AN EVALUATION OF AIR POLLUTION LEVELS IN SYDNEY, NOVA SCOTIA.

APCD 70 - 1

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ABSTRACT

Air pollution levels for the period 1965 to 1970 are presented for Sydney, Nova Scotia. These data indicate that the levels are high even for a "steel city" and that there has been an overall increase during the five year period. Air pollution has been shown to be directly related to the steel production in the city. A comparison of air pollution in Sydney, Nova Scotia, and Hamilton, Ontario, has been made. The major source of air pollution is the large iron and steel complex of the Sydney Steel Corporation. A secondary source is the bituminous coal-fired heating plants. The lack of any air pollution control programme in Sydney is producing a general deterioration of the quality of the ambient air.

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INTRODUCTION

The City of Sydney, Nova Scotia, is located on the northern extremity in the eastern part of Cape Breton Island. In 1966, Sydney had a population of 32,767(1). The city is surrounded by relatively flat terrain in the southwest, west and northwest and in the northeast by a wide shallow valley opening into a gently sloping plain on which Sydney Airport is located(2).

The principal industry in the city is a large iron and steel manufacturing complex consisting of coke ovens, two blast furnaces, 5 open hearth furnaces, a sintering plant and associated process operations. In December, 1967, Sydney Steel Corporation (a Crown Corporation of the Nova Scotia Government) was formed. Since that time new production records have been set and the plant's financial picture has improved considerably(3). In 1969 more than 1,000,000 ingot tons of steel were produced(4).

The air pollution problem in Sydney, Nova Scotia, has been previously assessed by this department. Katz (1958) reports on the period February to November 1958. Katz and McKay (1959) report on the period February to September 1959. Katz, Sanderson and McKay (1965) report on the period 1959 to 1965. This study which has been requested by the Nova Scotia Department of Health covers the period 1965 to 1970.

AIR SAMPLING NETWORK

In early 1958 dustfall receptacles were installed at 12 sampling sites. This was the start of the air pollution study. In 1959, 4 A.I.S.I. Tape Samplers were added to the network. In 1961, 11 lead peroxide candle instruments were also added.

In the period 1965 to 1970 the air sampling network in Sydney consisted of the following sampling stations: (see Fig.1)

Station Number	Location	Dustfall	Sulphation	COHS
1	Don Bosco School	X [1]	X [1]	X [2]
2	Whitney School	X		
3	Rudderham's & Victoria	X [1]		
4	Broadway & Victoria	X [1]		
5	General Office	X	X	
6	Constantine School	X	X	
7	Church & Lingan	X		
8	Ashby School	X [1]	X [1]	
9	City Hospital	X	X	
10	Radar Station	X	X	
11	McArthur's Centre	X		
12	Murphy Road	X		
13	Riverview H.S.	X	X	X [1]
14	Provincial Building		X	X [1]
15	Eastmount			X

Note: 1. Discontinued June 1968.

2. Discontinued May 1969.

In June 1968 the air pollution survey was reduced by 4 dustfall stations, 2 lead peroxide candles and 2 tape samplers. This was done to ease the work load of Mr. J. MacArthur. In May 1969 because of difficulties with the instruments the survey was reduced to one A.I.S.I. tape sampler.

SAMPLING PROCEDURES

The Sydney air pollution survey is operated by Mr. J. MacArthur of the Nova Scotia Department of Public Health. The equipment used for this survey was supplied by the Department of National Health and Welfare who also provided advice and technical assistance as required.

The container used for dustfall is a nalgene decanter of polyethylene, 4 inches in diameter at the open end, and 8.5 inches in height. The sampling period is approximately 30 days. Each sample is analyzed for water-soluble and insoluble matter, ash, combustible matter and iron content in ash. Results are expressed in units of tons per square mile per month. Analysis is performed by personnel of the Nova Scotia Department of Public Health in Halifax.

Lead peroxide candle instruments are used to measure the sulphation rate. The "candles" are exposed for 30 day periods and are analyzed for sulphate by the barium sulphate method. Results are expressed as milligrams of SO_3 per 100 cm^2 per day. This analysis is performed by the Nova Scotia Department of Public Health in Halifax.

