FRASER RIVER ACTION PLAN

Atmospheric Contributions to the Still Creek-Burnaby Lake-Brunette River Watershed 1996

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Atmospheric Contributions to the Still Creek - Burnaby Lake - Brunette River Watershed

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Abstract

The impact of emissions from urban sources to ambient air pollution is not considered to be large in comparison to water discharge sources. The Still Creek-Burnaby Lake-Brunette River watershed drains into the Fraser River near New Westminster B.C. and was chosen for assessment as an example of the urban influence on a large river. Rain samplers were used to collect inorganic and organic pollutants washed from the air during a single rainfall event. Two sites were used for an integrated sample over the course of the rain event. From the rain samples analyses concentrations and deposition values were calculated. The concentration of inorganic and organic chemicals from a single rainfall event can be considerable, especially in the first few moments of rainfall. Rainfall cleans the air of contaminants and these contaminants appear to be from sources relatively close to the sampling. In this sampling program atmospheric transport from a distance did not appear to be a strongly influencing factor.

Résumé

L'impact des émissions d'origine urbaine sur la pollution de l'air ambiant n'est pas important, considère-t-on, en comparaison des sources de rejet dans l'eau. On a choisi d'évaluer le bassin versant du ruisseau Still - lac Burnaby - rivière Brunette, qui se draine dans le fleuve Fraser près de New-Westminster, en Colombie-Britannique, pour illustrer l'effet d'une zone urbaine sur un cours d'eau d'importance. On a utilisé des collecteurs de précipitation pour prélever les polluants inorganiques et organiques extraits de l'air par la pluie. On a fait des prélèvements à deux sites en vue de constituer un échantillon intégré au cours de la chute de pluie. L'analyse des échantillons de pluie a permis de déterminer les concentrations et les taux de dépôt. La quantité de produits inorganiques et organiques extraite par l'eau de pluie au cours d'une seule chute de pluie peut être considérable, surtout au tout début de la chute de pluie. La pluie débarrasse l'air des contaminants qu'il contient, et ces contaminants semblent provenir de sources relativement proches du point d'échantillonnage. Le transport atmosphérique à grande distance ne constituait pas, semble-t-il, un facteur très important dans le cadre de ce programme d'échantillonnage.

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Introduction

Watershed

The watershed that drains into Still Creek, Burnaby Lake and Brunette Rivers ultimately drains into the Fraser River at New Westminster B.C. The drainage area is 9091 hectares and forms a valley system that runs approximately west-to-east. There is a diverse assortment of pollution sources within this area: residential areas occur in the north, south and south-west; medium industrial areas occur to the west, east and south-east. As well, pollution from traffic sources is a concern as the area is surrounded by major roadways with Highway 7 running along the north side and Highway 1 along the south side. To the east a major intersection connects these two highways (Figure 1).

Sampling

The sampling plan was to collect precipitation at two locations at either end of the Burnaby Lake area after a period of dry and stagnant air within the airshed. The Douglas Road site was on Still Creek where it flowed into Burnaby Lake; this site was in the middle of a commercial/industrial area. The second site was at Hume Park on the Brunette River which was on the outflow side of Burnaby Lake close to the confluence with the Fraser River; this area was park land near a busy roadway. The rainfall sample collection period was planned to be from the start of the rainfall to either the end of the event or when rainfall intensity precluded the possibility of any contaminants being left in the local air mass (Baker *et al.*, 1981).

Two modified MIC Rainfall samplers were used to collect the samples. The inorganics were collected in a plastic bag lining a bucket of known diameter; this equipment is standard in Environment Canada's Canadian Air and Precipitation Monitoring Network (CAPMoN, 1985). The organics were collected on an XAD-2 resin in a Teflon tube attached to a square Teflon-coated funnel that is a part of the equipment used by Environment Canada's National Water Research Institute (NWRI) sampling program for organics. The equipment was modified to remove the automated portions that were not needed as personnel were present at the start and stop of sampling.

Samplers were not exposed to the atmosphere until the precipitation event began, and sampling continued until rainfall intensity diminished to a drizzle, which provided enough sample volume for lab analyses purposes.

Field Quality Assurance

To ensure that there was no dry deposition to the samplers and that only precipitation samples were collected, samplers were not opened to the atmosphere until the precipitation event began, and sampling was stopped when rainfall intensity diminished to almost non-measurable, and an adequate sample was collected. Field blanks were obtained by using the same sample media (plastic bag for inorganics, and XAD-2 resin in a Teflon tube) and setting these media in the samplers before the rain event. They were then removed and sent to the laboratory for analyses.

Lab Quality Assurance

The laboratory prepared the field blanks by: for the inorganics, adding 500 milliliters of distilled de-ionized water to the sample bag and allowing any contaminants to be extracted from the bag; for the organics, extracting the XAD-2 resin directly for any contaminants present.

Lab Analyses

Sample analyses for thirty-six inorganic parameters (listed below) in water were carried out in accordance with the procedures described in "Methods for Chemical Analyses for Water, Wastes"

(USEPA), "Manual for the Chemical Analyses for Water, Wasteswaters, Sediments and Biological Tissues" (B.C. MoE), and/or "Standard Methods for the Examination of Water and Wastewater" (APHA).

Sample analyses for metals in water were carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" - 19th Edition, 1995 (APHA), with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 (EPA). The procedures may involve preliminary sample treatment by acid digestion or filtration (EPA Method 3005), followed by instrumental analyses by atomic absorption spectrophotometry (EPA Method 6010), and/or inductively coupled plasma-mass spectrophotometry (EPA Method 6020).

