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Exploratory Lead Studies in High Traffic Density Areas in Vancouver, Toronto and Montreal

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EXPLORATORY LEAD STUDIES IN HIGH TRAFFIC DENSITY AREAS IN VANCOUVER, TORONTO AND MONTREAL

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ABSTRACT

Special exploratory surveys were conducted in three Canadian cities to measure atmospheric lead concentrations during peak periods in areas of high traffic density. The airborne particulate lead levels at six typical busy intersections in Vancouver, Toronto, and Montreal were considerably higher than reported average ambient levels. The overall average lead values for the period from 6:00 hours to 21:00 hours were 8.2 μgm^{-3}, 8.4 μgm^{-3}, and 4.0 μgm^{-3} in Vancouver, Toronto and Montreal respectively.

The elevated average concentrations of lead and the relatively large variation during sampling reflect the combustion of leaded gasolines in the survey areas. The lead levels may be sufficiently high to give rise to adverse physiological effects in high exposure population groups.

RESUME

Des études exploratoires ont eté effectuées dans trois villes Canadiennes dans le but de déterminer la teneur en plomb dans 1'air ambiant près des artères principales aux heures de pointe. Les concentrations de plomb dans les poussières à 6 intersections situées au centre-ville à Vancouver, Toronto et Montréal étaient beaucoup plus élevées que celles généralement rapportées. La moyenne des concentrations de plomb pour la période de 6:00 heures jusqu'à 21:00 heures était de 8.2 μgm^{-3}, de 8.4 μgm^{-3} et de 4.0 μgm^{-3} respectivement à Vancouver, Toronto et Montréal.

Ces niveaux élevés de plomb et la variation relativement considérable des échantillons seraient dûs à 1'usage d'essence contenant du plomb aux endroits échantillonés. Les concentrations de plomb rapportées seraient suffisament élevées pour produire des effets physiologiques adverses parmi cette partie de la population qui serait le plus exposée.

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1. INTRODUCTION

Several studies of ambient lead concentrations in air have shown that urban residents have a higher average level of lead in their blood than rural dwellers (1, 2). While it is conceded that this difference may be due in part to variation in dietary lead intake, it is felt that the difference is primarily caused by the intake of lead from air. Any health effects caused by the increased exposure to lead appear to be subtle, because it does not cause any apparent clinical lead poisoning.

There are numerous sources of lead emission in urban environments, however, over 98% of all lead emissions result from the combustion of gasoline (3). The lead emitted to the atmosphere in this manner is predominantly in the form of small particles with a mass median diameter (MMD) of approximately 0.25μ (4). Particles of this size may remain airborne for long periods of time. Studies on aerosols in this size range indicate that 25 to 50% (wt.) of the inhaled particulates would be deposited in the airways (5,6). Furthermore, it is reasonable to assume that all deposited lead would be absorbed into the body.

Since lead is a known poison, it is necessary to identify the conditions that result in excessive human exposure. Information is necessary to permit some assessment of the exposure of population groups such as police, taxi drivers, municipal workers, commuters and other individuals who spend significant amounts of their time on busy downtown streets. In view of the foregoing, special exploratory surveys were conducted in three

Canadian cities to measure atmospheric lead concentrations at peak periods to determine whether a more extensive sampling program should be undertaken and at which locations. Because of the exploratory nature of the surveys, contracts were let to consultants in each of the cities to carry out the work under the direction of the Special Studies Section, Surveillance Division of the Air Pollution Control Directorate. The B.C. Research Council conducted the Vancouver survey (7) in early July, 1972 while the Ontario Research Foundation (8) worked in the Toronto area during the same period. The Montreal survey was done by Eco-Research Limited (9) in mid-March, 1972.

2. METHODS AND PROCEDURES

Six sites were selected in each city. Five 3-hour samples were to be taken at each station between 06:00 hours and 21:00 hours. The sampling period included both week-days and weekends.

2.1 Vancouver. Suspended particulates were collected at six sites using Hi-Vol samplers located along major traffic arteries (Appendix I). The samplers were located at the curbside with the inlet approximately 4 feet above the road level. Linear air velocity through the filter averaged about 108 ft. per minute. Gelman fiberglass filters (Type A) which are 99.97% efficient at 0.3μ and 95% efficient at 0.05μ were used. Membrane filters were scheduled for use but unavoidable problems with equipment suppliers necessitated the switch to Hi-Vols and fiberglass filters.

Filters were conditioned (24 hours at 50% R.H. and 70°F) before and after exposure, prior to weighing. Weather conditions during the sampling period are indicated in Appendix II.

Lead was extracted from one-half of each filter using hot 30% nitric acid for two hours. Lead was determined on filter extracts using an atomic absorption spectrophotometer. Considerable care was exercised in handling the filters and extracts to ensure that contamination was minimized.

2.2 Toronto. The six locations used in the Toronto survey are shown in Appendix I. The specially designed samplers were located at the curbside with the inlet approximately 5½ feet above the road level. Linear flowrates through the 0.4μ Nuclepore filters averaged about 37 feet per minute. Filters were conditioned (65% R.H. and 70°F) prior to weighing both before and after exposure.

Efforts were made to sample under dry conditions and not within 48 hours after a heavy rain. Weather conditions during the sampling period are shown in Appendix II.

Filters were halved and the lead was extracted in 10% nitric acid for 1 hour at 55°C. Lead concentrations in extract solutions were determined by atomic absorption spectrophotometry with flameless atomization procedure. Extreme precaution was observed to minimize contamination of filters and extracts.

2.3 Montreal. Suspended particulates were collected using special sampling devices at 6 locations in the downtown Montreal area (Appendix I). Samplers were located on the top of telephone

booths, approximately 10 feet from the street. Membrane filters with nominal pore size of 0.8μ and average linear flowrates of 51 feet per minute were employed. Because of difficulties in sensitivity of analyses, the sampling period was extended from 3 to 6 or 18 hours over the weekend period. Considerable inclement weather was experienced during the sampling period, as outlined in Appendix II.

Lead was extracted from half filter samples by nitric acid digestion. The lead concentration of the extract was determined by atomic absorption spectrophotometry.

3. RESULTS AND DISCUSSION

The lead results obtained from the three surveys can generally be regarded as high when compared to general urban particulate lead levels (1-2.5 $\mu g.m^{-3}$). It must be noted, however, that the objective of the exploratory surveys was to measure particulate lead concentration during peak periods in locations which would reflect above average levels. This could be described as a "worst case approach".

The results will be discussed on an individual survey basis and then general conclusions will be drawn. Although sampling was only done on a 15 hour per day basis, 24 hour daily averages were projected from the data by using a maximum ambient value of 2.5 $\mu g.m^{-3}$ for missing night data (10). During the first half of 1971, the average ambient lead level in downtown Toronto was 1.1 $\mu g.m^{-3}$, with a maximum value of 1.5 $\mu g.m^{-3}$. This supports the idea that the projected 24 hour averages may be somewhat high.

3.1 Vancouver. The raw data for the Vancouver survey are shown in Appendix III. The lead content in the air varied from 0.8 $\mu g.m^{-3}$ to 21.9 $\mu g.m^{-3}$. The cumulative frequency distribution curve for the data is shown in Figure 1. The 25%, 50% and 75% frequency values were 4.0 $\mu g.m^{-3}$, 7.4 $\mu g.m^{-3}$, and 12.2 $\mu g.m^{-3}$ respectively. The average concentrations of lead in the air on different days at the various sampling sites are presented in Table 1. The projected 24 hour daily averages are also included in Table 1.

There was a noticeable drop in the lead concentration during the weekend. It was associated with the decreased traffic density. Daily variation in lead concentration on week days was probably a function of the prevailing weather. As indicated in Appendix II, Friday was rather windy.