A.I.S.I. Tape Samplers are used to measure the soiling index. A measured volume of air is continuously drawn through a circular area on a paper filter tape producing a stain or spot as a result of the deposited particulate matter. Mr. J. MacArthur has been supplied with an A.I.S.I. spot evaluator. He "reads" the tapes in Sydney and forwards the results to Ottawa for evaluation. The soiling index is expressed as the number of COH units per 1000 linear feet of air drawn through the filter.

RESULTS

Dustfall

The dustfall rates for the period 1965 to 1970 are compared to the rates for the 1959-65 period (Fig.2). The average dustfall rate for the 1965-70 period was 58.6 tons/square mile/month, an increase of 8.2 tons/square mile/month (16.3%) from the 1959-65 period. Figure 2 also compares the average monthly amount of iron in total solids for the two periods (i.e. 1959-65 and 1965-70). The amount of iron increased to 11.4 tons/square mile/month in 1965-70, an increase of 2.7 tons/square mile/month (31%).

Figure 3 shows the distribution of dustfall and iron with distance from the site of the Sydney Steel Mill. Don Bosco School (Station 1), Whitney School (Station 2) and Rudderham's and Victoria (Station 3) show very high dustfall values (an average of 161 tons/square mile/month). These three stations are approximately ½ mile from the steel mill. The next seven stations (Stations 4-10) have medium dustfall values (an average of 41.6 tons/square mile/month). All of these stations are between ½ and 2 miles from the site of the steel mill. MacArthur's Centre (Station 11), Murphy Road (Station 12) and Riverview High School (Station 13) have lower values of dustfall (an average of 19.4 tons/square mile/month). These stations are between 2 and 4 miles from the site of the steel mill. This figure illustrates that the dustfall rates decrease as the distance from the steel mill increases. As expected, the iron content

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of total ash is the highest at the stations nearest the steel mill and lowest at the stations farthest from the steel mill.

Figure 4 compares the average dustfall rates for Whitney School (Station 2 - a high pollution station), General Office (Station 5 - a medium pollution station) and Murphy Road (Station 12 - a low pollution station) for the period 1965-70. The averages are calculated for two periods per year, i.e. May-September (the non-heating season) and October-April (the heating season). It can be seen that the seasonal fluctuations are not noticeable for Whitney School and are only minor for the other two stations. The peaks are for the non-heating season. This indicates that during the May-September period there is an increase in dustfall (probably due to the dust arising from open fields and garden plots).

At Whitney School there is a slight decrease in average dustfall from October-April 66/67 to May-September 68. This parallels the reduced productivity at the steel mill during the same period. The average total dustfall increases in the period May-September 68 to October-April 69/70. This time the increase in total dustfall parallels a significant increase of productivity at the steel mill during the same period.

Although Murphy Road station is approximately 2 miles from the steel mill it appears to be in the area of influence of the mill, i.e. an average dustfall of 19.8 tons/square mile/month is too high for background dustfall.

The highest total dustfall recorded was at Whitney School (Station 2) where the reading was 521.3 tons/square mile/month for January 1970.

Sulphation

Figure 5 compares the average sulphation rates for three stations viz Constantine School (Station 6), Provincial Building (Station 14) and Riverview (Station 13) for the periods 1962-65 and 1965-70(1). For each year a non-heating season (May-September) and a

Note (1) Sulphation rates given in the report by Sanderson, Katz and McKay(1965) were too high by 30.6%. This is due to an error in calculation which was recently discovered. Values given in Figure 5 have been corrected by 30.6%.

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heating season (October-April) was chosen. The values for the non-heating season are plotted at July and the values for the heating season are plotted at January.

The effect of coal-fired heating plants is clearly shown. There is a peak in the sulphation rate for each heating season. This indicates that the high sulphation rate in Sydney is due in part to the processes at the steel mill and in part to the coal-fired heating plants. At Constantine School (Station 6), the average sulphation rate for the eight non-heating seasons is 1.7 mg SO_3/100 cm^2/day whereas the average rate for the eight heating seasons is 3.9 mg SO_3/100 cm^2/day. This shows a 71% increase in the sulphation rate during the heating season.

Figure 5 also indicates that the sulphation rates are highest (average 2.8) at Constantine School (Station 6) and lowest (average .3) at Riverview (Station 13) for the period 1962-70.