Meteorology

The period preceding the sampling study was dry for about five days with light and variable winds.

On February 28 a major low pressure system developing in the Gulf of Alaska began moving rapidly eastward. As this intense late winter storm tracked towards the central coast cloud cover thickened in the afternoon, steady rain began over most of the area between 5 and 6 p.m. and winds at most stations in the lower mainland began to blow from the east. At Vancouver International Airport winds in the afternoon and early evening blew from the southeast from 5 to 10 knots, overnight winds at the airport were consistently from the east (as high as 18 knots with gusts to 25 knots). Winds at Pitt Meadows in the afternoon were from the southwest around 5 knots and in the early evening as the low pressure system approached winds blew varying from the north-to-northeast-to-east at 6 knots. In the early morning hours of the 1st, winds with a predominately easterly component were widespread across the lower mainland. The frontal system associated with the weather system crossed the south coast in the afternoon of March 1st. Vancouver International Airport received 49.6 mm of rain during the storm and easterly winds gusted to 45 km/h. The minimum temperature was 3°C during the sampling period, and shortly thereafter snow began falling in the area.

Data and Discussion

The inorganic parameters that were measured included pH, ammonia, nitrate, nitrite, ortho-phosphate, total dissolved phosphate, total phosphate, aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, calcium, chromium, cobalt, copper, lead, lithium, magnesium, manganese, molybdenum, nickel, potassium, selenium, silver, strontium, thallium, tin, uranium, vanadium, zinc, total carbon, organic carbon and inorganic carbon. The metals were measured for both total and dissolved forms. Of these 37 parameters only 26 were present in measurable quantities, but not at both sites: pH, ammonia, nitrate, nitrite, phosphate, total dissolved phosphate, total phosphate, aluminum, antimony, arsenic, barium, boron, cadmium, calcium, cobalt, copper, lead, magnesium, manganese, molybdenum, nickel, potassium, strontium, zinc, total carbon and organic carbon (see Table 1. Total and Dissolved Metals. and Table 2: Deposition - total and dissolved metals also Figure 2: Concentration of Total Metals and Figure 3: Deposition of Total Metals).

The organic parameters that were measured included 22 polyaromatic hydrocarbons (PAHs), 8 chlorophenolics (CPs), 59 polychlorinated biphenyls (PCBs) and 33 organochloride pesticides. Of these, only 15 PAHs and one CP were present in measurable quantities (see Table 4: PAHs Concentration - Douglas Road and Hume Park sites, Table 5: PAHs Deposition - Douglas Road and Hume Park sites and Table 6: Chlor Phenols Deposition - Douglas Road and Hume Park sites).

Inorganics

Concentration Values

pH values were about 4.3 and 4.4 at the Douglas Road and Hume Park sites. This is lower than the 'natural' pH of background rain water at pH 5.65. The acidity of the rainfall is likely due to the presence of significant amounts of nitrate in the atmosphere. The pH at the Douglas Road site was lower than the downstream site, as would be expected due to expected higher nitrogen oxides from the perceived

higher traffic and industry density in the Hume Road area. The total measurements for nitrogenous compounds was higher at Douglas than at Hume.

Aluminum is slightly higher in both dissolved and total forms at the Hume Park site, and may be due to more local sources near the park.

Antimony was present at both sites in similar amounts and mainly in the soluble form (Table 3: Percentage of Dissolved Metals). Possible sources of soluble antimony may be from batteries, fire retardants, rubber vulcanizing or colouring, fireworks manufacture, mordants in textile and leather processing, and a colouring agent in paint and glass manufacture.

Boron and molybdenum were only detected at the Douglas Road site, but near the laboratory detection limit levels.

Cadmium was detected at both sites almost all in the soluble form. The concentration at the Hume Park site was approximately three time greater than that at the Douglas Road site, indicating a local source. Cadmium, a known carcinogen, can come from sources such as soldering, electroplating, Ni-Cd batteries, photography, lithography, process engraving, lubricants, and phosphor manufacturing.

Calcium was detected in significant amounts (0.1-0.2 mg/l) at both sites, in similar concentrations for both dissolved and total forms. This is likely due to road dust or marine salts.

Cobalt was only detected at the Hume Park site in the total form, but at the detection level.

The phosphorus compounds were higher at Douglas, but similar in magnitude. Arsenic, barium, copper, lead, magnesium, manganese, nickel, potassium, strontium and zinc were detected in small amounts at both sites, in similar concentrations for both dissolved and total forms. This may indicate a ubiquitous but low level source within the watershed.

Carbon was only measured at the Hume Park site where all of the carbon was present in the dissolved form. This is likely due to diesel fumes from nearby transportation, or local machinery solvent cleaning operations.

Deposition Values

Depositions rates were calculated by consideration of the sample container area and the sample time. Results were reported in terms of milligrams per square meter per day ($mg/m^2/day$). Deposition values are reported in Table 2, values range from 0.0001 to 11.6 $mg/m^2/day$. The highest values occur for nitrate, ammonia, calcium, magnesium, potassium and zinc. The nitrogen compounds of nitrate and ammonia have possible sources in combustion of transportation fuels, but, considering the eastern wind flow pattern preceding the rainfall, they may also be from agricultural sources (Belzer *et al.*, 1997) in the eastern portion of the Fraser Valley, although these sources are some distance away. The calcium, magnesium and potassium are usually associated with road dusts or sea salt sources, and both may be possible. The zinc is normally associated with transportation and tire wear, and this is likely in this urban area.

Organics

Concentration Values

The Polycyclic Aromatic Hydrocarbons (PAHs) concentrations that were present in measurable quantities are reported in Table 4, and Table 5. Of the 22 PAHs analyzed, 15 were found at the Douglas Road site and only 10 were found at the Hume Park site.

