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Environment Canada  
Environmental Protection Service  
Pacific Region  
Yukon Branch

A SEARCH FOR EPIDEMIOLOGICAL  
EFFECTS OF WOODSMOKE POLLUTION  
IN WHITEHORSE

by  
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Notice: The author's observations and conclusions are her own and do not necessarily reflect the views of the Environmental Protection Service, Environment Canada.

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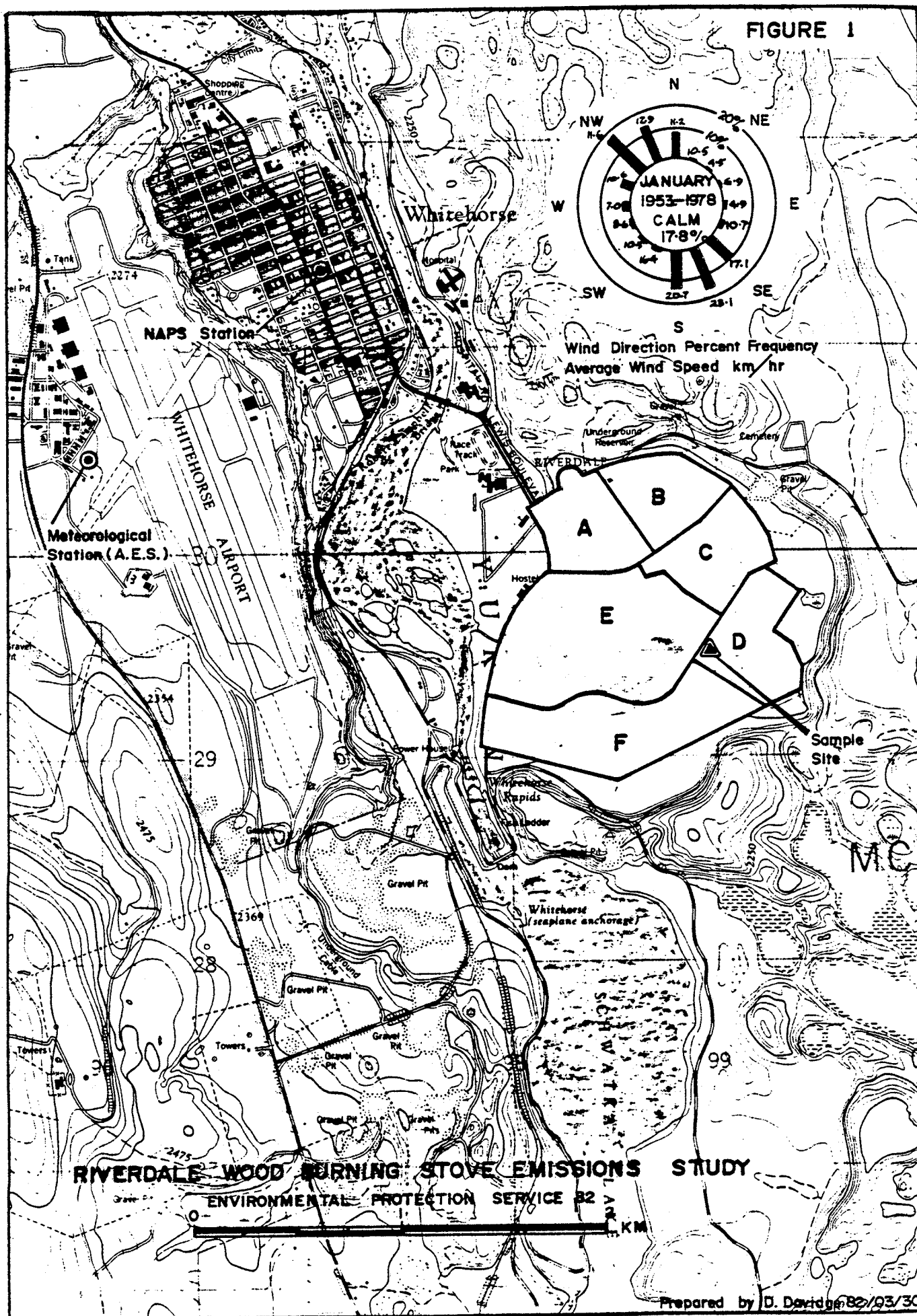
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## 1.0 INTRODUCTION