A plot of the diurnal variation of particulate lead concentration at the six sites (Figure 2) indicated that the peak concentration for all sites was for the sampling period ending at 18:00 hrs. These peaks may have been a result of traffic peaking more sharply during the evening rush hour. The displacement of the curves from the time axis was strongly associated with traffic density. Sampling site No. 1 was located on one of the heavily travelled access routes to the north shore and had a higher traffic density than any of the other sites.

The overall average concentration of lead in the air of the area surveyed was 8.2 $\mu g.m^{-3}$ for 15 hour peak period sampling. The projected 24 hour daily average was 6.0 $\mu g.m^{-3}$. On the average, lead comprised about 5% of the total particulate matter collected.

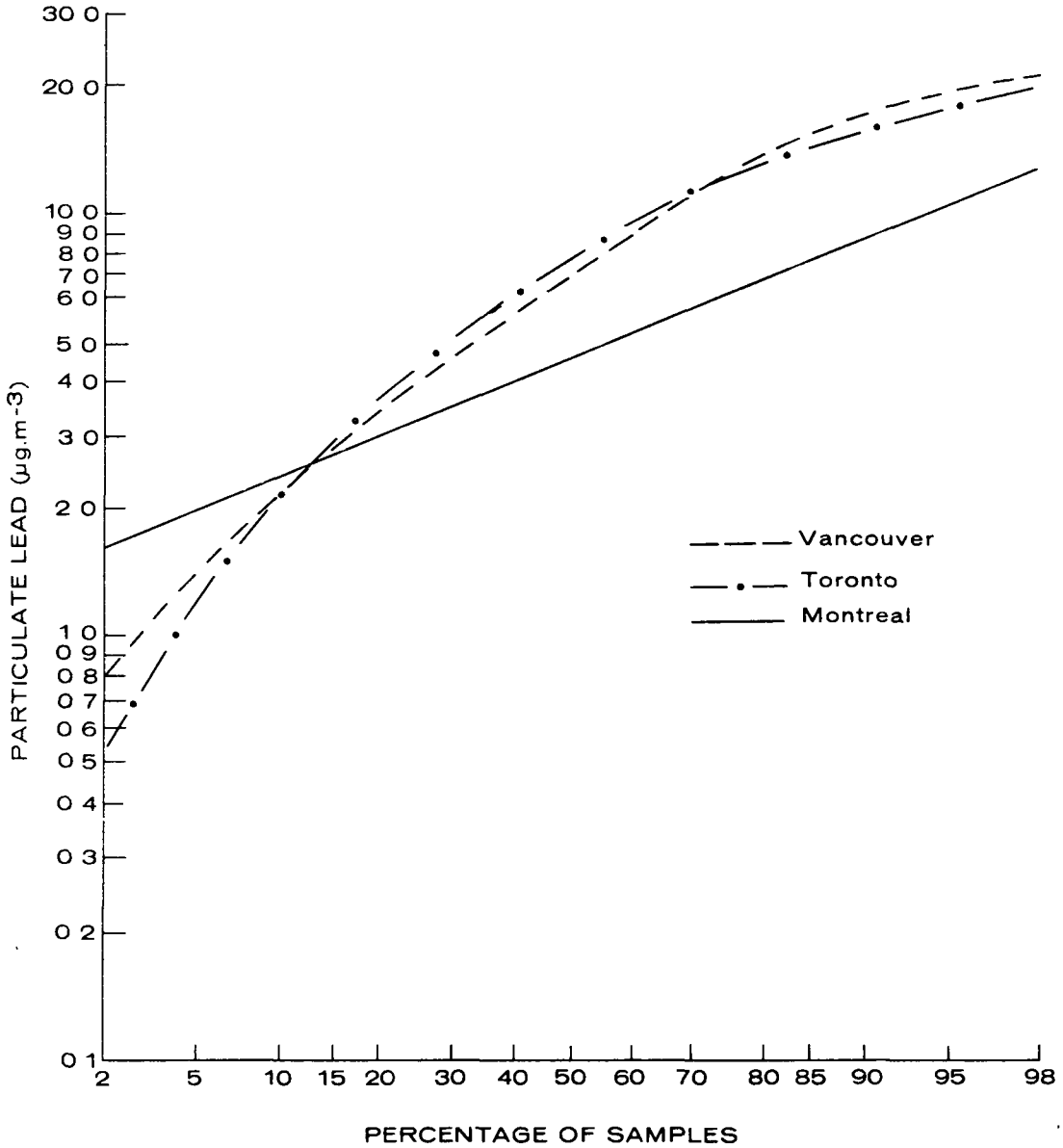

Figure 1 Cumulative frequency distribution curves for airborne particulate lead in Vancouver, Toronto and Montreal

TABLE 1

AVERAGE AIRBORNE LEAD CONCENTRATIONS ($\mu g m^{-3}$) IN VANCOUVER

Sampling Site	1		2		3		4		5		6		Average for Day	
Day	15 hr.	24 hr.	15 hr.	24 hr.	15 hr.	24 hr.	15 hr.	24 hr.	15 hr.	24 hr.	15 hr.	24 hr.	15 hr.	24 hr.
Friday, July 7, 1972	15.7	10.8	3.5	3.1	4.0	3.4	11.0	7.8	3.3	3.0	11.1	7.9	8.1	6.0
Saturday, July 8, 1972	13.5	9.4	4.4	3.7	3.5	3.1	6.0	4.7	4.4	3.7	8.3	6.1	6.7	5.1
Sunday, July 9, 1972	10.7	7.6	3.8	3.3	1.9	2.1	5.9	4.6	3.0	2.8	8.6	6.3	5.6	4.5
Monday, July 10, 1972	15.3	9.8	6.7	5.1	6.7	5.1	13.0	9.1	10.7	7.6	11.8	8.3	10.5	7.3
Tuesday, July 11, 1972	12.5	8.8	5.8	4.6	3.9	3.4	13.7	9.5	9.7	7.0	14.8	10.2	10.1	7.2
Site Average	13.5	9.3	4.9	4.0	4.0	3.4	10.0	7.2	6.2	4.8	10.9	7.7	*8.2	*6.0

*Overall Average.