Rainfall concentration values are typically higher for PAHs at the Douglas Road site; the concentration values at Hume Park are lower with 12 compounds at the detection level. Except for acenaphthene and benz(a)anthracene where the values are similar in magnitude although slightly higher at the Douglas

road site, the other compound concentrations are significantly different, indicating that the sources are probably nearby/ local and higher at the Douglas Road site.

One technique to assess source types is to choose one chemical and ratio the other chemicals to it and thereby normalize the data to remove any effect of magnitude on the results. Phenanthrene was measurable in both samples and is representative of transportation sources. For that reason, it was used to normalize data for comparison purposes. A ratio of the individual PAHs at both sites to phenanthrene showed similar values indicating a similar atmospheric source type. There were more total low molecular weight (LMW) PAHs compared to the high molecular weight (HMW) PAHs. This was probably due to the fact that temperatures were near freezing and that the less volatile PAH fraction may not have been present in the atmosphere. Dry deposition may have already deposited these HMW PAHs to the ground and water areas immediately at the source site.

Deposition Values

Deposition values for PAHs and Chlorinated Phenols (CPs) are reported in Table 5 and

Table *6*. Values are given in kg/km^2/day based on the sampler size/opening.

The deposition values for the LMW PAHs (naphthalene, phenanthrene) and the HMW PAHs (fluoranthene, pyrene, chrysene and benzo(b +j)fluoranthene) range from <1 to 19 g/km^2/day. Pentachlorophenol was the only measured chlorophenol in rainwater and had a deposition of 11.4 g/km^2/day at Douglas Road.

Rainwater from the whole drainage area to the location of the air sampling sites would collect metals and PAHs from a broad area: 21.56km^2 area in the Still Creek area would pass by the Douglas Street station; beyond this area another 47.8 km^2 of drainage would pass by the Hume Park station. The impact of the deposition may be reduced as the water passes through Burnaby Lake where sediments may be lost.

Deposition to the Watershed

Deposition to the Still Creek-Burnaby Lake-Brunette River watershed is a sum of varying deposition rates throughout the watershed. The Douglas Road and Hume Park sampling sites in this study had 15 and 11 measurable PAHs respectively during this rainfall event. The sites are approximately 6-7 kilometers apart and if there was a common source, would have the same PAHs measured and in similar concentration ranges. This was not the case as the Douglas Road site had more and higher PAH concentrations reported. However a total measurable PAH value of 62 g/km^2/day for Douglas Road and 20.1 g/km^2/day for Hume Park could be considered with the true depositional impact lying somewhere between these two site values. The effective drainage areas for the sites are 21.56 km^2 for Douglas Road and 47.8 km^2 for Hume Park. This would imply a deposition of 1336.72 and 960.8 gm total PAHs respectively, at these site for this single rainfall event.

The impact of this atmospheric deposition could result in an accumulation of metals and PAHs that could effect the biota. For example, if we assume a uniform deposition rate within this water shed: 245 g pentachlorophenol would be deposited during the period of this one rainfall event; and 106 g benzo(b+j)fluoranthene and/or fluoranthene would have deposited for the rainfall event.

Summary and Conclusions

This study was done as a preliminary assessment of the impact of ambient air sources of pollutants on a local watershed area. Metals and PAHs were chosen as representative contaminants of industrial and urban processes that were commonly found in the air. These contaminants were found in the rainfall at both sites but in different types and amounts. The impact of the wash-out of these chemicals on the land, water and biota have not been assessed but can be expected to contribute to degradation of the environment.

The Still Creek-Burnaby Lake-Brunette River watershed drains into the Fraser River near New Westminster B.C. This watershed was chosen for assessment as an example of the urban influence on a large river. Rain samplers were used to collect inorganic and organic pollutants washed from the air during a single rainfall event. The two sites used were in industrial and urban areas and did show a difference in rain concentrations and chemical species found. The industrial area was more contaminated than the urban site.

Urban sources of air pollution can impact land and water within the range of air transportation of those pollutants. Often this transport is minimal and the pollution effect is noticed close to the source, especially during rainfall events. The impact of ambient air pollution is not normally large in comparison to water discharge sources.

The rain sample concentration and deposition values were used to assess possible sources. Because the chemicals and amounts were quite different, they were attributed to sources relatively close to the sampling sites. In this sampling program, atmospheric transport did not appear to be a strongly influencing factor, but there is the possibility of regional transport of ammonia from the eastern portion of the Fraser Valley.

This single rainfall event is only a picture of one set of environmental conditions. Longer more extensive measurements are needed to assess the true impact of wet atmospheric deposition processes. More importantly, there is a need for evaluation of the atmospheric processes and the subsequent drainage of this “Still Creek-Burnaby Lake-Brunette River” into the Fraser River, and the impact of an urban watershed on a large river system.

References

Baker, M.B., D. Caniparoli and H. Harrison, An analysis of the first year of MAP3S rain chemistry measurements, Atmos. Environ., 15: 43-55, 1981 2

Belzer, W., C. Evans and A. Poon, Atmospheric Nitrogen Concentrations in the Lower Fraser Valley, Fraser River Action Plan Report #97-23, 1997 5

CAPMoN, Site Operations Reference Manual- Precipitation, Canadian Air and Precipitation Monitoring Network, Environment Canada, Downsview Ontario, 1985 2

Tables

Table 1. Total and Dissolved Metals.

