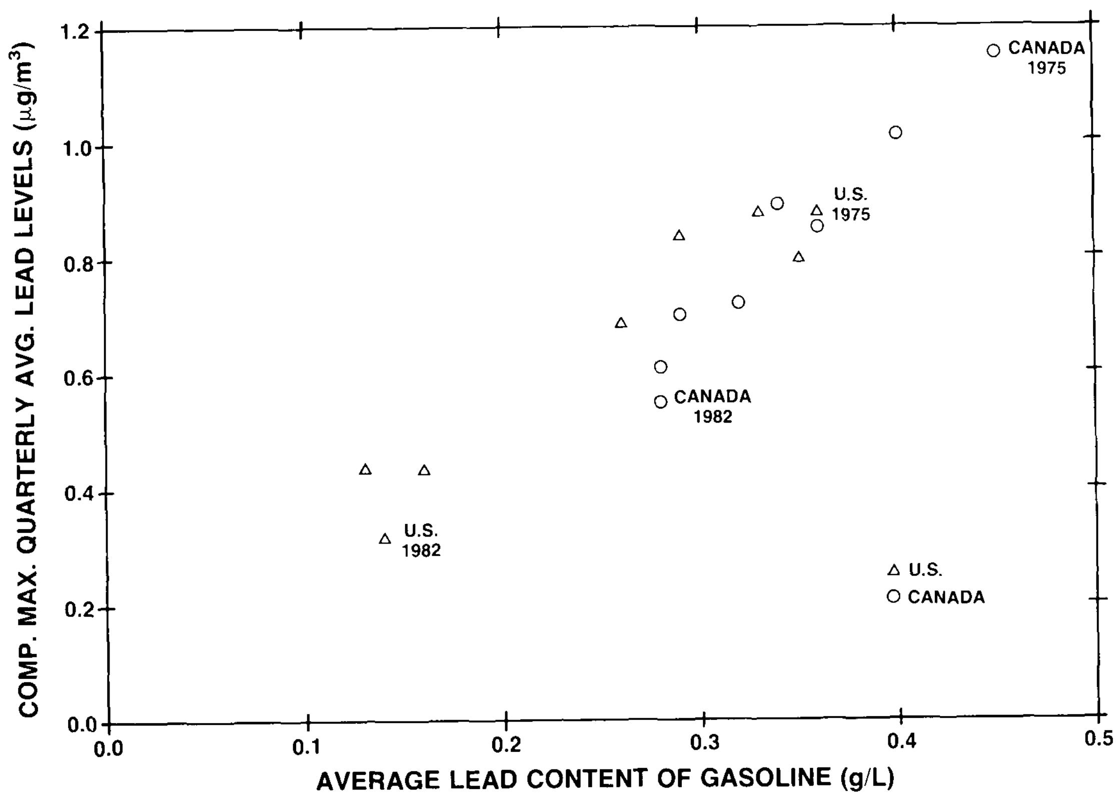


FIGURE 6 CANADIAN AND U.S. AVERAGE GASOLINE LEAD CONTENTS AND COMPOSITE MAXIMUM QUARTERLY AVERAGE LEAD LEVELS 1975-1982

The average lead content of gasoline was used rather than total lead consumption so that data for the two countries could be plotted on the same scale. As shown in Table 5, however, the relationship between lead consumption and average lead content of gasoline in Canada was affected by decreased Canadian gasoline demand during 1981 and 1982.

In both countries, the composite maximum quarterly average ambient lead levels have decreased with the decrease in the average lead content in gasoline. In 1982 the average lead content of gasoline in the United States was 50 percent lower than the Canadian average and the composite maximum quarterly average lead concentration for U.S. sites was 42 percent lower than that for comparable Canadian lead monitoring sites.