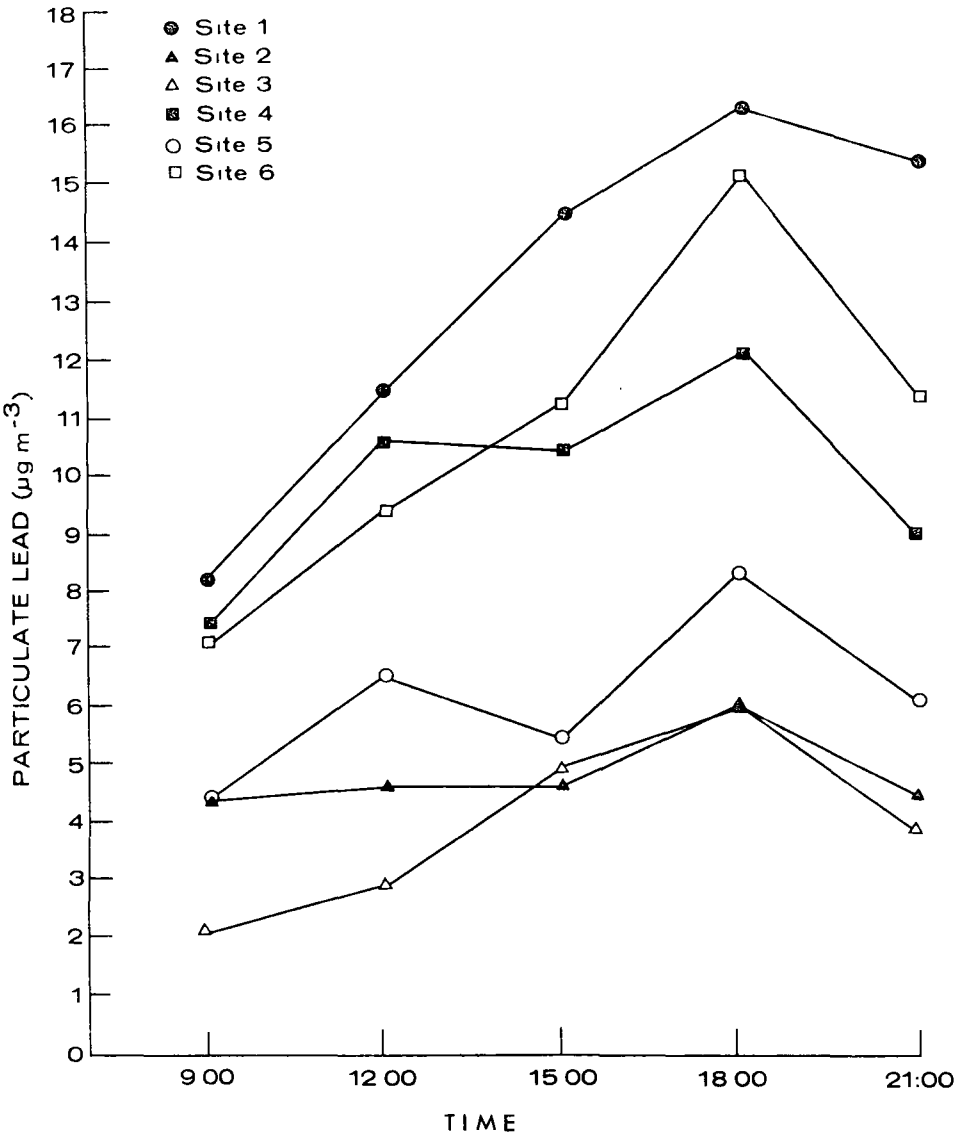

Figure 2. Diurunal variation of particulate lead in Vancouver

3.2 Toronto. The raw data for the Ontario Research Foundation survey in the downtown Toronto area are shown in Appendix III. The concentration of lead in the air varied from a low of 0.4 $\mu g.m^{-3}$ to a high of 22.3 $\mu g.m^{-3}$. An examination of the cumulative frequency distribution curve (Figure 1) of the lead values indicated that 25 per cent of the samples were less than 4.4 $\mu g.m^{-3}$, 50 per cent were less than 7.8 $\mu g.m^{-3}$ and 75 per cent were less than 12.0 $\mu g.m^{-3}$. The average concentration during the sampling period (15 hrs.) and projected daily averages for the various sites and days during which sampling took place are shown in Table 2.

As in the Vancouver study there was a noticeable decrease in lead concentration on Saturday. This drop was probably associated with decreased traffic density. Inclement weather (Appendix II) did not permit sampling on Sunday when presumably the lowest lead concentrations would have occurred.

The diurnal average lead concentrations remain relatively constant during the day (Figure 3). There was a trend toward a slight maximum value during the 15:00 to 18:00 hour period, followed by evening decreases. The peaking of values was much less pronounced than the Vancouver results. The trend toward the 15:00 to 18:00 hour peak may have resulted from more sharply peaking traffic density during the evening rush hour. However, the fact that the 15:00 to 18:00 hour sampling period may have covered the evening rush hour more accurately than the 6:00 to 9:00 hour sampling period depicted the effect of the morning rush hour must not be overlooked. While the displacement of the curves from the origin was probably

TABLE 2

AVERAGE AIRBORNE LEAD CONCENTRATIONS ($\mu g.m^{-3}$) IN TORONTO

Sampling Site	1		2		3		4		5		6		Average for Day	
Day	15 hr.	24 hr.	15 hr.	24 hr.	15 hr.	24 hr.	15 hr.	24 hr.	15 hr.	24 hr.	15 hr.	24 hr.	15 hr.	24 hr.
Wednesday, July 12, 1972	13.3	9.2	12.1	8.4	5.3	4.2	11.3	7.9	8.5	6.2	4.3	3.6	9.1	6.6
Thursday, July 13, 1972	10.3	7.3	18.1	12.1	4.0	3.4	10.9	7.7	1.7	2.0	2.9	2.7	8.0	5.9
Saturday, July 15, 1972	5.0	4.0	10.6	7.5	2.7	2.6	7.7	5.7	5.0	4.0	2.4	2.4	5.5	4.3
Tuesday, July 18, 1972	11.1	7.8	12.6	8.7	5.8	4.5	10.8	7.6	8.8	6.4	2.1	2.2	8.5	6.2
Wednesday, July 19, 1972	15.7	10.7	15.2	10.3	8.5	6.2	4.8	3.9	9.2	6.6	5.0	4.0	9.7	6.9
Thursday, July 20, 1972.	12.7	12.0	17.1	11.5	5.1	4.1	2.6	2.5	12.4	8.6	6.3	4.8	10.2	7.2
Site Average	11.8	8.2	13.7	9.4	5.3	4.2	8.4	6.1	7.9	5.8	3.3	3.0	*8.4	*6.2

*Overall Average.