			Total	Total	Dissolved	Dissolved
			Douglas Rd.	Hume Park	Douglas Rd.	Hume Park
Sample Date (start)			2/28/9716:00	2/28/97 16:00	2/28/97 16:00	2/28/97 16:00
Sample Date (stop)			3/1/97 2:56	3/1/97 3:23	3/1/97 2:56	3/1/97 3:23
No. Days			0.4556	0.4743	0.4556	0.4743
Sampler Area (m^2)			0.058	0.058	0.058	0.058
Rainfall (mm)			11.5	12.9	11.5	12.9
Spl Volume (L)			0.667	0.7482	0.667	0.7482
Units =mg/l	**Detection**	**Symbol**				
Hydrogen Ion	NA	**H+**	4.2646	4.3661		
Ammonia Nitrogen		**NH_3-N**	0.4360	0.2673		
Nitrate Nitrogen		**NO_3-N**	0.4608	0.4043		
Nitrite Nitrogen	<0.001	**NO_2-N**	0.0100	0.0080		
Ortho-Phosphate:P	<0.001	**PO_4-P**	0.0050			
Total Phosphate:P	<0.001	**T-P-Dis**	0.0060	0.0000		
Total Phosphate:P	<0.001	**T-P**	0.0160	0.0130		
Aluminum	<0.005	**Al**	0.0360	0.0420	0.0090	0.0100
Antimony	<0.00005	**Sb**	0.0002	0.0001	0.0002	0.0001
Arsenic	<0.0001	**As**	0.0003	0.0003	0.0002	0.0002
Barium		**Ba**	0.0025	0.0016	0.0021	0.0013
Beryllium	<0.0005	**Be**				
Bismuth	<0.0005	**Bi**				
Boron	<0.001	**B**	0.0010	0.0010	0.0010	0.0010
Cadmium	<0.00005	**Cd**	0.0001	0.0016	0.0001	0.0015
Calcium	<0.02	**Ca**	0.2100	0.1200	0.1900	0.1200
Chromium	<0.0005	**Cr**				
Cobalt	<0.0001	**Co**		0.0001		
Copper	<0.0005	**Cu**	0.0024	0.0030	0.0019	0.0024
Lead		**Pb**	0.0019	0.0011	0.0010	0.0006
Lithium	<0.001	**Li**				
Magnesium	<0.005	**Mg**	0.0960	0.0760	0.0870	0.0690
Manganese		**Mn**	0.0023	0.0027	0.0017	0.0019
Molybdenum	<0.00005	**Mo**	0.0001			
Nickel	<0.0001	**Ni**	0.0004	0.0006	0.0004	0.0006
Potassium	<0.01	**K**	0.0700	0.1200	0.0600	0.1300
Selenium	<0.001	**Se**				
Silver	<0.00001	**Ag**				
Strontium	<0.0001	**Sr**	0.0012	0.0008	0.0010	0.0008
Thallium	<0.00005	**Tl**				
Tin	<0.0005	**Sn**				
Uranium	<0.00001	**U**				
Vanadium	<0.001	**V**				
Zinc	<0.002	**Zn**	0.0100	0.0140	0.0100	0.0140
Carbon - Total	<0.5	**C**			2.6000	2.6000
Carbon - Total Inorganic	<0.5	**TIC**				
Carbon - Total Organic	<0.5	**TOC**			2.3000	2.2000

Table 2: Deposition - total and dissolved metals

			Total	Total	Dissolved	Dissolved
			Douglas Road	Hume Park	DouglasRoad	Hume Park
Sample Date (start)			2/28/97 16:00	2/28/97 16:00	2/28/97 16:00	2/28/97 16:00
Sample Date (stop)			3/1/97 2:56	3/1/97 3:23	3/1/97 2:56	3/1/97 3:23
No. Days			0.4556	0.4743	0.4556	0.4743
Sampler Area (m^2)			0.058	0.058	0.058	0.058
Rainfall (mm)			11.5	12.9	11.5	12.9
Spl Volume (L)			0.667	0.7482	0.667	0.7482
Units = $mg/m^2/day$	**Detection Limit**	**Symbol**				
Hydrogen Ion	NA	**H+**	0.0001	0.0001		
Ammonia Nitrogen		**NH_3-N**	11.0065	7.2701		
Nitrate Nitrogen		**NO_3-N**	11.6313	10.9961		
Nitrite Nitrogen	<0.001	**NO_2-N**	0.2524	0.2176		
Ortho-Phosphate:P	<0.001	**PO_4-P**	0.1262	ND		
Total Phosphate:P	<0.001	**T-P-Dis**	0.1515	ND		
Total Phosphate:P	<0.001	**T-P**	0.4039	0.3536		
Aluminum	<0.005	**Al**	0.9088	1.1423	0.2272	0.2720
Antimony	<0.00005	**Sb**	0.0053	0.0035	0.0048	0.0033
Arsenic	<0.0001	**As**	0.0076	0.0082	0.0050	0.0054
Barium		**Ba**	0.0624	0.0442	0.0520	0.0359
Beryllium	<0.0005	**Be**	ND	ND	ND	ND
Bismuth	<0.0005	**Bi**	ND	ND	ND	ND
Boron	<0.001	**B**	0.0252	0.0272	0.0252	0.0272
Cadmium	<0.00005	**Cd**	0.0015	0.0441	0.0015	0.0411
Calcium	<0.02	**Ca**	5.3012	3.2637	4.7963	3.2637
Chromium	<0.0005	**Cr**	ND	ND	ND	ND
Cobalt	<0.0001	**Co**	ND	0.0027	ND	ND
Copper	<0.0005	**Cu**	0.0606	0.0816	0.0479	0.0653
Lead		**Pb**	0.0471	0.0303	0.0262	0.0158
Lithium	<0.001	**Li**	ND	ND	ND	ND
Magnesium	<0.005	**Mg**	2.4234	2.0670	2.1962	1.8766
Manganese		**Mn**	0.0589	0.0740	0.0442	0.0503
Molybdenum	<0.00005	**Mo**	0.0015	ND	ND	ND
Nickel	<0.0001	**Ni**	0.0101	0.0163	0.0101	0.0163
Potassium	<0.01	**K**	1.7671	3.2637	1.5146	3.5357
Selenium	<0.001	**Se**	ND	ND	ND	ND
Silver	<0.00001	**Ag**	ND	ND	ND	ND
Strontium	<0.0001	**Sr**	0.0303	0.0218	0.0252	0.0218
Thallium	<0.00005	**Tl**	ND	ND	ND	ND
Tin	<0.0005	**Sn**	ND	ND	ND	ND
Uranium	<0.00001	**U**	ND	ND	ND	ND
Vanadium	<0.001	**V**	ND	ND	ND	ND
Zinc	<0.002	**Zn**	0.2524	0.3808	0.2524	0.3808
Carbon - Total	<0.5	**C**	ND	ND	65.6341	70.7139
Carbon - Total Inorganic	<0.5	**TIC**	ND	ND	ND	ND
Carbon - Total Organic	<0.5	**TOC**	ND	ND	58.0610	59.8348