From 1981 to 1986 the Environmental Protection Service of Environment Canada has been studying the woodsmoke pollution problem in Riverdale, a suburb on the east side of Whitehorse (pop 17,250 in 1986) in south central Yukon. As shown in Figure I, Riverdale, with an estimated population between 3500 and 4000, is situated in a basin formed on three sides by steep forested slopes up to 30 meters high and by the Yukon river on the fourth side. The climate of Whitehorse, described as being continental subarctic, is effected by its nearness (150 km) to the Gulf of Alaska and by the area's mountainous terrain. The degree of air pollution in Riverdale is dependent on the topography and meteorological conditions of the area. The highest episodes of woodsmoke pollution tend to occur during periods of low wind speeds and air temperature inversions.

Increased use of wood stoves has resulted in a substantial increase in air pollution in the Whitehorse area as well as in communities such as Yakima, Washington; Albuquerque, New Mexico; Vail and Aspen, Colorado; Reno, Nevada; Missoula, Montana; Medford, Oregon and Juneau, Alaska. In several of these areas local governments have instituted public education programs along with voluntary and/or mandatory restrictions on wood burning in order to reduce wood smoke pollution.

In light of the recorded levels of particulate emissions in Riverdale during the past four winter seasons, the Environmental Protection Service wished to see if there were corresponding epidemiological effects. It chose to study the relationship between primary school absenteeism and woodsmoke pollution.



## 2.0 HISTORY OF WOODSMOKE POLLUTION MONITORING IN RIVERDALE

In 1981, after receiving complaints about woodsmoke pollution in the Riverdale area of Whitehorse, the Environmental Protection Service (EPS) installed two high volume air samplers at different Riverdale sites to determine the total suspended particulate (TSP) in the ambient air. At the two sites air samples were taken simultaneously for 24 hour periods every four days. The study was repeated in 1981 and 1982 on a three day cycle. Results showed strong pollution episodes could occur (McCandless, 1982).

In November 1982 a small mobile laboratory was established at Grey Mountain School, (Site I). In order to measure the following woodsmoke pollution parameters:

- Total suspended particulate (TSP)
- Fine respirable particulate
- Carbon monoxide
- Polycyclic aromatic hydrocarbons (PAHs) in the gaseous phase
- Meteorological conditions

At the same time high volume sampler sites were established at two other Riverdale locations as noted in Figure II. The results of this research were reported in 1984 by R. McCandless in his paper "Impact of Residential Wood Combustion on Measured Particulate and PAH Concentrations in Whitehorse, Y.T." in conjunction with the report "Pollution From Woodstoves in Riverdale Yukon Territory" written by Senes Consultants who derived the following equations for the relationship between mean wind speeds at the Whitehorse airport and TSP, for the three high volume sampling sites in Riverdale.