The low rate at Riverview (Station 13) can be explained by the fact that this station is in a rural area and approximately 3.5 miles from the steel mill. To explain the higher sulphation rates at Constantine School (Station 6) than at the Provincial Building (Station 14) the following is suggested:

1. Constantine School is closer to the site of the coke ovens than is the Provincial Building.
2. Constantine School being south of the coke ovens receives more of the effect of the coke ovens than does the Provincial Building (which is in a SSW direction from the coke ovens).

The highest sulphation rate recorded was at Constantine School. This was 7.3 mg SO_3/100 cm^2/day obtained during December 1967.

Soiling Index

Figure 6 compares the average monthly soiling indices during seven months of 1968 with the average monthly soiling indices during 1969 at Eastmount (Station 15). The average COH value during the last

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seven months of 1969 shows an increase of 21% over the average COH value during the same period in 1968.

The higher COH values during October-April are due to the effect of the coal-fired heating plants operating during this period. Part of this increase may also result from the increased productivity of the steel mill during this period as compared to the May-September period (Figure 11). The lower COH values during June-September may also be explained by the fact that the winds during this period shift from a west to a south and southwest direction[5]. This shift reduces the amount of particulates carried from the steel mill to the Eastmount Station (which is west of the steel mill).

Figure 7 compares the soiling index at Eastmount (Station 15) with that at Don Bosco School (Station 1). The average COH value at Eastmount is 1.22 COH units/1,000 linear feet of air whereas at Don Bosco School it is .26 COH units/1,000 linear feet of air. The decrease of soiling index at Eastmount and the increase of soiling index at Don Bosco School during the summer months is shown. These changes are due to the shift of wind direction from west to south and southwest during the summer months.

The higher COH values at Eastmount are due to the station being far enough away from the steel mill to receive a high proportion of the suspended particulates. Don Bosco School, on the other hand, being closer to the steel mill probably does not receive as many suspended particulates because of an "umbrella effect". The suspended particulates leaving the stacks at the steel mill may not have come down to sampling level when the plume has reached Don Bosco School. However, Eastmount being further away could receive these suspended particulates since they have had time to descend to ground level. This explanation would have to be verified.

Wind Roses

Figures 8 and 9 show the wind roses for the Sydney Airport for the period 1965-70. The major wind directions are from the south,

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southwest, west and north. In the period October-April, 73% of the time the winds are from these directions (south: 17.8%, southwest: 20.0%, west: 17.4% and north: 17.8%). In the period May-September 80.5% of the winds are from these four directions (south: 25.6%, southwest: 30.3%, west: 9.8%, and north: 14.8%).

The above figures show the wind direction shift from the west to south and southwest during May-September. As explained previously, this accounts for the decrease in the soiling index at Eastmount (Station 15) and increase in the soiling index at Don Bosco School (Station 1).

Steel Production

Production figures for Sydney Steel Corporation are shown in Figure 10. Although production of steel, iron, sinter, and coke are given, steel production is the most important because all of the other products are a function of the steel production. Production at Sydney Steel Corporation decreased substantially during 1966-67. In 1968 the steel production began to increase and has been increasing since that time. Production of iron and coke has increased accordingly. The sinter production has been fairly constant with a substantial decrease during October-April (69/70) period. The reasons for this decrease are not known.

An attempt has been made to correlate steel production at Sydney Steel to total dustfall in Sydney (Figure 11). The steel production shows a decrease from October 1966 to September 1967 but a substantial increase during 1968, 1969 and 1970. The total dustfall is relatively constant but shows a sharp increase for the period October-April (69/70). Average steel production is 68.9 thousand tons per month. The increase in the period October-April (69/70) is 18.2 thousand tons per month (26%). Average dustfall is 58.6 tons/square mile/month. The increase in the period October-April (69/70) is 20.2 tons/square mile/month (35%).

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Sydney, N.S. Compared With Hamilton, Ont.

For comparison purposes Sydney, Nova Scotia and Hamilton, Ontario, were chosen since both cities are "steel cities". Total dustfall and sulphation rates are compared.