TABLE 5 CANADA AND U.S. TOTAL LEAD CONSUMPTION AND AVERAGE LEAD CONTENT IN GASOLINE (1975-1982)

	CANADA		UNITED STATES	
Year	Total Gasoline Lead Consumption (10^3 tonnes)	Average Lead Content of Gasoline (g/L)	Total Gasoline Lead Consumption (10^3 tonnes)	Average Lead Content of Gasoline (g/L)
1975	15.8	0.45	155	0.36
1976	14.6	0.40	157	0.35
1977	13.1	0.36	156	0.33
1978	12.2	0.34	126	0.29
1979	11.9	0.32	119	0.26
1980	11.0	0.29	71	0.16
1981	10.5	0.28	49	0.13
1982	9.3	0.28	48	0.14

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APPENDIX A

LEAD MONITORING SITE SELECTION AND
DESCRIPTION OF NAPS MONITORING STATIONS

A.1 MONITORING OBJECTIVES FOR AMBIENT AIR LEAD*

Monitoring objectives determine the criteria for physical station location. To clarify the nature of this linkage between monitoring objectives and the location of a particular monitoring site, the concept of spatial scale of representativeness is used. The goal in siting stations is to correctly match the spatial scale represented by the sample of monitored air with the spatial scale most appropriate for the monitoring objective of the station. The scales of representativeness of most interest for lead monitoring are as follows:

Microscale - This scale would typify areas such as downtown street canyons and traffic corridors where the general public would be exposed to maximum concentrations from mobile sources. Because of the very steep ambient Pb gradients resulting from Pb emissions from mobile sources (See Section A.2.1) the dimensions of the microscale for Pb generally would not extend beyond 15 m from the roadway. Emissions from stationary sources such as secondary lead smelters may, under fumigation conditions, likewise result in high ground level concentrations at the microscale.

Middle Scale - This scale generally represents lead air quality levels in areas up to several city blocks in size. However, the dimensions for middle scale roadway type stations would probably be in the order of 50-150 m because of the exponential decrease in lead concentration with increasing distances from roadways. The middle scale could include schools in city centre areas which are close to major roadways.

Neighbourhood Scale - The neighbourhood scale would characterize air quality conditions throughout some relatively uniform land use area with dimensions in the 0.5 to 4.0 km range. Stations of this scale would provide monitoring data in areas representing conditions where children live and play. Monitoring in such areas is important since this segment of the population is more susceptible to the effects of lead.

A.2 SELECTION OF LEAD MONITORING SITES

Monitoring data for ambient lead levels are required for major urbanized areas, particularly where Pb levels have been shown or are expected to be of significant concern. Such locations are to be expected in urban areas having high population densities and accompanying high traffic densities.

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* U.S. Federal Register, Pt. 58, App. D & E, 1982.

The United States Environmental Protection Agency (EPA) recommends that, as a minimum, two lead monitoring sites be established in any urban area that has a population exceeding 500 000. For areas where the lead levels are due primarily to automotive sources, the station should be selected as follows: (a) one microscale or middle scale station located near (1) a major roadway (>30 000 average daily traffic, ADT) or (2) in the fumigation zone of an industrial point source, in order to measure maximum lead concentrations, and (b) one neighbourhood scale station representative of lead air quality in a highly populated area which has high traffic density or is influenced by an industrial point source.

A.2.1 Lead Concentration Gradients in the Vicinity of Roadways

Studies indicate that lead levels decrease exponentially with distance from the roadway. Thus, the highest concentrations are found close to the roadway and stations located in such areas are most often representative of the microscale and middle scale.

Figure A1 presents an example of lead concentrations at different heights and distances from a roadway. This set of measurements was taken in the vicinity of a 58 500 ADT roadway in Cincinnati* during the spring of 1980. Concentrations were determined at three different elevations at each of three different setback distances. This study showed that lead concentrations were greatest at the 1.1 m breathing level height for each setback distance. Concentration differences by height diminished as setback distances increased beyond 7 m.

A.2.2 U.S. EPA Recommended Probe Siting Criteria for Lead Monitoring

Probe Height. As for other pollutants, optimal placement of the sampler inlet for lead monitoring would be at the breathing height level. However, practical factors such as prevention of vandalism and safety precautions must also be considered. Lead gradients in the vertical in the vicinity of roadways are not large in the first 6 to 7 m as noted above. Given these considerations, EPA recommends that sampler inlets for microscale lead sites must be 2-7 m above ground level. For middle or neighbourhood scale sites, increased diffusion results in vertical concentration gradients which are not as great as for the small scales. Thus, the recommended height for these scales of sites is 2-15 m.

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* U.S. Environmental Protection Agency, "Field Study to Determine Spatial Variability of Lead from Roadways", EPA-450/4-83-002, 1981.