Site I,

$$\text{TSP} = 155 e^{-0.095\bar{u}} \quad -r = -0.785$$

Site II,

$$\text{TSP} = 196 e^{-0.081\bar{u}} \quad -r = -0.866$$

Site III,

$$\text{TSP} = 246 e^{-0.081\bar{u}} \quad -r = -0.76$$

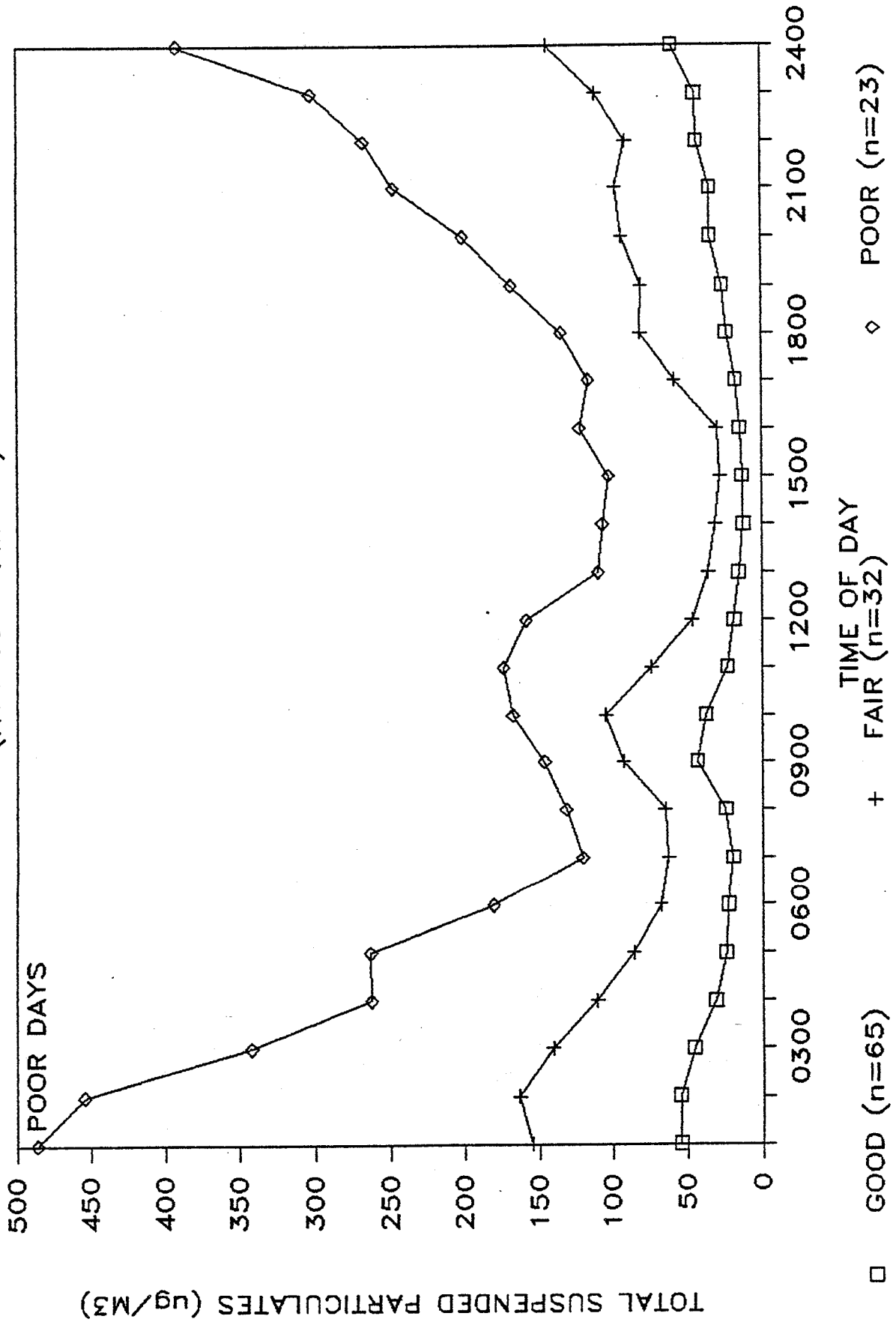
where  $\bar{u}$  = Whitehorse mean wind speed (24 hour average) and  $-r$  = correlation coefficient

The next year between December 1983 and March 1984, a high volume sampler was located only at site III, the Sternwheeler Village area in Riverdale. On any given day during the previous winter season, this Site III had consistently recorded the highest TSP levels of the three sampling stations. During the winter of 1983-84 TSP samples were taken every three days.

In November 1984, a high volume sampler and an integrating nephelometer with data logger and modem was installed at the Grey Mountain site. A nephelometer records the degree of scattering of light in air which is in direct proportion to the total suspended particulate in air. This combination of instruments allowed the TSP at Grey Mountain School to be obtained on an hourly basis as well as over 24 hour periods. Graph I shows an example of this. Because of the installation of this equipment in 1984 the public has been able to obtain information on the levels of woodsmoke pollution in Riverdale through periodic daily radio announcements and a direct telephone hook-up to the woodsmoke pollution report.

In the fall of 1985, the high volume sampler and nephelometer - computer combination were again installed at the Grey Mountain School for use during the 1985-86 winter wood burning season. A summary of the total suspended particulate over the four winter seasons is shown on Table I.

Graph 1  
MEAN HOURLY T.S.P. VALUES  
(NOV 85 - FEB 86)





In conjunction with the research done in Riverdale over the past four years, three surveys dealing with the woodsmoke pollution problem have been made. The results are based on the wood stove usage of Riverdale single and multiple residences only. For the purposes of the 1982 and 1983 surveys, a wood burning home was defined as one using at least one cord of wood per year.