The average dustfall rates for Sydney during 1968 and 1969 are 50.0 and 63.0 tons/square mile/month respectively. For Hamilton, the average dustfall is 37.1 and 32.8 tons/square mile/month for 1968 and 1969 respectively. In Sydney, the average sulphation rate for 1968 is .96 mg SO_3/100 cm^2/day and for 1969 it is 1.34 mg SO_3/100 cm^2/day. In Hamilton, the average sulphation rates for 1968 and 1969 are .98 and .96 mg SO_3/100 cm^2/day respectively.

Before any conclusions can be drawn from the above comparisons the following should be noted:

1. General sampling procedures differ from one city to another (e.g. number and location of stations, instruments used, analytical procedures, etc.).
2. Results obtained are affected by local climatic conditions (e.g. winds, precipitation, humidity, etc).

For these reasons, the rate of change in air pollution levels for both cities from 1968 to 1969 is more relevant than the absolute values in any one year.

Figure 12 indicates the rate of total dustfall in Sydney for 1968 and 1969. The average for each year is given and the increase in total dustfall during 1969 (from the 1968 values) is 13 tons/square mile/month (26%). This can be compared to the total dustfall for the same two years in Hamilton (Figure 13). In Hamilton, the total dustfall during 1969 decreased from the 1968 value by 4.3 tons/square mile/month (11.6%).

Sulphation rates for Sydney are shown in Figure 14 and for Hamilton in Figure 15. In Sydney, the average sulphation rate during 1969 increased from the 1968 rate by .37 mg SO_3/100 cm^2/day (36%). In Hamilton, the average sulphation rate during 1969 decreased from the 1968

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rate by .02 mg SO_3/100 cm^2/day (2.0%).

DISCUSSION

Estimated Emissions from Sydney Steel[6]

1. Blast Furances

Based on the production figures (Fig.10) the dust emitted by the two blast furnaces would be in the range of 8.5 to 24.0 tons per day. With high efficiency air pollution control equipment such as electrostatic precipitators this could be cut down to 1 or 2 tons per day.

2. Open Hearths

With oxygen lancing, 6.8 lbs. of dust are produced per ton of finished steel. Using the Sydney Steel production figures the range of dust emitted would be 3.4 to 10.2 tons per day.

3. Sinter Plant

Approximately 20 lbs. of dust are produced for every ton of sinter. At Sydney Steel, dust emitted by the sinter plant would be in the range of 1 to 8 tons per day.

Dust emitted from the coke ovens and the boiler plant can also be sizeable. The actual amount of dust from the coke ovens is difficult to calculate. The amount is dependent on various factors, e.g. leaks, method of quenching, etc. The amount of dust from the boiler plant can be calculated at the rate of 25 lbs. per ton of coal burned.[7]

Residential coal-fired heating plants

The effects of the residential coal-fired heating plants are difficult to estimate. Particulate emissions from iron and steel mill operations are sizeable in comparison with other sources of particulate pollutants, e.g. emissions from 13 open hearth furnaces without air pollution control equipment are equivalent to particulate emissions from about 35,000 coal-fired home heating plants.[6] The five open-hearth furnaces at Sydney can be equated to 13,500 coal-fired home heating

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plants. It is estimated that approximately 25% of the houses in Sydney use coal-fired home heating plants. This would give approximately 2,000 units. Another 2,000 equivalent can be added to account for schools, hospitals, etc.

The above would indicate that the contribution of particulates from the residential units is about one quarter of the contribution of the open hearths. However, the height of the emissions must be taken into account. With equal emissions and wind velocities, for a 10 meter height of emission the ground level concentration is 10 times the ground level concentration for a 30 meter emission height[8]. Considered from this aspect, the effect during the heating season of the residential coal-fired heating plant is significant.

There is also an increase in the sulphation rate during the heating season (October-April). This increase is in part due to the coal-fired heating plants. It is suggested that the increased production at Sydney Steel during October, November and December of 1968 and 1969 is responsible for an increase in the sulphation rate during that period. This is borne out by the greater fluctuations in the sulphation rate during the heating seasons of 1968 and 1969 as compared with the lower fluctuations during previous periods (Fig.5).