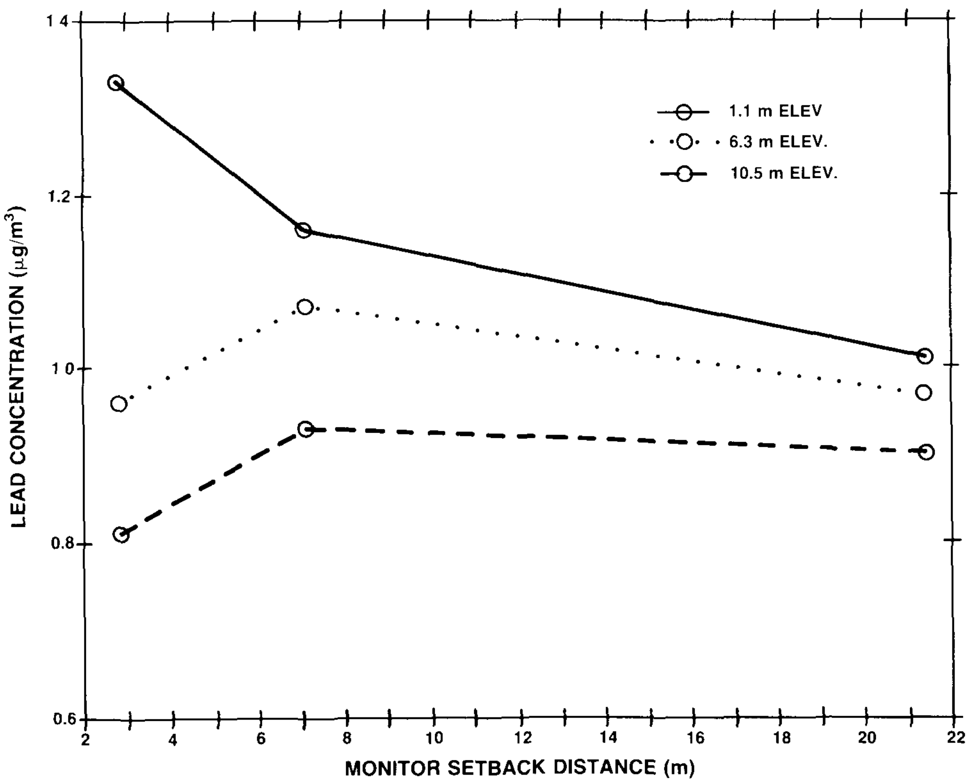

FIGURE A1 AVERAGE 24-h CONCENTRATION OF LEAD AT VARIOUS ELEVATIONS AND SETBACK DISTANCES (CINCINNATI STUDY)

Spacing from Roads. Ambient levels of lead near roadways are a function of the traffic volume and are most pronounced within the first 15 m on the downwind side of roadways. EPA recommends that microscale stations designed to measure the peak concentrations from mobile sources be located between 5 and 15 m from a major roadway (>30 000 ADT). For middle scale stations, a range of acceptable distances from roadways is given in Table AI. This table also provides recommended separation distances between a roadway and neighbourhood scale sites.

A complete summary of EPA recommended probe siting criteria for lead monitoring sites is included in Table A2, including requirements for spacing from obstructions.

A.3 DESCRIPTION OF NAPS LEAD MONITORING SITES

In 1983, there were a total of 105 TSP sites in the NAPS network reporting particulate lead data. Sixty-three of these sites, located in census metropolitan areas (CMAs) greater than 200 000 population, were selected to determine their conformance

TABLE A1 SEPARATION DISTANCE BETWEEN LEAD MONITORING SITES AND ROADWAYS (Edge of Nearest Traffic Lane)

	Separation distance between roadways and stations (m)		
Roadway average daily traffic (vehicles per day)	Micro-scale	Middle Scale	Neighbourhood Scale
<10 000	5-15	>15-50*	>50*
20 000	5-15	>15-75	>75
<40 000	5-15	>15-100	>100

* Distances should be interpolated based on traffic flow

TABLE A2 SUMMARY OF U.S. EPA RECOMMENDED PROBE SITING CRITERIA FOR LEAD MONITORING SITES*

Scale	Height above ground (m)	Distance from roadway (m)	Distance from obstructions
Micro	2-7	5-15	1) >20 m from trees 2) 270° unrestricted air flow around sampler
Middle, Neighbourhood	2-15	Varies with traffic (see Table A1)	1) >20 m from trees 2) 270° unrestricted air flow around sampler.