The initial survey by the Environmental Protection Service (EPS), Environment Canada and the federal departments of Indian and Northern Affairs (DIAND), and Energy, Mines and Resources (EMR) was reported in 1982. It was based on the 334 Riverdale residents who returned a mailed questionnaire concerning wood stove usage in Riverdale.

In 1983 EPS and EMR conducted a more detailed survey based on 1211 Riverdale homes, using both visual observation of wood piles in front of homes and interviews of wood stove users. A detailed study of the results of these two surveys is to be found in the unpublished report "Wood Burning Survey Results for the Riverdale Subdivision of Whitehorse, Yukon 1982 and 1983" by M.R. Orecklin and R. McCandless.

In the fall of 1985, a telephone survey concerning the woodsmoke pollution problem was conducted by the Bureau of Statistics of the Territorial Government in conjunction with the City of Whitehorse Board of Health and the Energy Branch of the Government of Yukon. In the Riverdale area 97 residents with wood burning homes were interviewed.

A comparison of the results of all three surveys is shown on Table II.

TABLE I  
WHITEHORSE 24 HOUR  
TOTAL SUSPENDED PARTICULATE MATTER IN  $\mu\text{g}/\text{m}^3$

Period, Place	Samples	Minimum	Maximum	Mean	Standard Deviation
Whitehorse Fed. Bldg. Winter 80-83	45	6	157	28	27
Whitehorse Riverdale Jan.-Feb.81	26	7	72	23	17
Nov.81-Feb.82	36	9	222	70	53
Nov.82-Mar.83					
Site I	49	2	370	73	83
Site II	22	1	433	97	113
Site III	34	14	589	130	146
Dec.83-Feb.84					
Site III	19	19	553	138	144
Nov.84-Mar.85					
Site I*	151	2	270	59	53
Nov.85-Feb.86					
Site I*	120	1	485	81	85

\* TSP values obtained from nephelometer as well as high volume sampler.