Table 3: Percentage of Dissolved Metals

			% Dissolved Douglas Road	% Dissolved Hume Park
Sample Date (start)			2/28/97 4:00 PM	2/28/97 4:00 PM
Sample Date (stop)			3/1/97 2:56 AM	3/1/97 3:23 AM
No. Days			0.4556	0.4743
Sampler Area (m^2)			0.058	0.058
Rainfall (mm)			11.5	12.9
Spl Volume (L)			0.667	0.7482
Units = % except pH	**Detection Limit**	**Symbol**	**Diss ug**	**Diss ug**
Hydrogen Ion	NA	**H+**		
Ammonia Nitrogen		**NH_3-N**		
Nitrate Nitrogen		**NO_3-N**		
Nitrite Nitrogen	<0.001	**NO_2-N**		
Ortho-Phosphate:P	<0.001	**PO_4-P**		
Total Phosphate:P	<0.001	**T-P-Dis**		
Total Phosphate:P	<0.001	**T-P**		
Aluminum	<0.005	**Al**	25.00%	23.81%
Antimony	<0.00005	**Sb**	90.04%	92.31%
Arsenic	<0.0001	**As**	66.36%	66.67%
Barium		**Ba**	83.28%	81.15%
Beryllium	<0.0005	**Be**		
Bismuth	<0.0005	**Bi**		
Boron	<0.001	**B**	99.91%	100.00%
Cadmium	<0.00005	**Cd**	98.46%	93.21%
Calcium	<0.02	**Ca**	90.48%	100.00%
Chromium	<0.0005	**Cr**		
Cobalt	<0.0001	**Co**		0.00%
Copper	<0.0005	**Cu**	79.13%	80.00%
Lead		**Pb**	55.64%	52.10%
Lithium	<0.001	**Li**		
Magnesium	<0.005	**Mg**	90.62%	90.79%
Manganese		**Mn**	74.91%	68.02%
Molybdenum	<0.00005	**Mo**		
Nickel	<0.0001	**Ni**	99.77%	100.00%
Potassium	<0.01	**K**	85.71%	108.33%
Selenium	<0.001	**Se**		
Silver	<0.00001	**Ag**		
Strontium	<0.0001	**Sr**	83.26%	100.00%
Thallium	<0.00005	**Tl**		
Tin	<0.0005	**Sn**		
Uranium	<0.00001	**U**		
Vanadium	<0.001	**V**		
Zinc	<0.002	**Zn**	99.99%	100.00%
Carbon - Total	<0.5	**C**		
Carbon - Total Inorganic	<0.5	**TIC**		
Carbon - Total Organic	<0.5	**TOC**		

Table 4: PAHs Concentration - Douglas Road and Hume Park sites

Concentration in Rainfall
ug/l

	Douglas Road	**Hume Park**
Sample Date (start)	28-2-97 16:00	28-2-97 16:00
Sample Date (stop)	1-3-97 2:56	1-3-97 3:23
No. Days	0.4556	0.4743
Sampler Area (m2)	0.058	0.058
Rainfall (mm)	11.5	12.9
Spl Volume (L)	0.667	0.7482
Internal Standards		
2-Fluoro-9-fluorenone %	99	125
PCB 209 %	115	103
Tetrachloro-m-xylene %	101	90
Polycyclic Aromatic Hydrocarbons(ug)	**Douglas**	**Hume**
Naphthalene	**0.765**	**0.254**
Acenaphthylene	**0.075**	**0.027**
Acenaphthene	**0.060**	**0.040**
Fluorene	**0.105**	**0.053**
Phenanthrene	**0.285**	**0.134**
Anthracene	**0.045**	
Benzo(g,h,i)perylene	**0.090**	
Fluoranthene	**0.210**	**0.080**
Pyrene	**0.195**	**0.053**
Benzo(c)phenanthrene		
Benz(a)anthracene	**0.030**	**0.013**
Chrysene	**0.195**	**0.053**
Benzo(b+j)fluoranthene	**0.195**	**0.027**
Benzo(k)fluoranthene	**0.060**	
Benzo(a)pyrene	**0.060**	
Dibenz(a,h)anthracene		
Indeno(1,2,3-c,d)pyrene	**0.090**	