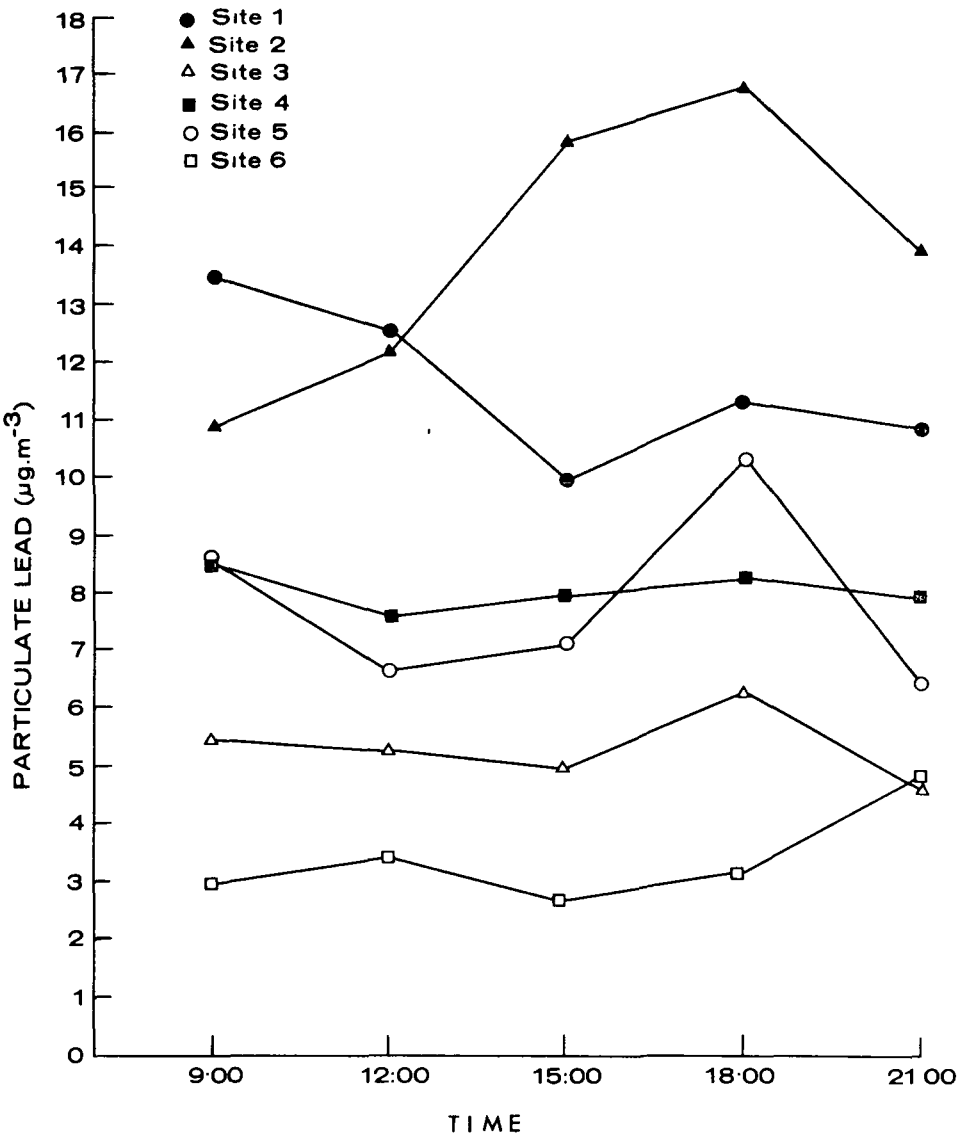

Figure 3. Diurnal variation of particulate lead in Toronto

related to traffic density, eight hour volume counts taken at all sites two years ago did not show the expected association. It was assumed that changes in traffic patterns (during the past two years) may have rendered the counts inaccurate at present.

The overall average concentration of lead in the air in the downtown Toronto area was 8.4 $\mu g.m^{-3}$ for the 15 hour peak sampling period. When projected on a 24 hour daily basis the average value was 6.2 $\mu g.m^{-3}$. The lead comprised about 4% of total particulate matter collected which was in close agreement with the Vancouver results.

3.3 Montreal. The raw data for the survey conducted in Montreal by Eco-Research Limited are presented in Appendix III. Eco-Research did not adhere to the agreed sampling schedule thereby reducing by about 40% the data that may have been compared with the other surveys. Three hour sampling periods from 6:00 to 21:00 hours were used for week day sampling. During the weekend sampling various sample periods were used as outlined in Appendix II. The concentration of lead in the air varied from 0.4 $\mu g.m^{-3}$ to 12.4 $\mu g.m^{-3}$. The cumulative frequency distribution (Figure 1) for the Montreal data was plotted where a 3 hour sampling period was used. The 25%, 50% and 75% frequency values were 3.3 $\mu g.m^{-3}$, 4.7 $\mu g.m^{-3}$ and 6.4 $\mu g.m^{-3}$. In general the results were considerably lower than either Vancouver or Toronto. The average concentration during the periods sampled and the projected 24 hour daily averages are presented in Table 3.

The results may have been low in view of the fact that the weather was inclement during the sampling operation. In addition,

TABLE 3

AVERAGE LEAD CONCENTRATION ($\mu g.m^{-3}$) IN MONTREAL

Sampling Site	1		2		3		4		5		6		Average for Day	
Day	15 hr.	24 hr.	15 hr.	24 hr.	15 hr.	24 hr.	15 hr.	24 hr.	15 hr.	24 hr.	15 hr.	24 hr.	15 hr.	24 hr.
Wednesday, March 15, 1972	3.7	3.2	3.7	3.2	2.9	2.7	5.4	4.3	2.6	2.6	4.5	3.7	3.8	3.3
Thursday, March 16, 1972	4.1	3.5	3.0	2.8	4.6	3.8	4.8	3.5	2.2	2.3	5.0	4.0	3.9	2.9
Friday, March 17, 1972	8.6	6.3	6.2	4.8	6.2	4.8	7.2	5.5	5.2	4.2	7.4	5.6	6.8	5.1
Saturday, March 18, 1972	-	4.3	-	2.2	-	1.5	-	1.0	-	3.3	-	2.1	-	2.4
Sunday, March 19, 1972	2.3	2.2	1.6	1.9	2.0	2.2	1.0	1.5	1.8	2.0	1.3	1.8	-	1.6
Site Average	4.8	4.4	3.4	3.1	3.5	3.0	4.0	3.2	3.1	3.0	4.3	3.5	*4.0	*3.4

*Overall Average.

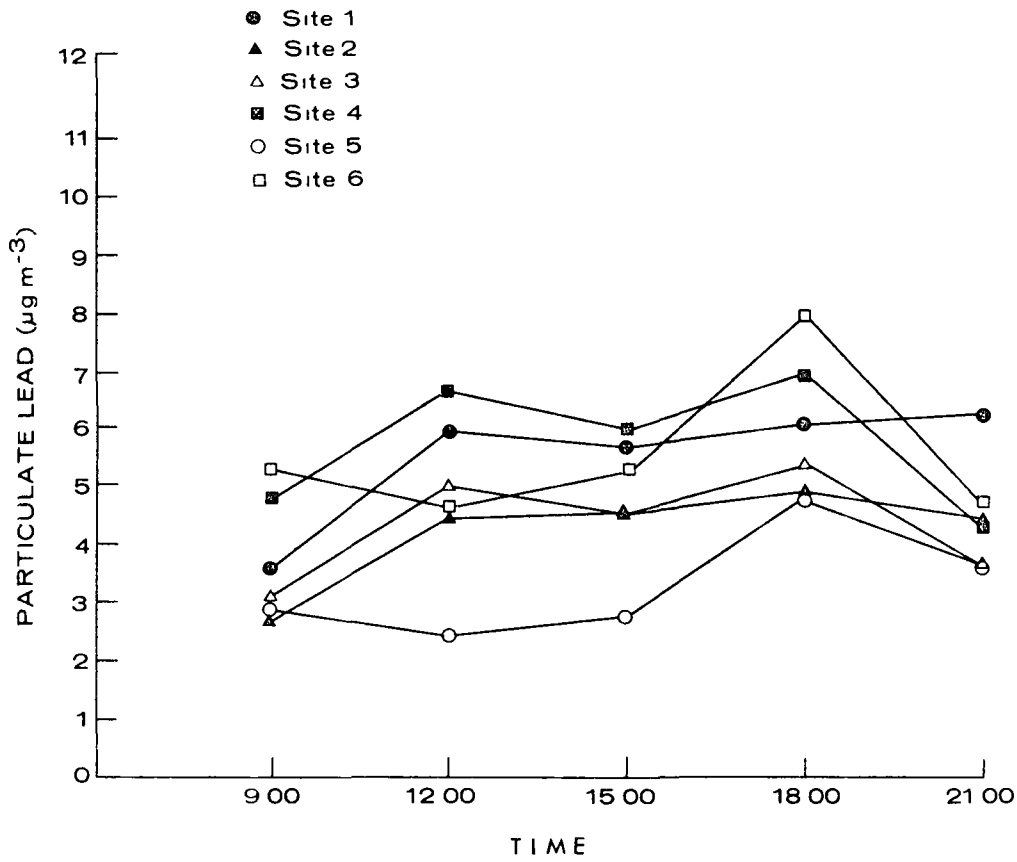

Figure 4 Diurnal variation of particulate lead in Montreal

the samples in Montreal were collected using 0.8μ filters while 0.3μ and 0.4μ filters were used in Vancouver and Toronto respectively. Perhaps the most important difference in the Montreal study was the location of the samplers. In Toronto and Vancouver the samplers were at the curbside with the inlets 4 to 5 feet above street level. The samplers in Montreal were located approximately 10 feet back from the curb on top of telephone booths. In this situation the inlets were 10 to 12 feet above street level.