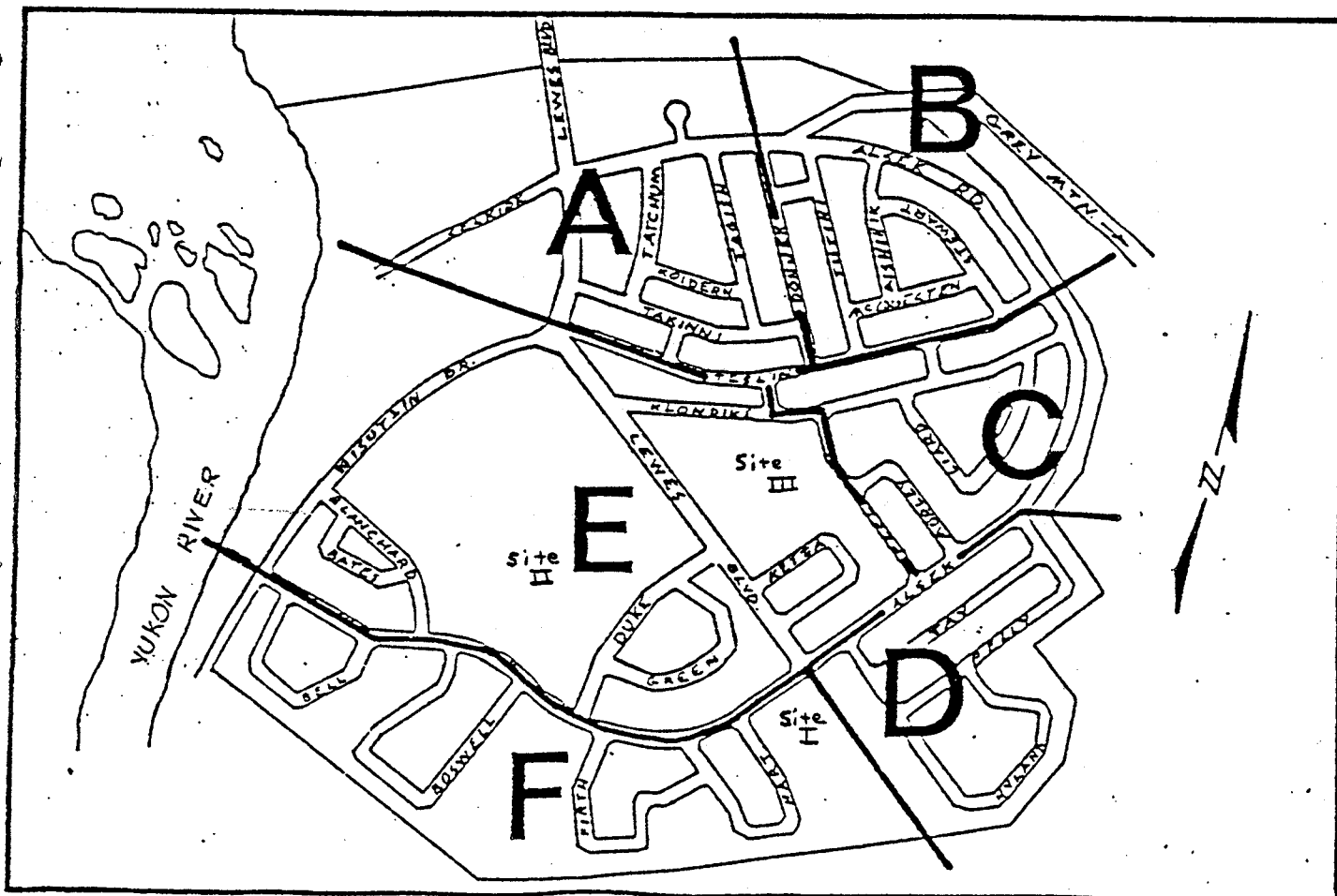
TABLE II

% Wood Users in Riverdale

Location	% Wood Users in Riverdale		
	1982	1983	1985
Zone A	40.4	29.9	
B	49.0	50.6	
C	47.5	58.7	
D	82.4	80.7	
E	57.4	59.5	
F	84.5	73.0	
C,D,E,F*	68.0	68.0	
Riverdale as a whole	62.0	59.4	45

\*Most of children attending Grey Mountain School live in the area composed of Zone C,D,E & F.

Figure II  
Location of Zones in Riverdale



### 3.0 RATIONALE FOR PRESENT STUDY

Research has shown that there is a direct correlation between negative human health effects and the presence of particulate matter including polycyclic aromatic hydrocarbons obtained from the burning of wood. PAHs are of concern because of their potential for adverse biological effects including the transformation of some of these substances to mutagens and carcinogens by mammalian microsomal enzyme systems. In a 1982 report on woodsmoke pollution in Whitehorse, it was found that the cancer agent benzo(a)pyrene as well as other PAHs were present. Since PAHs are absorbed on airborne particulate matter, their potential carcinogenic effect on human health depends largely on particulate size.<sup>9</sup> Particulate smaller than 7 $\mu$ m in diameter can be transported through the upper respiratory tract into the bronchioles and alveoli of the lungs.

Within the past eight years several epidemiological studies have been made relating woodsmoke pollution to the health of children and adults with chronic obstructive pulmonary diseases (COPD) such as emphysema, bronchitis and asthma. It was thought that the growing lungs of a child should be more sensitive to insult than the adult lungs. Therefore, children should be more susceptible to adverse air quality.

During 1978-1979 school children and adults in Missoula, Montana, population 62,000, were observed and tested.<sup>8</sup> Missoula is situated in an area surrounded by the Rocky Mountains, which help to cause frequent temperature inversions in the city. During 1978 the annual geometric mean for total suspended particulate (TSP) in Missoula was 81  $\mu$ g/m<sup>3</sup>. Missoula school children consistently exhibited worse

pulmonary function and lower measurements of medium and small air resistance than those from nearby areas of lower TSP emission. Also, the pulmonary function of adults with COPD decreased as the TSP increased.

A Michigan study suggested that preschool children who live in homes heated by a wood burning stove are more likely to develop symptoms of respiratory tract illness than children of similar ages and socio economic status who do not live in wood heated homes.<sup>7</sup> During the winter months, a statistically significant number of children living in homes heated by wood burning stoves did develop severe symptoms of respiratory illness which are associated with persistent air way irritation.