* U.S. Federal Register, Pt. 58, App. D&E, 1982.

to EPA siting criteria and categorized by scale of representativeness. Sites in St. John's, Charlottetown, Saint John and Regina were also examined so that at least one major urban area in each province was included.

A.3.1 Site Classification

The distribution of selected NAPS lead monitoring sites by scale of representativeness is given in Table A3. Table A4 contains the characteristics (sampler height, distance from roadway, ADT and scale of representativeness) of each of the 67 sites examined.

TABLE A3 CLASSIFICATION OF NAPS NETWORK LEAD SITES (MAJOR CMAs) BY SCALE OF REPRESENTATIVENESS

Number of Sites	Microscale	Middle Scale	Neighbourhood Scale
67	6	28	33

The majority of the sites fit in the middle or neighbourhood scales of representativeness. Of the six microscale sites, only one is located near a roadway with ADT >30 000, and none were located near known industrial point sources. Eleven of the 28 middle-scale sites were located close to roadways 30 000 ADT.

A.3.2 Special Curbside Lead Monitoring Project

In April-May of 1983, a special curbside lead monitoring project was carried out at 10 sites in 5 cities (Vancouver, Edmonton, Toronto, Montreal, Ottawa) to determine relationships between lead exposure at microscale-curbside locations to those at nearby NAPS monitoring stations*. All samplers except one were within 2-7 m of the roadway edge (one site was within 0.5 m) and inlet heights were in the range of 1 to 4 m. ADT's of the nearest roadways ranged from 15 000 to 68 000 with a mean of 41 000 vehicles per day. In most cases, the nearest NAPS site to the curbside locations was a middle scale site. The three Vancouver sites recorded the highest lead levels during this special survey with values two to five times (on average) higher than those measured at the closest NAPS site. The other sites ranked in approximate order of traffic counts on the nearest roadway. Concentrations measured at the microscale locations were in all cases higher than those measured at the nearest corresponding middle or neighbourhood scale NAPS site, as would be expected.

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* Findlay, W.J., "Particulate Lead Concentrations of Curbside Sampling Sites in Canadian Urban Areas", Internal EPS report.