There appeared to be a significant decrease in lead concentration on the weekends. This was very difficult to assess, however, as any weekend decrease may have been confounded with the variation in sampling time. The probable occurrence of an inversion condition on March 17th caused the lead values to increase considerably.

Evaluation of the diurnal variation in lead concentration indicated that the levels remained relatively constant during most of the day (Figure 4). All sites showed a slight maximum value during the 15:00 to 18:00 hour period, followed by evening decreases. Two of the sites showed very pronounced evening rush hour peaks. Four of the six sites showed a slight tendency to peak at noon, a tendency not displayed in the Vancouver or Toronto surveys. Though traffic density values were not recorded with the data it was assumed that the peaking was strongly associated with traffic flow. It was felt that the three upper curves on the graph reflected areas of greater traffic density than the three lower curves.

The average concentration of lead in the Montreal area was

4.0 $\mu g.m^{-3}$ during the sampling periods. This gave a 24 hour daily projected average of 3.4 $\mu g.m^{-3}$. The portion of particulates which result from lead in the Montreal survey was not determined.

4. CONCLUSIONS

The airborne particulate lead levels at six typical busy intersections in Vancouver, Toronto and Montreal were considerably higher than reported average ambient levels. It is reasonable to assume this is a result of lead emission from the combustion of leaded gasolines. Regrettably, weather conditions during the five day sampling periods in Montreal and Vancouver were such that maximum lead concentrations would not have been measured. A comparison of the results of these exploratory surveys may be made with the results of other more extensive studies by consulting Table 4. The results obtained by the three consultants generally agreed with the results obtained by the Chemistry Division on duplicate filter halves. Barring any gross errors or contamination during the actual sampling it must be concluded that the relatively large variation observed in the lead values were a true reflection of local short term changes occurring at the curbside sampling locations.

It would appear from the limited results of these surveys that population groups such as police, taxi drivers, municipal workers, commuters and other individuals who spend significant portions of their time on busy downtown streets may be exposed to sufficient quantities of lead to cause adverse physiological effects.

TABLE 4

ATMOSPHERIC LEAD CONCENTRATIONS

Ref.	Cities	Sampling Site Locations		No. of Samples	Sampling Period, Hours	Lead Conc. $\mu g.m^{-3}$ Average	Minimum	Maximum
		IN TRAFFIC						
11	Cincinnati	In automobiles driven on city streets and freeways	7-9 hrs.	20	2	14.2	7.2	19.5
			9-16 hrs.	8	7	9.1	7.0	12.3
			16-18 hrs.	8	2	15.2	9.3	21.1
	Los Angeles	In automobiles driven on streets and freeways	6-9 hrs.	48	3	29.9	10.9	54.3
			9-16 hrs.	48	7	21.6	4.5	39.2
			16-18 hrs.	45	2	21.0	8.7	43.1
		1½ meters above ground at Commercial, residential, and Freeway Sites						
12	Detroit	Three sites (5-150 m from traffic)		20	13-731	4.8	1.0	11.8
	New York	Five sites (2-75 m from traffic)		47	10-104	4.1	1.0	13.2
	Los Angeles	Four sites (4-20 m from traffic)		52	11-232	7.6	0.4	18.4
13	Los Angeles	Ground level 9 m from freeway		6		12.2		
		Ground level 12 m from freeway		6		13.2		
		Ground level 1600 m from freeway		6		4.6		
		4th Floor 90 m from freeway		6		6.4		
		CLOSE TO TRAFFIC						
14	Los Angeles	Central City		105	2 or 24	6.6	<1.0	>13.0
	Los Angeles	Central City		169	2 or 24	4.3	<1.0	>13.0
15	Northeast	9-15 m from traffic (1 m above ground)	Traffic					
			Heavy	10	8	2.1	0.6	4.7
			Moderate	10	8	1.1	0.6	1.6
			Light	10	8	0.4	<0.1	0.8

Cont'd.

TABLE 4 (Cont'd)

Ref.	Cities	Sampling Site Locations	No. of Samples	Sampling Period, Hours	Lead Conc. $\mu g.m^{-3}$ Average	Minimum	Maximum
		CLOSE TO TRAFFIC (Cont'd)					
16		Commercial, Residential, Rural and Industrial Sites					
	Cincinnati	Four sites (5-21 m above ground)	616	24-72	1.4	0.3	6.4
	Philadelphia	Seven sites ($1\frac{1}{2}$-21 m above ground)	1247	24-72	1.6	0.1	7.6
	Los Angeles	Eight sites ($1\frac{1}{2}$-29 m above ground)	1268	24-72	2.5	0.1	11.4
17	133 Cities	Central City (1-75 m above ground)	2007	24	1.4	<0.1	26.6
	Detroit	Central City (45 m above ground)	33	24	2.4	0.2	5.8
	New York	Central City (8 m and 25 m above ground)	76	24	2.1	0.2	8.9
	Los Angeles	Central City (5 m above ground)	19	24	3.6		14.1
7	Vancouver	1 m above ground at 6 Commercial sites, 6-21 hrs.	150	15	8.2	0.8	19.6
8	Toronto	5 ft. above ground at 6 Commercial Sites, 6-21 hrs.	150	15	8.4	0.9	21.2
9	Montreal	10 ft. above ground at 6 Commercial Sites, 6-21 hrs.	120	15	4.0	0.5	12.4
		GENERAL URBAN					
18	30 Cities	Central City (8-65 m above ground)	819	24	0.5	<0.1	6.3
	Detroit	Central City (27 m above ground)	25	24	0.4		1.7
	Los Angeles	Central City (24 m above ground)	21	24	1.7	0.1	6.3
17	10 Suburban Areas	(5-23 m above ground)	149	24	0.3	<0.1	4.5

5. RECOMMENDATIONS

It is recommended that longer term surveys at fewer sites should be considered in order to assess peak urban particulate lead levels more conclusively. Assuming that these preliminary values are a reasonable estimate of actual levels, studies should be undertaken in conjunction with the monitoring program to determine the actual intake of lead and effects among high exposure population groups, with particular reference to long term effects of various tissue levels of lead and disturbances of porphyrin metabolism.

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18. Air Pollution Measurements of the National Air Sampling Network. Analysis of Suspended Particulates Samples Collected 1957-1961. Public No. 978, Washington, D.C. (1962)

7. APPENDIX I

Sampling Locations

All sites were located in commercial areas. Examination of the sites by the various consultants indicated that there were no obvious interfering emission sources. In all cases the sites were located at busy intersections that would reflect the influence of gasoline combustion on airborne particulate lead.

The following contains site maps and description of the various locations where available.