The results of the Missoula and Michigan studies suggest that increased TSP does cause measurable health effects upon the human pulmonary system, and in particular to the small air ways of the respiratory tract. Woodsmoke pollution most likely causes reactive air way responses in small or medium bronchi as well as edema, increased mucus secretion, more viscous mucus and inflammation or constriction of the smooth bronchial muscles. The authors of these studies believe that these changes are reversible and short term for the majority of individuals, and may not lead to significant permanent lung damage. However, the long term effects are not known especially concerning the growing lungs of children.

In these epidemiological studies it should be noted how strongly the effects of covariables can affect the results. In 1978 a study in Hamilton, Ontario examined the relationship between air quality and respiratory health.<sup>13</sup> It postulated that long term exposure to lower levels of ambient air pollution may be responsible for subtle changes in chronic lung diseases.

This study showed that in many cases the effects of confounding variables had been underestimated in epidemiological studies of air pollution. Covariables such as parental or sibling smoking in the home, parental coughing or other respiratory illness, method of heating in the house, number of people in the house, and in individual bedrooms as well as the socio economic level of those studied all affect respiratory health. These factors may confound or mask a potential relationship between health and air pollution.

The above noted studies plus the fact that there has been an increasing number of complaints from residents of Riverdale concerning health problems in connection with woodsmoke pollution resulted in the present study to see if there were a measurable health related effect. As an initial epidemiological approach, the study of absenteeism in a Riverdale primary school was used because the school attendance records and pollution data for the past four years were readily available. Consequently the necessary funding for the study could be kept to a minimum.

#### 4.0 METHODOLOGY

In November 1985, EPS investigated a potential correlation between woodsmoke pollution and absenteeism at Grey Mountain Primary School (Site I) in Riverdale.

The daily absenteeism and attendance records from four grades (K-3) for the years 1982-85 were obtained from Grey Mountain School as well as from Selkirk, Takhini and Jack Hulland Primary Schools in the Whitehorse area. Initially it was hoped that these other schools could be used in the study in order to determine background levels for absenteeism rates. However, this approach was discarded since there was a minimum amount of time available for the study as a whole.

Woodsmoke pollution expressed as total suspended particulate (TSP) was entered on a daily basis during the winter months of the 1982-85 periods at the Grey Mountain school. This data was obtained as follows:

For the initial approach, the four school years of 1982 to 1985 were chosen for observation because they had the most complete records of total suspended particulate. In the winter months of 1982-83 when daily TSP was not obtained from the high volume sampler, the TSP was calculated using the expression for wind derived in the earlier meteorological study by Senes.<sup>14</sup> During the 1984-85 seasons TSP was obtained from the high volume sampler and the nephelometer.

## 5.0 RESULTS AND DISCUSSION

The results of this study are shown on Table III and Graph II. In all four years there was an increase in school absenteeism during days of TSP>100 as compared to non TSP days. Though the difference is definite, it is still slight. A similar comparison between TSP and absenteeism at another Whitehorse primary school with a corresponding enrollment to that at Grey Mountain but in an area of lower wood smoke pollution would clarify these present inconclusive results.

As noted in the Hamilton study earlier in this report epidemiological effects of air pollution can be affected by the presence of confounding variables. Any potential relationship between school absenteeism and wood smoke pollution may have been masked by the following:

- Most of the children attending Grey Mountain Primary School live within an eight block radius and consequently walk to school.
- As noted in Graph I, the worst periods of wood smoke pollution in Riverdale occur between the hours of 2200 and 0400 when children are indoors.
- The children come from a socio-economic background which can provide warm winter clothes and good health care.
- The attendance in the school seems to be one of the highest in Whitehorse.