TABLE A4 CHARACTERISTICS OF NAPS LEAD MONITORING STATIONS

City	Station Number	Address	Probe Height (m)	Distance from Roadway (m)	Average Daily Traffic (veh/day)	Scale of Representativeness
St. John's	10101	Duckworth/Ordinance	19	35	< 10 000	Neighbourhood*
Charlottetown	20101	56 Fitzroy Street	9	50	> 10 000	Middle
Halifax	30101	Barrington St. (N.S. Tech)	12	100	10 170	Neighbourhood
	30102	Univ. Dalhousie	18	--	--	Neighbourhood
	30114	Mt. St. Vincent Univ.	9.5	150	23 000	Neighbourhood
	30115	CFB Shearwater (Dartmouth)	11	1000	10 000	Neighbourhood
Saint John	40201	110 Charlotte St.	17	10	< 10 000	Middle*
Montreal	50102	Jardin Botanique	4	50	22 000	Middle
	50103	1050 St-Jean Baptiste	4	8	13 000	Micro
	50104	1125 Ontario Street	13	10	32 000	Middle
	50106	777 Laurentien Blvd.	12	45	35 000	Middle
	50109	Duncan/Décarie	4	20	> 100 000	Middle
				75	> 100 000	
	50110	Parc-Pilon (Mtl-Nord)	4	15	96 000	Micro
	50112	Boul. Laurentide (Pont-Viau)	3	70	74 000	Middle
	50113	Pie X/Cardinal (Laval)	4	5	10 000	Micro
	50116	3161 Joseph St. (Verdun)	15	250	> 80 000	Neighbourhood
Hull	50203	Gamelin/Joffre	5	150	10 000	Neighbourhood
Quebec	50303	801-4th Ave.	12	15	15 000	Middle
	50304	Parc Cartier Bréboeuf	4	75	2 500	Neighbourhood
	50306	1016 St-Cyrille/Painchaud	4	8	16 500	Micro
Ottawa-Hull	60101	88 Slater	17	5	11 000	Middle*
	60104	Wurtemburg/Rideau	4	80	32 000	Neighbourhood
Windsor	60201	Bedford St.	4	1000	8 137	Neighbourhood
	60202	444 Windsor Ave. (City Hall)	15	300	15 697	Neighbourhood
	60203	Riverside Dr./Little River	4	250	13 782	Neighbourhood
	60204	471 University	12	150	12 321	Neighbourhood
Toronto	60402	Eglington/400 Don Mills Rd.	9	300	39 000	Neighbourhood
	60403	Evans/Arnold	2	120	150 000	Middle
	60409	Redland Cres.	2	800	30 308	Neighbourhood
	60410	Kennedy/Lawrence	2	15	30 000	Micro
	60412	Bathurst/Wilson	2	50	225 825	Middle
	60413	Elmcrest Rd. (Etobicoke)	4	10	< 2 000	Neighbourhood
	60414	Sherbourne/Wilton	4.5	5	7 254	Middle
				250	95 710	
	60415	Queensway W./Hurontario	4	15	18 040	Middle
				400	41 647	
	60417	Breadalbane	16	100	51 957	Middle
Hamilton	60501	Barton/Sanford	4	18	18 650	Middle
	60503	Chatham/Frid	6	25	3 960	Neighbourhood
	60505	North Park Ave.	4	20	54 000	Middle
London	60901	King/Rectory	4	150	19 000	Neighbourhood
	60902	3272 Dundas	17	100	8 000	Neighbourhood
St. Catharines	61301	North St.	6	75	38 500	Middle
Kitchener	61501	Edna/Frederick	4.5	20	56 000	Middle
Winnipeg	70102	2120 Portage/Woodlawn	3	20	47 000	Middle
	70104	Union Stock Yards	3	55	13 000	Middle
	70118	Jefferson/229 Scotia	5	50	< 4 000	Neighbourhood
	70119	65 Ellen St.	4	55	14 071	Middle
	70120	604 St. Mary's Rd.	4	150	9 634	Neighbourhood
Regina	80109	1620 Albert Street	11	15	35 000	Middle
Edmonton	90121	17th St./105th Ave.	4	70	8 700	Neighbourhood
	90122	13335-127th St.	4	50	20 025	Middle
	90130	10255-104th St.	6.5	5	10 400	Micro
Calgary	90204	316-7th Ave. (Police Stn.)	9	25	16 150	Middle
	90218	18A St. S.E./Bonnybrook	4	36	18 000	Middle
	90222	39th St./29th Ave. N.W.	3.5	--	--	Neighbourhood
Vancouver	00102	100 Richmond	5	450	10 824	Neighbourhood
	00104	27th St./Ontario	18	200	10 824	Neighbourhood*
	00106	2294 West 10th Ave. (GVRD)	17	15	> 4 000	Neighbourhood*
				100	20-29 000	
	00108	250 West 70th Ave.	5	300	40 000	Neighbourhood
	00109	970 Burrard (Hydro)	4	20	21 224	Middle
	00110	E. Hastings/Kensington	4	150	40 000	Neighbourhood
	00113	Annacis Island, Delta	3	300	4 000	Neighbourhood
	00114	Municipal Hall Richmond	15	100	29 000	Neighbourhood
	00115	Newton Elem. Sch. Surrey	5	100	4 000	Neighbourhood
	00116	Fire Hall N. Vanc.	8	20	10-20 000	Middle
	00117	B.C. I.T. Burnaby	18	200	30-40 000	Neighbourhood*
Victoria	00303	1250 Quadra St. (8th St.)	12	18	12 000	Middle

* Exceeds maximum recommended sampling height.