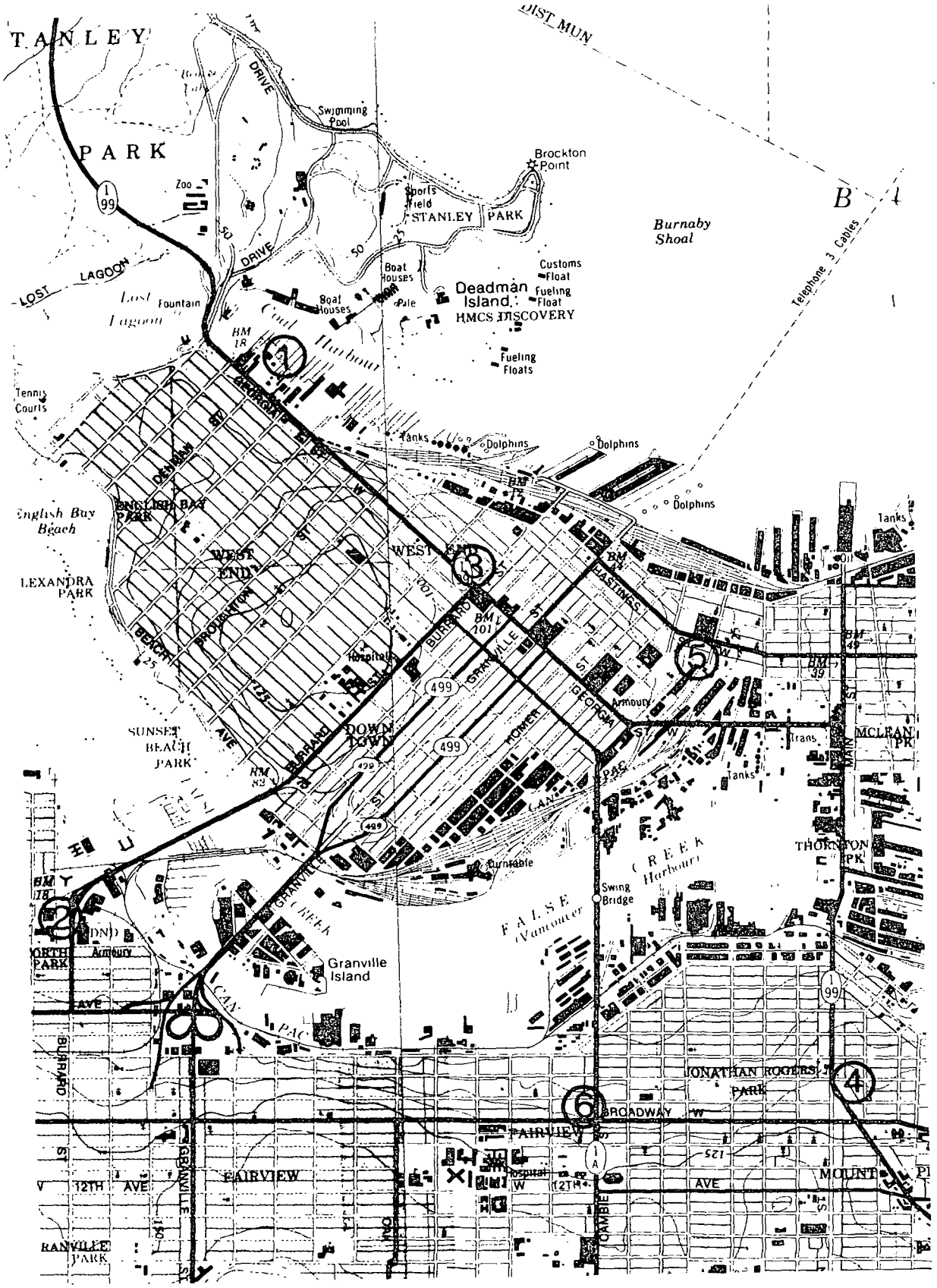

Figure 5. Sampling locations in the Vancouver area

TABLE 5

DESCRIPTION OF SAMPLING LOCATIONS IN VANCOUVER

Station Designation	Location	Traffic Volume	Date Counted	Comments on Location
1	Denman and Georgia	All sites 1,000 - 4,000 vehicles per hour	July, 1972	All sites were surrounded only by commercial establishments.
2	Burrard and Cornwall			
3	Burrard and Georgia			
4	Main and Kingsway			
5	Pender and Beatty			
6	Broadway and Cambie			

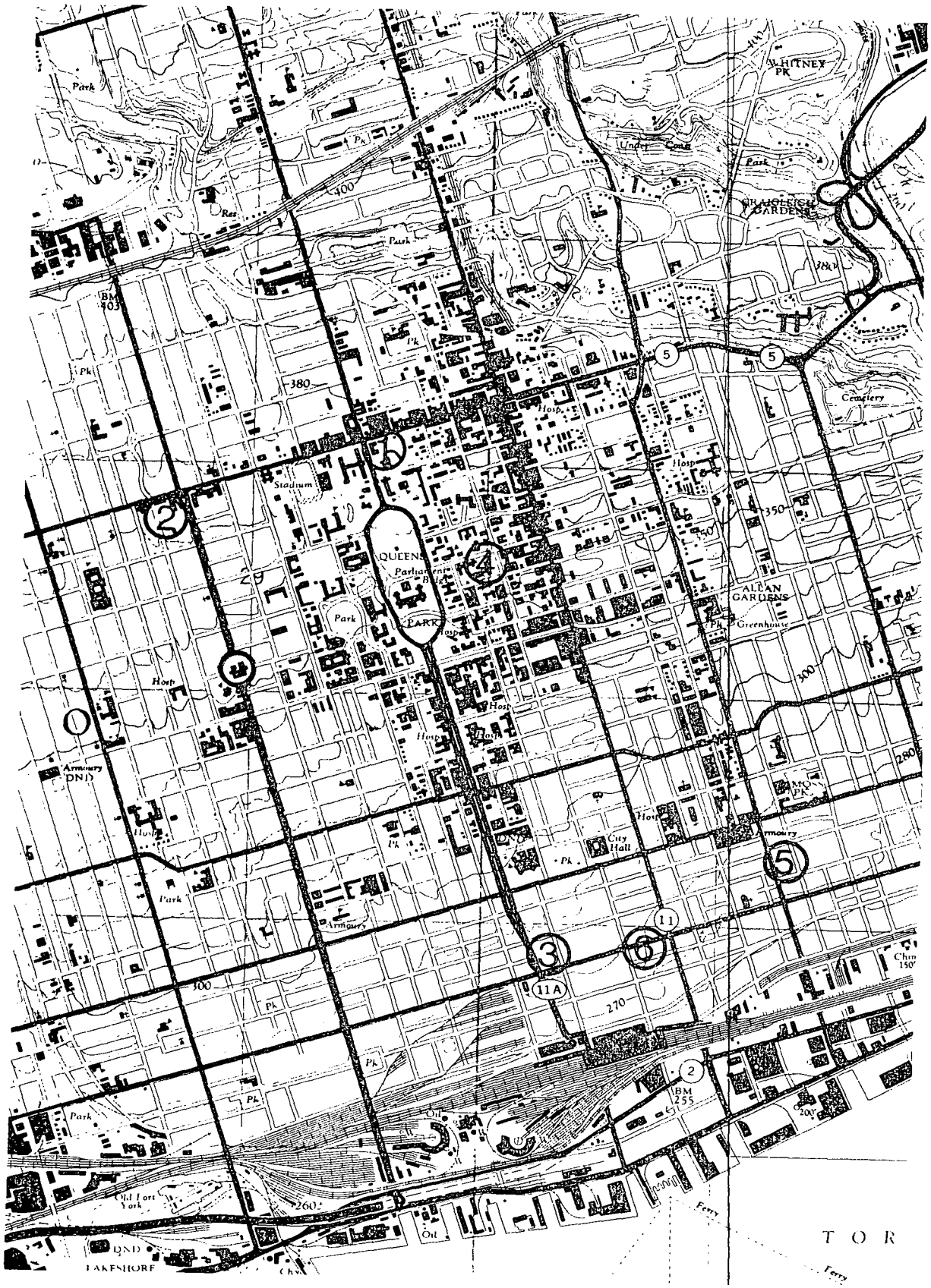

Figure 6. Sampling locations in the Toronto area

TABLE 6

DESCRIPTION OF SAMPLING LOCATIONS IN TORONTO

Station Designation	Location	8 Hour Traffic Volume	Date Counted	Comments on Location
1	Bloor & University, SE corner	34,802	May 26, 1969	With the exception of the Park Plaza Hotel, all buildings are 3-4 stories high, a relatively open area with buildings set back from sidewalks.
2	Spadina & Bloor, SW corner	20,140	April 1, 1970	Similar to Bloor and University.
3	University & Adelaide, SE corner	26,745	April 15, 1969	Tall office buildings close to sidewalk with large parking lot on NE corner.
4	Wellesley & Bay, SW corner	22,141	Oct. 12, 1971	Three (3) corners occupied by moderately tall buildings with construction across street from sampling location. SW corner an open area associated with new provincial government buildings.
5	Adelaide and Jarvis, NE corner	18,181	May 20, 1970	Older 3 storey buildings with open park area on SW corner. A small parking lot located on NE corner.
6	King and Bay, SE corner	14,455	June 3, 1970	A typical downtown intersection dominated by large office buildings, New Commerce Court (under construction) on SE corner and T.D. Centre are set back from sidewalk with open pedestrian areas.