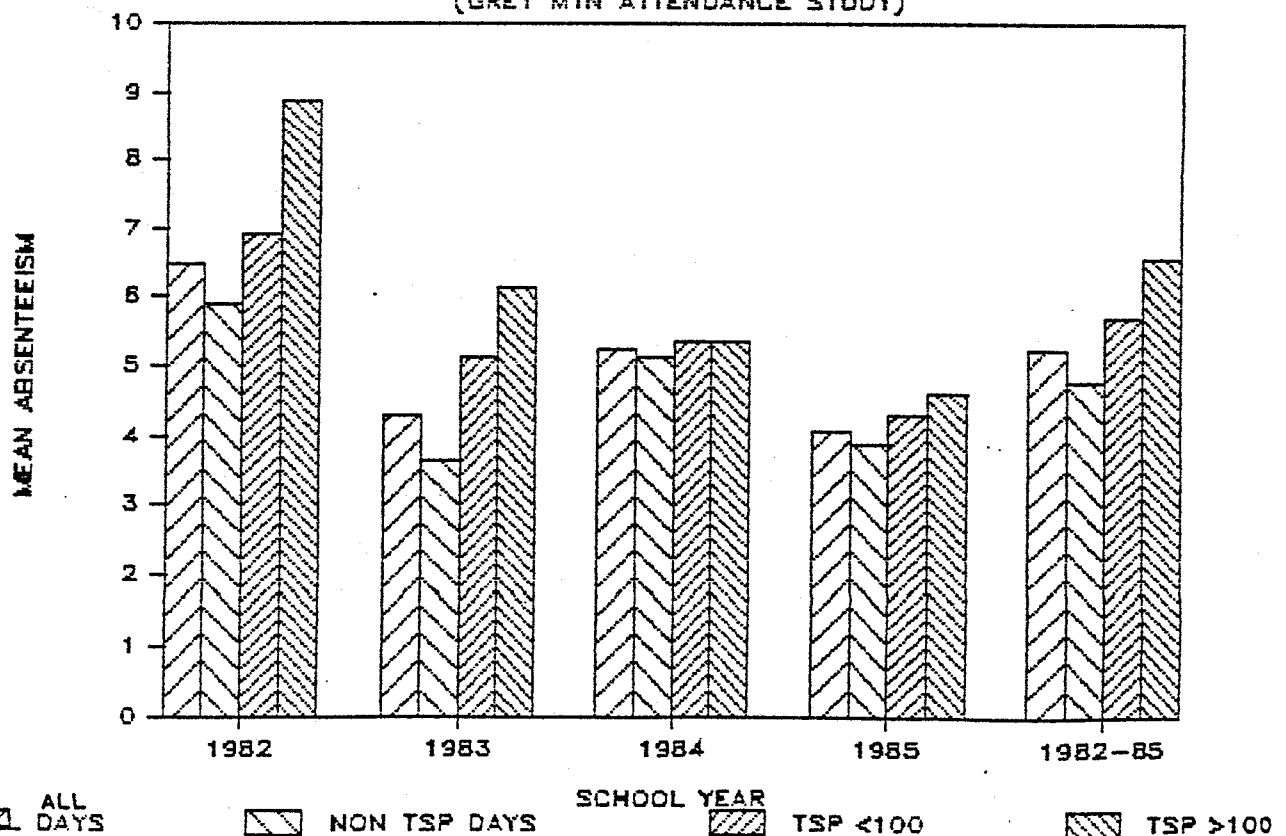


TABLE III

DESCRIPTIVE STATISTICS - GREY MTN ATTENDANCE STUDY		SCHOOL YEAR				
CRITERIA		1982	1983	1984	1985	1982-85
ALL DAYS	n	189	185	187	60	621
	MEAN	6.48	4.31	5.22	4.06	5.22
	S.D.	4.58	2.64	2.82	2.33	3.49
NON TSP DAYS	n	120	122	99	41	382
	MEAN	5.88	3.66	5.11	3.88	4.76
	S.D.	4.51	2.68	2.74	2.60	3.49
TSP <100	n	48	35	75	10	169
	MEAN	6.92	5.10	5.34	4.30	5.70
	S.D.	3.81	1.58	2.64	1.70	2.92
TSP >100	n	20	28	13	9	70
	MEAN	8.88	6.11	5.35	4.61	6.56
	S.D.	5.93	2.46	4.34	1.47	4.24

GRAPH II

# SCHOOL ABSENTEEISM (GREY MTN ATTENDANCE STUDY)



## 5.0 RESULTS AND DISCUSSION (cont)

Another approach in studying the wood smoke pollution problem in Riverdale would be to observe the health of those residents with allergies or chronic pulmonary disease. These individuals could keep a daily medical diary throughout the wood burning season over several years. Also they could be given specific tests on lung capacity on a regular basis.

Although the results of the Riverdale school absenteeism study are not conclusive at this point, the research mentioned earlier in this report along with the extensive monitoring of wood smoke pollution done by EPS over the past 5 years suggests that if wood is to fulfill its promise as a rational energy source, an effort should be made to reduce its negative impact on health.

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