Table 5: PAHs Deposition - Douglas Road and Hume Park sites

Drainage Deposition	**Douglas Road**		**Hume Park**		**Hume Park**
Sample Date (start)	28-2-97 16:00	28-2-97 16:00	28-2-97 16:00	28-2-97 16:00	
Sample Date (stop)	3-1-97 2:56	3-1-97 2:56	3-1-97 3:23	3-1-97 3:23	
No. Days	0.46	0.46	0.47	0.47	
Drainage Area (km^2)	**21.56**	**21.56**	**69.35**	**69.35**	
Effective area	**21.56**	**21.56**	**47.79**	**47.79**	
Rainfall (mm)	11.5	11.5	12.9	12.9	
Spl Volume (L)	0.667	0.667	0.7482	0.7482	
		Measured		**Measured**	**Calculated**
	Site	**Area**	**Site**	**Area**	**Hume Total**
PAHs	**$kg/km^2/day$**	**kg/event**	**$kg/km^2/day$**	**kg/event**	**kg/event**
Naphthalene	0.0193	0.4161	0.0069	0.3301	0.7462
Acenaphthylene	0.0019	0.0408	0.0007	0.0347	0.0755
Acenaphthene	0.0015	0.0326	0.0011	0.0521	0.0848
Fluorene	0.0026	0.0571	0.0015	0.0695	0.1266
Phenanthrene	0.0072	0.1550	0.0036	0.1737	0.3288
Anthracene	0.0011	0.0245			0.0245
Benzo(g,h,i)perylene	0.0023	0.0490	0.0000	0.0000	0.0490
Fluoranthene	0.0053	0.1142	0.0022	0.1042	0.2185
Pyrene	0.0049	0.1061	0.0015	0.0695	0.1756
Benzo(c)phenanthrene					
Benz(a)anthracene	0.0008	0.0163	0.0004	0.0174	0.0337
Chrysene	0.0049	0.1061	0.0015	0.0695	0.1756
Benzo(b+j)fluoranthene	0.0049	0.1061	0.0007	0.0347	0.1408
Benzo(k)fluoranthene	0.0015	0.0326			0.0326
Benzo(a)pyrene	0.0015	0.0326			0.0326
Dibenz(a,h)anthracene					
Indeno(1,2,3-c,d)pyrene	0.0023	0.0490			0.0490

Table 6: Chlor Phenols Deposition - Douglas Road and Hume Park sites

	Douglas Road	**Hume Park**	**Matrix Spike %**	**Spike Level (in ug)**
Sample Date (start)	28-2-97 16:00	28-2-97 16:00		
Sample Date (stop)	1-3-97 2:56	1-3-97 3:23		
No. Days	0.4556	0.4743		
Sampler Area (m2)	0.058	0.058		
Rainfall (mm)	11.5	12.9		
Spl Volume (L)	0.667	0.7482		
Internal Standards				
2-Fluoro-9-fluorenone %	99	125	-	-
PCB 209 %	115	103	88	0.26
Tetrachloro-m-xylene %	101	90	40	0.8
Chlorinated Phenolics	**kg/km2/day**	**kg/km2/day**	%	ug
Pentachlorophenol	**0.0114**	ND	107	0.5