Criteria for Desirable Pollution Levels

It is of interest to the general public to know "how bad" their air pollution really is. This can sometimes be difficult to establish because of the varying values given in the literature for a desirable level. Also, it is not usually valid to make direct comparisons between various cities. The main objections to doing this are:

1. Different sampling methods and different analytical procedures may be in use.
2. Different climatic conditions can affect certain measurements, e.g. sulphation rates.

It has been estimated that in rural areas the dustfall is approximately 5 tons/square mile/month[9]. In one study it was shown that at least 10% of a population expressed concern about the nuisance of air pollution when the dustfall levels exceeded 10 tons/square mile/month[10]. Another source reports that values above 25 tons/square mile/month are considered undesirable from a community welfare standpoint[6]. In Ontario, the ambient air quality criteria states that the concentration of dustfall for industrial or commercial land use shall not exceed 25 tons/square mile/month and for residential or rural land use it shall not exceed 13 tons/square mile/month[11]. These facts would indicate that the dustfall readings obtained in Sydney are higher than those for rural areas and that all stations (except No.11, 12 and 13) have readings that are undesirable from a community welfare standpoint. The American Industrial Hygiene Association states that no health effects of iron oxides can be demonstrated[12]. It recommends that air quality criteria for iron oxides must be based on the annoyance effects of visibility reduction and soiling.

The lead peroxide "candles" which measure total sulphation give only a rough indication of SO_2 concentrations[13]. It is, therefore, difficult to give "typical" values. In Ontario, the ambient air quality criteria for sulphation states that the concentration for industrial or commercial land use shall not exceed 1.0 mg SO_3/100 cm^2/day and for residential or rural land use it shall not exceed 0.4 mg SO_3/100 cm^2/day[11]. The sulphation rates obtained in Sydney during the period 1962-70 are all (except at Riverview) higher than given in the above criteria. Perhaps the magnitude of this problem can best be appreciated when one considers that the average sulphation rate in Sydney increased 36% from 1968 to 1969.

COH values below 1.0 are considered to represent clean air[9]. Green recommends a scale on which COH values of 0.9 or less are desirable[14]. On this basis, Eastmount (Station 15) would only fall into the category of clean air during July, August and September (Fig.6). For all other months, the COH values obtained are above 0.9 COH units. Almost all COH values obtained at Don Bosco School (Station 1) are less than 0.9 COH units. The low COH values obtained at the Don Bosco School Station might indicate

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that to obtain the soiling index peak it is necessary to move out a distance from the source. It is suggested that at Don Bosco ($\frac{1}{2}$ mile from the steel mill) the plumes are still elevated and pass overhead. On the other hand, at Eastmount (1 mile from the steel mill) the smoke particulates from the plume have diffused down to ground level and are sampled in the ambient air. Bradley found that highest COH values were obtained at approximately 1 mile from the site of the steel mill[2].

CONCLUSIONS

1. The fact that the air pollution in Sydney is a nuisance to its residents is readily apparent if one visits the city. All parameters indicate that the readings obtained exceed most desirable or acceptable limits as reported in the technical literature. Even more significant is the fact that the air pollution in this city has increased substantially since 1959-65 and has been increasing during the period 1965-70.

2. The coal-fired heating plants contribute to the air pollution in the city during the heating season. While the quantity of coal burned is not large, the particulates are emitted at a lower elevation than at the steel mill. For this reason, the effect of the coal-fired heating plants cannot be ignored.

3. If any progress is to be made in the control of the air pollution problem in Sydney, the active cooperation of the Sydney Steel Corporation will be required. Although the residential coal-fired heating plants contribute to the air pollution during the heating season the major source is the Sydney Steel Corporation.

4. In the absence of any control programme, the quality of the air in Sydney can be expected to continue to deteriorate as steel production increases.

5. The present high pollution level would indicate the need for an expanded monitoring programme. This should include continuous

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sulphur dioxide measurements and "high volume" sampling in order to determine the extent of any potential health hazard that may exist as a result of the air pollution situation in Sydney.

ACKNOWLEDGMENTS

The contribution of Mr. J. MacArthur and the staff of the Nova Scotia Department of Public Health in Sydney and Halifax in the operation of the survey and the analysis of samples is acknowledged. The authors are grateful to the staff of the Sydney Steel Corporation and the Cape Breton Development Corporation for the provision of production figures and to the Air Management Branch of the Department of Energy and Resources Management (Ontario) for the air pollution data on Hamilton. The authors are also indebted to Dr. H.P. Sanderson for helpful discussions and his assistance during the conduct of the study.