APPENDIX B

LEAD CONCENTRATION DATA FOR
NAPS NETWORK MONITORING STATIONS

TABLE BI ANNUAL GEOMETRIC MEAN LEAD CONCENTRATIONS ($\mu g/m^3$)
NAPS NETWORK SITES 1975-1983

STATION NUMBER	YEAR 1975	YEAR 1976	YEAR 1977	YEAR 1978	YEAR 1979	YEAR 1980	YEAR 1981	YEAR 1982	YEAR 1983	MAJOR CMA SITES
10101		0.44		0.31	0.26	0.21	0.21			*
20101		0.24	0.23	0.18	0.13			0.11		*
30101	0.30	0.20	0.18	0.16	0.10			0.10	0.09	*
30102	0.23	0.15	0.17	0.12	0.07	0.11	0.13	0.11	0.08	*
30114	0.15	0.11	0.10	0.07	0.06	0.06	0.11	0.08		*
30115	0.10	0.05	0.05	0.04	0.02	0.03	0.07		0.03	*
30310			0.42	0.29	0.17	0.18		0.25	0.17	
30311			0.36	0.32	0.25	0.30	0.36	0.30	0.19	
30408					0.01	0.03		0.04	0.03	
40102	0.76	0.55	0.42	0.32	0.39	0.34	0.34		0.24	
40201	0.47	0.31	0.23	0.19	0.21	0.19	0.20	0.17	0.12	*
50102	1.14	1.20	0.94	0.76	0.65		0.19	0.17		*
50103	0.80	0.78	0.69	0.56	0.44	0.46				*
50104							0.49	0.44	0.40	*
50105		1.01		0.73	0.64					
50106		1.06	1.04	0.79	0.63	0.49				*
50107	1.00	0.74	0.91	0.62	0.72	0.71				
50108	0.86	0.88	0.64	0.55	0.46	0.44		0.14	0.14	
50109	2.62	2.26	1.61	1.35	1.36	1.35	0.63	0.79	0.72	*
50110			0.85		0.49	0.46				*
50111		0.57	0.42	0.35	0.35	0.29				
50112		1.14		0.35	0.31	0.34	0.32	0.26	0.21	*
50113		0.37	0.36	0.34		0.24	0.20	0.17	0.14	*
50115				1.51						
50116							0.42	0.41	0.33	*
50201	0.92									
50203				0.32	0.27	0.26	0.27	0.26	0.18	*
50301	1.03			0.71	0.66	0.57				
50302			0.67	0.61	0.64	0.50				
50303	1.04		0.66	0.66	0.62	0.55			0.32	*
50304			0.89	0.78		0.57				*
50305				0.55	0.49					
50306							0.31	0.26	0.26	*
50402						0.42				
50403						0.35				
50502				0.21	0.19	0.17				
50503					0.51	0.59	0.52		0.39	
50601					0.36	0.40	0.33		0.41	
50701										
50801				0.38	0.35	0.36	0.39	0.37	0.28	
50901				0.47	0.37	0.45	0.39			
51002			0.30	0.23	0.21		0.15			
51101										
51201				0.28	0.25	0.25	0.23	0.23	0.17	
51301										
60101	1.18	0.81	0.67	0.53	0.50	0.39	0.40	0.34	0.24	*
60104				0.36	0.26	0.13	0.14	0.17		*
60105							0.20	0.18	0.11	
60201	0.39	0.36	0.37		0.24		0.11	0.11	0.06	*
60202	0.70	0.60	0.62	0.68	0.38	0.35	0.26	0.23	0.18	*
60203	0.36	0.38		0.31	0.15	0.10		0.05	0.06	*
60204						0.34	0.24	0.26	0.26	*
60301	0.24	0.21	0.13	0.13	0.09	0.10	0.13			

TABLE BI ANNUAL GEOMETRIC MEAN LEAD CONCENTRATIONS ($\mu g/m^3$)
NAPS NETWORK SITES 1975-1983 (Cont'd)