Figures

Figure 1: Sampling area

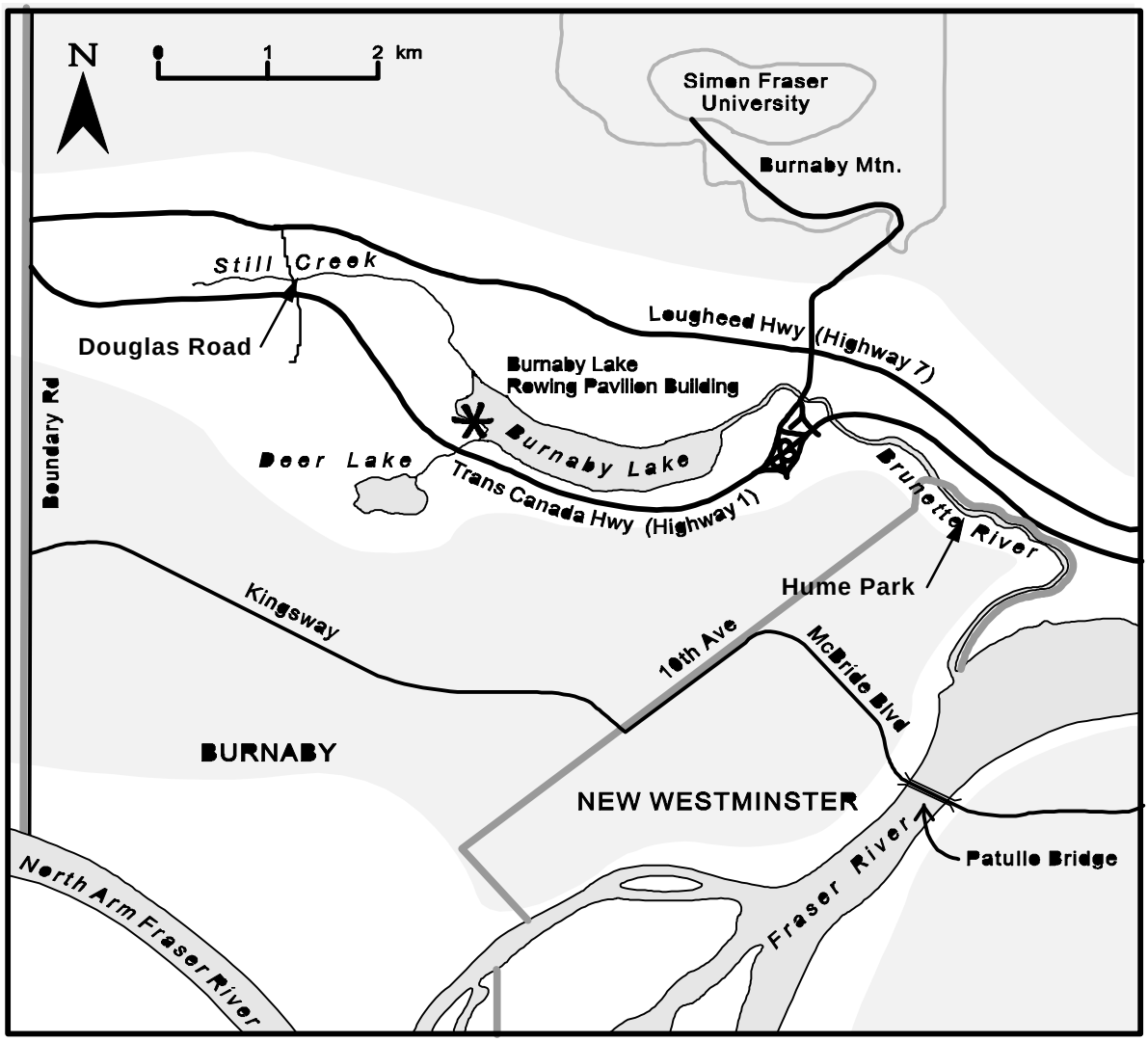

Figure 2: Concentration of Total Metals

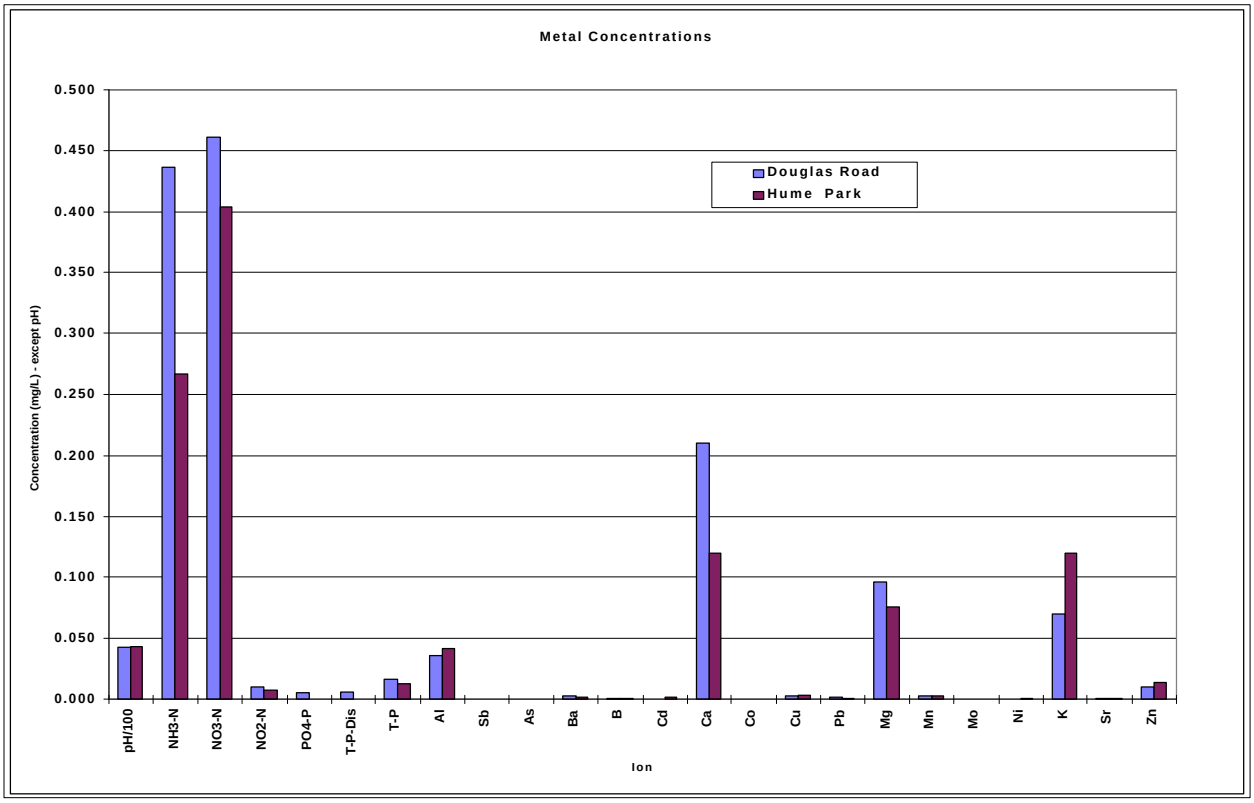

Figure 3: Deposition of Total Metals