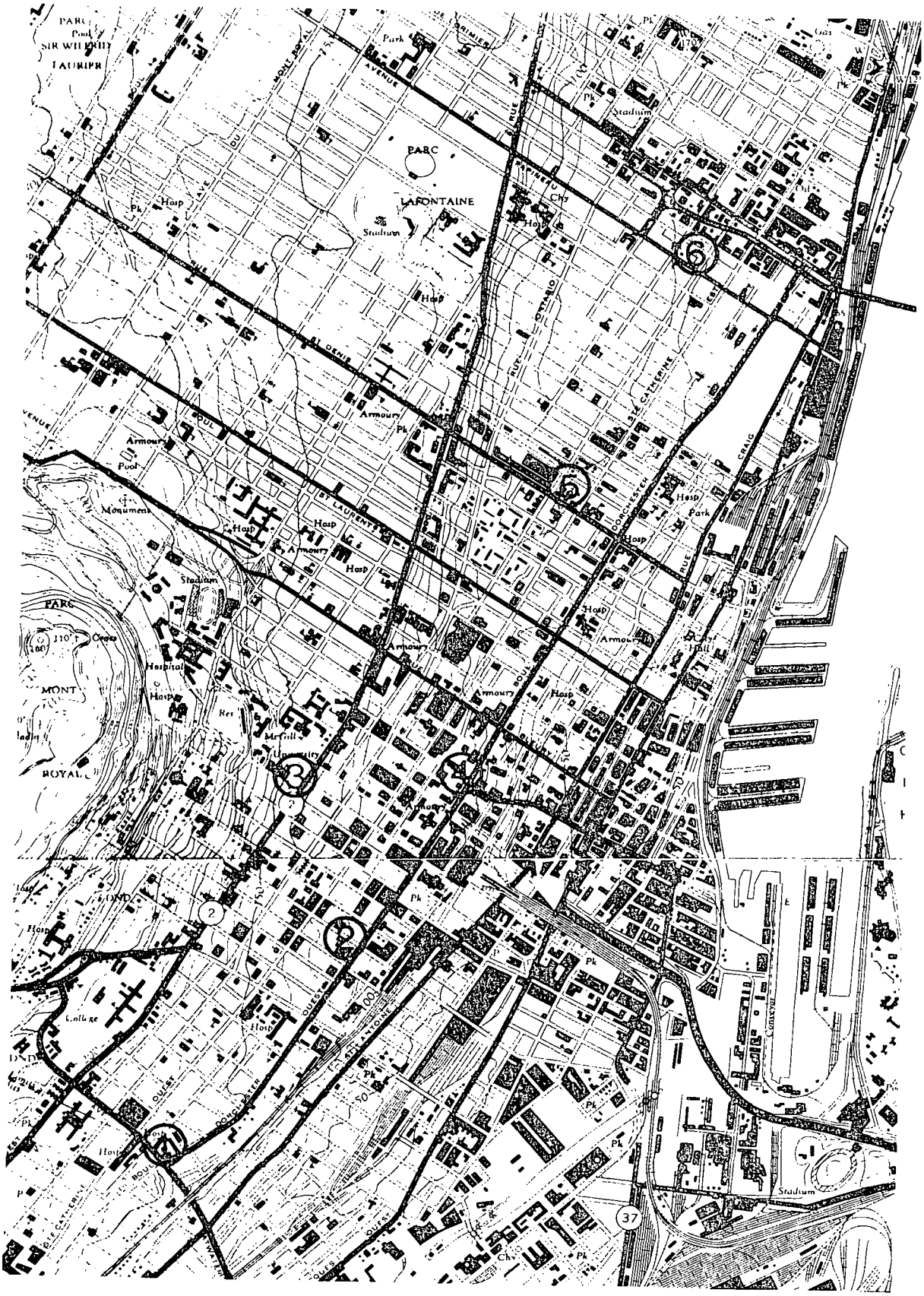

Figure 7. Sampling locations in the Montreal area

TABLE 7

DESCRIPTION OF SAMPLING LOCATIONS IN MONTREAL

Station Designation	Location	Comments on Location
1	Atwater & Ste. Catherine	Near a major bus terminal. Commercial area.
2	Ste. Catherine and Crescent	Commercial area.
3	Sherbrooke and Metcalfe	Commercial area.
4	Dorchester and University	Commercial area.
5	Ste. Catherine and St. Denis	Commercial area.
6	Ste. Catherine and Papineau	Commercial area.

8. APPENDIX II

Sampling Periods and Prevailing Weather Conditions

Several meteorological factors may significantly affect the concentration of lead in the air. Particulate material including lead in the air may be entrapped in atmospheric precipitation. It is probable that the lead aerosol emitted from the combustion of leaded gasolines remains in a soluble form as halide salts or possibly sulfate. However, even very insoluble lead dioxide, PbO_2, will react with atmospheric sulphur dioxide to produce soluble sulfate. In addition, the quantity of lead in the atmosphere seems to be reduced with increasing wind speeds and increasing depths of atmospheric mixing.

TABLE 8

SUMMARY OF SAMPLING PERIODS AND PREVAILING WEATHER CONDITIONS IN VANCOUVER

Date	Time	Weather
Friday, July 7, 1972	6:00 to 21:00 hours	Sunny, moderately windy
Saturday, July 8, 1972	6:00 to 21:00 hours	Cloudy, rain from 6:00 to 8:00 hrs., light wind.
Sunday, July 9, 1972.	6:00 to 21:00 hours	Cloudy, rain from 10:00 to 11:00 hrs.
Monday, July 10, 1972	6:00 to 21:00 hours	Cloudy, rain from 13:00 to 14:00 hrs.
Tuesday, July 11, 1972	6:00 to 21:00 hours	Rain all day.

TABLE 9

SUMMARY OF SAMPLING PERIODS AND PREVAILING WEATHER CONDITIONS IN TORONTO

Date	Time	Weather
Wednesday, July 12, 1972	6:00 to 21:00 hrs.	Hot and humid, no rain, calm.
Thursday, July 13, 1972	6:00 to 14:00 hrs.	Sampling curtailed because of heavy thunder showers commencing at 13:30 hrs. Low to moderate wind velocities.
Friday, July 14, 1972	-	Clear, but no sampling because of rain on previous day.
Saturday, July 15, 1972	6:00 to 21:00 hrs.	Brief shower at 8:00 hrs. Rain showers commenced at 14:00 hrs. and continued for remainder of day. Moderate wind velocities.
Sunday, July 16, 1972	-	Clear, but no sampling because of rain on previous day.
Monday, July 17, 1972	-	Rain forecast, but did not materialize.
Tuesday, July 18, 1972	6:00 to 21:00 hrs.	Hot and humid, no rain. Low to moderate wind velocities.
Wednesday, July 19, 1972	6:00 to 21:00 hrs.	Hot and humid, no rain. Low wind velocities.
Thursday, July 20, 1972	6:00 to 12:00 hrs.	Hot and humid, no rain. Low wind velocities.