STATION NUMBER	YEAR 1975	YEAR 1976	YEAR 1977	YEAR 1978	YEAR 1979	YEAR 1980	YEAR 1981	YEAR 1982	YEAR 1983	MAJOR CMA SITES
90121	0.12	0.11	0.13	0.20					0.13	*
90122	0.20	0.14	0.11	0.26					0.32	*
90123	0.32	0.40	0.32	0.35						
90130			0.26						0.35	*
90203	0.12	0.12		0.18						
90204		0.22	0.36	0.33					0.43	*
90218	0.15	0.12	0.16	0.24					0.39	*
90222	0.15	0.08	0.06	0.11					0.22	*
90301	0.17	0.19	0.17	0.21						
90401	0.13	0.11	0.10							
90501	0.12	0.09	0.05	0.08						
99001		0.10			0.22	0.21				
102	0.81	0.80	0.69	0.63	0.60	0.63	0.66	0.55	0.41	*
104	0.84	0.77	0.76	0.62	0.55	0.65	0.68	0.52	0.50	*
105										
106	0.91		0.72	0.60	0.70	0.66	0.60	0.45	0.41	*
108	0.83	0.91	0.83	0.75	0.72	0.56		0.52	0.40	*
109		1.29	0.98	0.80	0.75	0.73	0.88	0.74	0.56	*
110	0.57	0.58	0.55	0.48	0.42	0.49	0.51	0.40	0.33	*
111				0.42	0.41	0.41	0.51	0.46	0.34	*
113							0.37	0.31	0.24	*
114							0.65	0.54	0.46	*
115							0.41		0.29	*
116								0.54		*
117							0.76	0.62	0.51	*
202						0.26	0.28	0.25	0.15	
301		0.56	0.46	0.36	0.43					
302		0.61	0.59	0.42	0.42	0.40	0.52	0.42	0.45	*
401				0.53	0.55	0.47		0.53		
601										
9001	0.29	0.26	0.19	0.24	0.19	0.19	0.24	0.22		
TOTAL NO. OF SITES	57	57	67	82	79	84	75	80	81	67
COMP. ANN. MEAN	0.55	0.49	0.48	0.43	0.39	0.34	0.32	0.27	0.25	

TABLE BI ANNUAL GEOMETRIC MEAN LEAD CONCENTRATIONS (µg/m^3) NAPS NETWORK SITES 1975-1983 (Cont'd)

STATION NUMBER	YEAR 1975	YEAR 1976	YEAR 1977	YEAR 1978	YEAR 1979	YEAR 1980	YEAR 1981	YEAR 1982	YEAR 1983	MAJOR CMA SITES
60401	0.91			0.66	0.44	0.28				
60402				0.36	0.22	0.14	0.17	0.18	0.19	*
60403	1.34		1.22	0.99	0.75	0.87	1.10	0.66	0.46	*
60409	0.38		0.21		0.15	0.05	0.09	0.03	0.02	*
60410				0.42	0.34	0.28	0.28	0.20	0.34	*
60411		2.04	1.94							
60412			1.34		1.12	0.84		0.56	0.45	*
60413					0.21	0.12		0.28	0.28	*
60414					0.88	0.60	0.56	0.50	0.39	*
60415				0.47	0.26	0.24	0.62	0.32	0.09	*
60417								0.17	0.28	*
60501	0.88				0.62	0.50	0.60	0.42	0.40	*
60503		0.49		0.39	0.36	0.28	0.29	0.26	0.24	*
60505			0.83	0.68	0.76	0.55	0.62	0.33	0.40	*
60602	0.31		0.26				0.09	0.11	0.14	
60605	0.65		0.37	0.43	0.36		0.20		0.26	
60705								0.06		
60801	0.43		0.39	0.23	0.22	0.11	0.18	0.17	0.14	
60806						0.04	0.04	0.04	0.05	
60901	0.78		0.55	0.58	0.47	0.34	0.21	0.26	0.27	*
60902	0.53		0.30	0.23	0.20	0.17	0.10	0.10	0.09	*
61001	0.61		0.55	0.36						
61004					0.19	0.11	0.05	0.09	0.15	
61103				0.38	0.34	0.30	0.23	0.21	0.22	
61201						0.07	0.10	0.14		
61301				0.35	0.26	0.15	0.23	0.16	0.27	*
61401				0.29						
61501				0.76		0.44	0.66	0.43	0.52	*
61601					0.25					
61602							0.14	0.09	0.10	
61701						0.36	0.19	0.18	0.16	
61801							0.11	0.08	0.09	
70101	1.00	0.70	0.83							
70102	0.43	0.38		0.57	0.55	0.54	0.40	0.29	0.30	*
70103	0.56									
70104	0.31	0.27	0.28	0.23	0.36	0.30	0.20	0.14	0.14	*
70118		0.28	0.31	0.22	0.34	0.24	0.21	0.13	0.14	*
70119				0.50	0.58	0.47	0.36	0.25	0.22	*
70120						0.37	0.27	0.19	0.18	*
70201	0.27	0.22	0.26			0.26	0.24	0.13	0.21	
70401										
80102	0.23	0.15	0.12	0.14	0.10	0.09	0.13	0.13	0.08	
80108	0.41	0.32	0.25	0.25		0.18	0.23	0.24		
80109					0.37	0.27		0.27	0.27	*
80201										
80202	0.33	0.29	0.24							
80203	0.15	0.11	0.10	0.10	0.12	0.10		0.12	0.12	
80209						0.20	0.21	0.15		
80301	0.29	0.21	0.16	0.15	0.16	0.13	0.17	0.17	0.14	
80401	0.26	0.23	0.22			0.16	0.20	0.16		
80601										
90103	0.19	0.17	0.20	0.21						
90114	0.21	0.17								