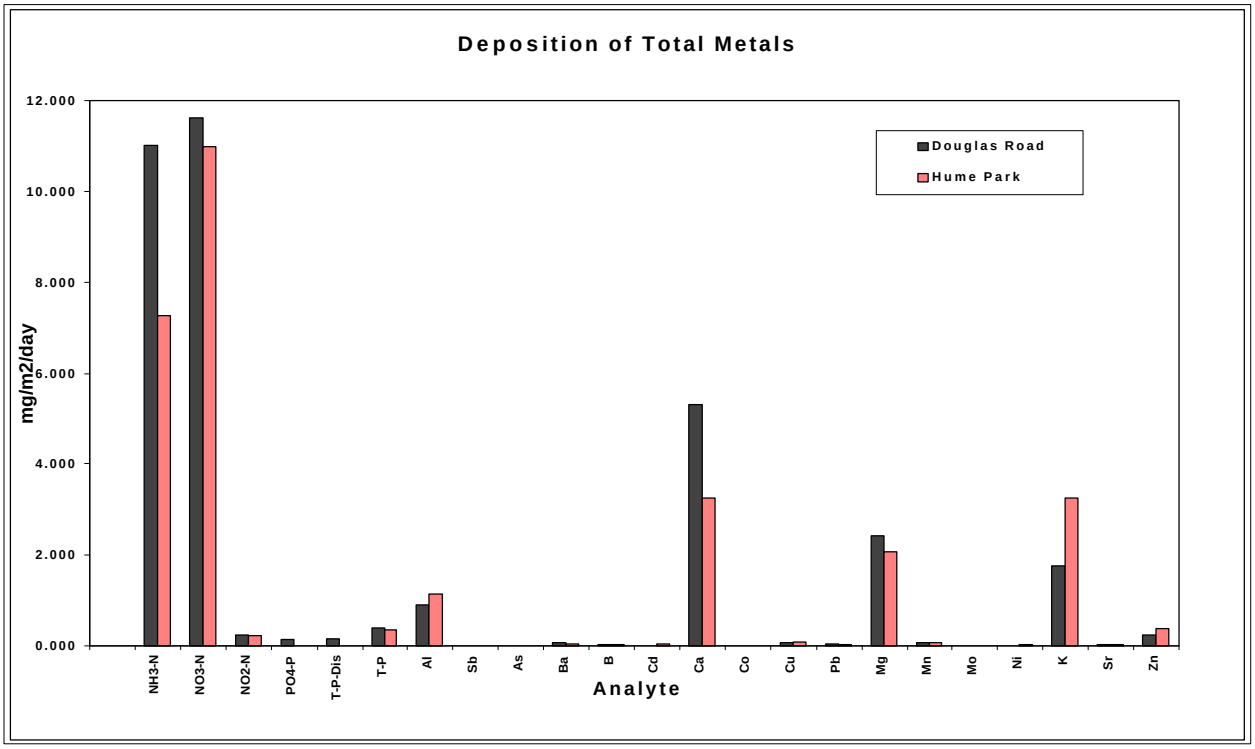

Figure 4: Concentration of Polycyclic Aromatic Hydrocarbons

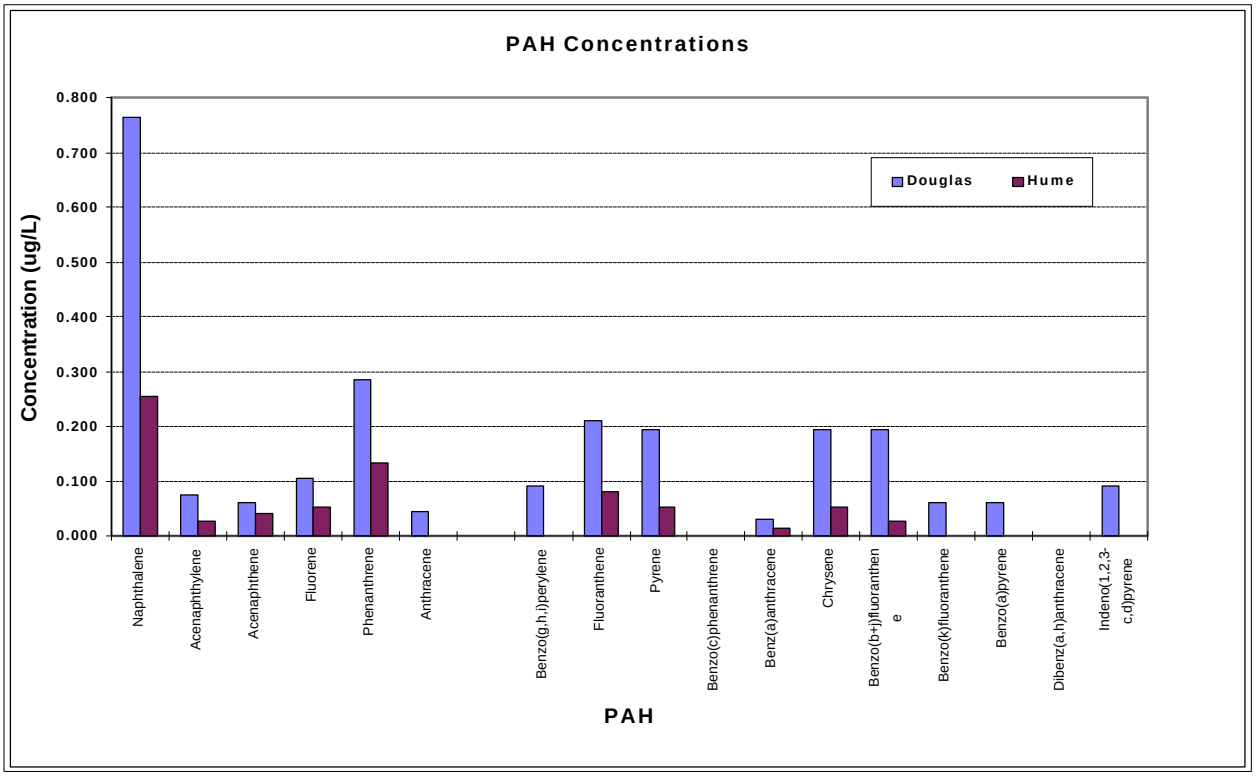

Figure 5: Deposition of Polycyclic Aromatic Hydrocarbons