TABLE 10

SUMMARY OF SAMPLING PERIODS AND PREVAILING WEATHER CONDITIONS IN MONTREAL

Date	Time	Weather
Wednesday, March 15, 1972.	6:00 to 21:00 hrs.	Cloudy with periods of light snow.
Thursday, March 16, 1972.	6:00 to 24:00 hrs.	Cloudy. Thunderstorm with hail in evening.
Friday, March 17, 1972.	0:00 to 24:00 hrs.	Rain, drizzle and fog all day.
Saturday, March 18, 1972.	0:00 to 24:00 hrs.	Rain changing to snow in early morning. Gusty winds.
Sunday, March 19, 1972.	0:00 to 8:00 hrs.	Sunny all day.

9. APPENDIX III

Raw Data

The evaluation of atmospheric concentrations of heavy metals is best determined by collection of the suspended particulate matter by passing air through membrane filters at a known flowrate for measured periods of time. The use of membrane filters, or equivalent, allows for retention of smaller respirable particles, as well as larger particles. This appears to be the most acceptable method of sampling for estimating levels of pollutants that may affect human, animal or plant well-being.

All the raw data gathered during the three exploratory surveys are given in Tables 11-13.

TABLE 11

PARTICULATE LEAD VALUES AT SIX LOCATIONS IN VANCOUVER

Friday, July 7, 1972	Particulate Lead ($\mu g.m^{-3}$)					
Time	1	2	3	4	5	6
6 - 9	11.8	4.77	1.96	6.42	2.03	7.56
9 - 12	11.6	2.76	2.94	11.5	2.49	8.47
12 - 15	15.8	1.78	4.66	10.2	2.32	8.73
15 - 18	17.6	5.48	6.13	17.4	4.70	16.7
18 - 21	21.9	2.84	4.34	9.62	4.72	14.0
Saturday, July 8, 1972						
Time						
6 - 9	3.13	0.84	0.80	2.19	1.35	4.41
9 - 12	11.6	2.91	2.29	4.39	2.28	7.70
12 - 15	14.6	4.14	3.30	9.67	4.31	7.99
15 - 18	19.6	7.27	5.68	6.54	7.91	12.9
18 - 21	18.8	6.91	5.50	7.38	6.18	8.33
Sunday, July 9, 1972						
Time						
6 - 9	3.31	0.84	0.80	1.62	0.90	2.31
9 - 12	5.67	2.96	1.01	2.62	1.02	4.41
12 - 15	14.7	4.36	2.70	7.91	3.10	10.7
15 - 18	18.2	4.43	2.59	9.69	5.11	13.8
18 - 21	11.6	6.39	2.17	7.75	4.74	11.7
Monday, July 10, 1972.						
Time						
6 - 9	-	8.12	4.48	14.4	10.7	11.0
9 - 12	16.3	7.40	5.09	16.9	14.2	11.4
12 - 15	12.6	6.94	9.54	8.50	10.8	11.0
15 - 18	14.6	7.18	10.0	12.5	13.0	12.2
18 - 21	17.5	4.01	4.55	12.9	4.51	13.3
Tuesday, July 11, 1972						
Time						
6 - 9	15.1	7.19	2.41	12.4	7.08	10.4
9 - 12	12.4	7.39	3.18	17.9	12.9	15.1
12 - 15	14.9	6.06	4.65	16.0	6.98	18.1
15 - 18	12.6	6.03	6.02	14.7	10.6	20.2
18 - 21	7.52	2.53	3.44	7.72	10.7	10.0

TABLE 12

PARTICULATE LEAD VALUES AT SIX LOCATIONS IN TORONTO

Wednesday, July 12, 1972	Particulate Lead ($\mu g\ m^{-3}$)					
Time	1	2	3	4	5	6
6 - 9	21.1	11.6	5.6	18.8	10.8	0.9
9 - 12	15.5	6.7	4.4	10.5	8.2	4.0
12 - 15	13.0	13.5	8.4	9.5	8.0	1.8
15 - 18	9.0	14.5	5.5	10.2	10.5	0.9
18 - 21	8.0	14.2	2.6	7.6	5.3	5.8
Thursday, July 13, 1972						
Time						
6 - 9	11.5	14.9	3.2	12.6	1.4	2.1
9 - 12	-	18.3	4.4	8.2	2.0	0.4
12 - 14	9.1	21.2	4.3	11.9	-	6.2
Saturday, July 15, 1972						
Time						
6 - 9	2.5	3.5	1.3	4.8	10.2	0.4
9 - 12	5.7	8.1	1.8	7.0	2.9	0.5
12 - 15	4.3	14.4	1.9	10.4	3.7	0.4
15 - 18	6.9	13.9	3.3	9.2	3.2	4.1
18 - 21	5.7	13.3	5.1	6.9	-	6.5
Tuesday, July 18, 1972						
Time						
6 - 9	15.7	9.4	6.1	8.6	10.4	0.8
9 - 12	8.6	9.9	5.2	12.1	8.8	1.7
12 - 15	9.5	14.7	3.8	12.5	5.6	1.4
15 - 18	12.3	16.3	8.9	11.0	12.0	-
18 - 21	9.6	12.6	5.0	9.6	7.0	4.5
Wednesday, July 19, 1972						
Time						
6 - 9	13.4	8.6	11.4	4.4	4.7	6.9
9 - 12	13.8	13.5	11.2	5.1	7.7	7.8
12 - 15	14.1	15.7	6.6	3.6	11.1	3.5
15 - 18	17.2	22.3	7.6	2.9	15.5	4.5
18 - 21	20.2	16.1	5.7	7.8	6.9	2.4
Thursday, July 20, 1972						
Time						
6 - 9	16.9	17.6	5.1	2.2	14.6	6.8
9 - 12	18.9	16.6	5.0	3.0	10.3	5.8

TABLE 13

PARTICULATE LEAD VALUES AT SIX LOCATIONS IN MONTREAL

Wednesday, March 15, 1972	Particulate Lead ($\mu g.m^{-3}$)					
Time	1	2	3	4	5	6
6 - 9	3.3	1.5	3.2	4.9	3.7	4.8
9 - 12	3.1	4.1	2.1	6.6	1.2	3.3
12 - 15	3.5	3.5	2.4	6.0	2.4	3.0
15 - 18	4.7	4.7	3.4	6.1	2.7	5.9
18 - 21	3.3	4.6	3.3	3.4	3.1	5.2
Thursday, March 16, 1972						
Time						
6 - 9	1.5	2.7	3.8	4.0	2.2	4.7
9 - 12	5.0	2.8	5.0	3.9	1.6	3.5
12 - 15	3.7	2.7	4.7	6.5	1.4	7.0
15 - 18	5.7	4.1	5.2	4.9	3.3	5.9
18 - 21	4.7	2.9	4.1	4.6	2.3	3.7
21 - 6	2.4	2.3	2.4	1.4	2.4	-
Friday, March 17, 1972						
Time						
6 - 9	6.1	3.8	5.1	5.4	2.8	6.5
9 - 12	9.8	6.6	7.8	9.6	4.6	7.2
12 - 15	8.0	7.7	6.7	6.0	4.6	5.7
15 - 18	8.3	6.1	7.6	10.0	8.6	12.4
18 - 21	11.0	6.8	3.8	5.1	5.6	5.2
Saturday, March 18, 1972						
Time						
21 - 12	3.5	2.2	1.3	0.7	3.5	-
12 - 6	5.2	2.2	1.8	1.3	3.1	1.6
Sunday, March 19, 1972						
Time						
6 - 12	2.1	1.5	1.0	0.5	1.0	1.0
12 - 18	-	1.7	3.0	1.5	2.6	1.7