TABLE B2 MAXIMUM QUARTERLY AVERAGE LEAD CONCENTRATIONS ($\mu g/m^3$) NAPS SITES IN MAJOR CMAs WITH 5/8 YEARS DATA RECORD 1975-1982

STATION NUMBER	YEAR 1975	YEAR 1976	YEAR 1977	YEAR 1978	YEAR 1979	YEAR 1980	YEAR 1981	YEAR 1982
20101		0.40	0.37	0.33	0.97	0.20	0.20	0.17
30101		0.23	0.27	0.23	0.17			0.15
30102	0.40	0.23	0.27	0.23	0.17	0.20	0.15	0.15
30114	0.23	0.17	0.17	0.17	0.13	0.13	0.17	0.13
40201	0.97	0.53	0.45	0.47	0.30		0.23	0.27
50102	1.57	1.37	1.20	1.00	0.83		0.33	0.33
50103	1.07		0.83	0.90	0.57	0.70		
50106		1.75	1.33	1.33	0.80	0.75		
50109	3.43	2.90	2.00	1.90	1.73	1.85	1.30	1.13
50112		1.97		0.70	0.47	0.50	0.50	0.37
50113		0.67	0.45	0.53		0.37	0.30	0.23
50303	2.10		1.07	1.13	0.73	0.80		
60101	1.67	1.20	0.90	0.93	0.60	0.53	0.50	0.47
60104				0.77	0.40	0.45	0.30	0.33
60201	0.53	0.60	0.47		0.40		0.27	0.23
60202	0.83	0.87	0.73	0.80	0.47	0.57	0.40	0.33
60203	0.60	0.57		0.55	0.30	0.20		0.20
60402				0.83	0.53	0.40	0.40	0.40
60403	1.80		1.47	1.50	0.97	1.63	1.50	1.00
60409	0.70		0.43		0.23	0.27	0.25	
60410				0.90	0.73	0.73	0.57	0.53
60414				2.03	1.40	1.13	0.73	0.80
60415				0.83	0.53	0.70	0.90	0.73
60503		0.90		0.77	0.53	0.47	0.57	0.60
60505			1.20	1.17	0.90	1.03	0.80	0.70
60901	1.20		0.80	0.90	0.63	0.53	0.40	0.43
60902	0.77		0.53	0.53	0.40	0.80	0.23	0.23
61301				0.73	0.43	0.30	0.33	0.33
70102		0.57		1.25	0.83	0.73	0.53	0.47
70104	0.53	0.40	0.47			0.53	0.33	0.20
70118		0.47	0.40	0.43	0.43	0.30	0.33	0.20
70119				0.70	1.00	0.77	0.43	0.37
102		1.67		1.17	1.03	0.90	1.17	1.27
104	1.40	1.47	1.20	1.10	1.20	1.07	1.30	1.47
106	1.27		1.23	0.97	1.40	1.10	1.17	0.87
108		1.63	1.50	1.50	1.23	1.20		1.17
109		1.80	1.53	1.13	1.33	1.10	1.30	1.07
110	0.77	0.93	0.87	0.97	0.93	0.70	1.00	0.77
111				0.73	0.80	0.93	0.97	0.85
302		1.00	0.93	0.87	0.70	0.57	0.80	0.67
TOTAL NO. OF SITES	19	24	27	37	38	36	34	36
COMP. MAX. QTRLY. AVG.	1.15	1.01	0.85	0.89	0.72	0.70	0.61	0.55