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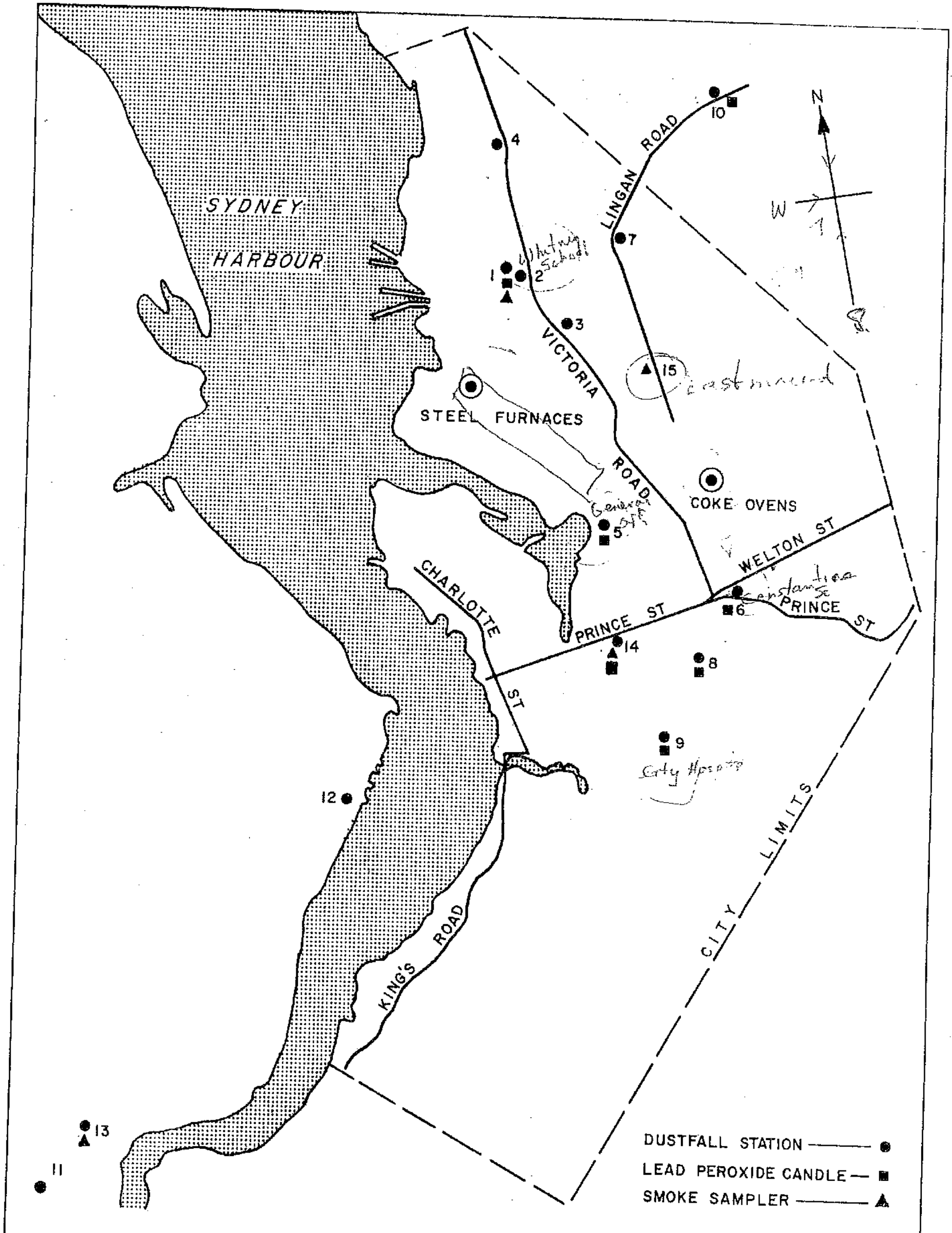
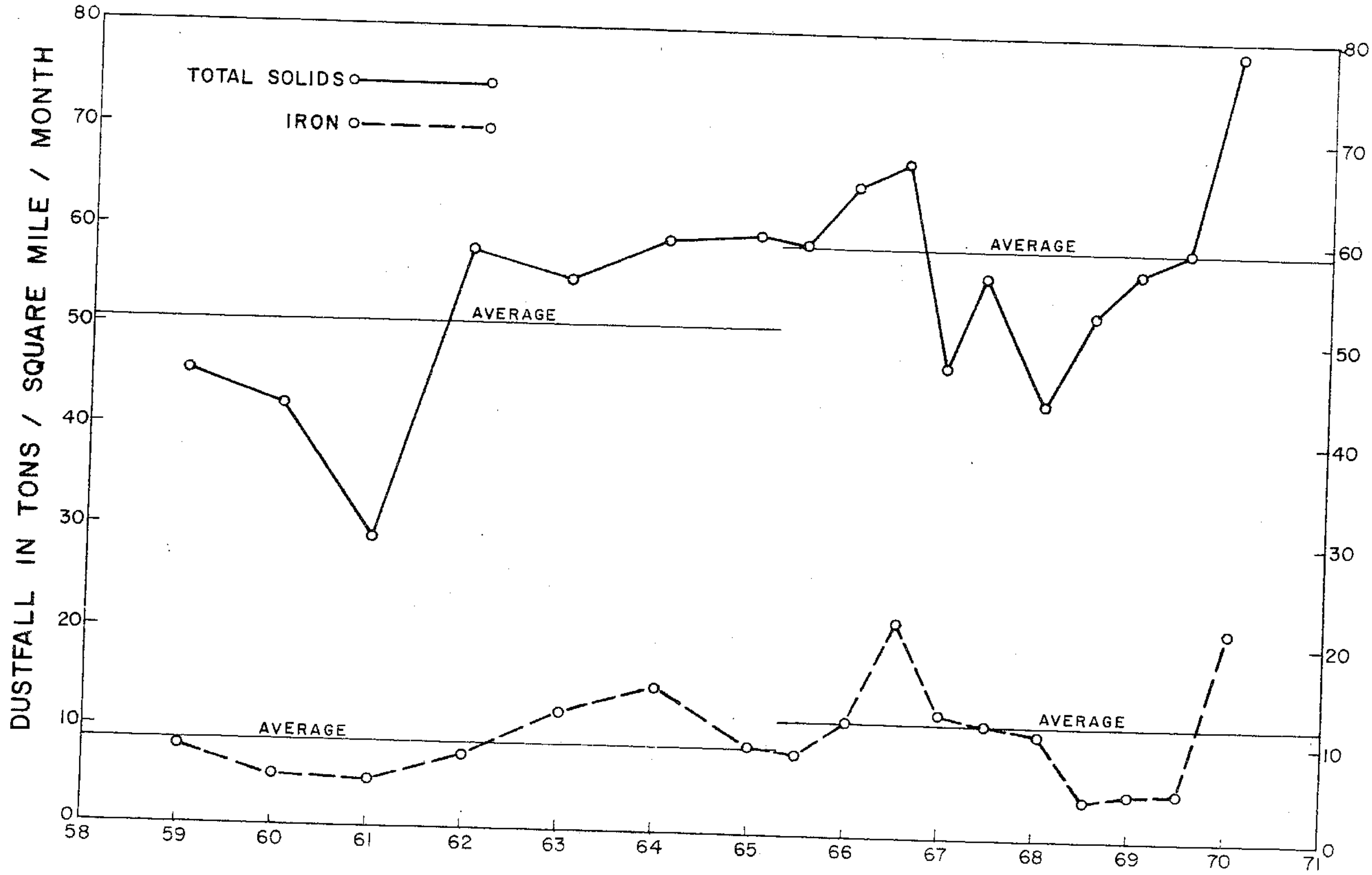


Fig. 1. SYDNEY AIR POLLUTION SURVEY (1965)

0 .1 .2 .3 .4 .5
SCALE IN MILES



AVERAGE DUSTFALL RATES AND IRON IN TOTAL SOLIDS FOR YEARS 1959-1970
IN SYDNEY, N.S.

Fig. 2

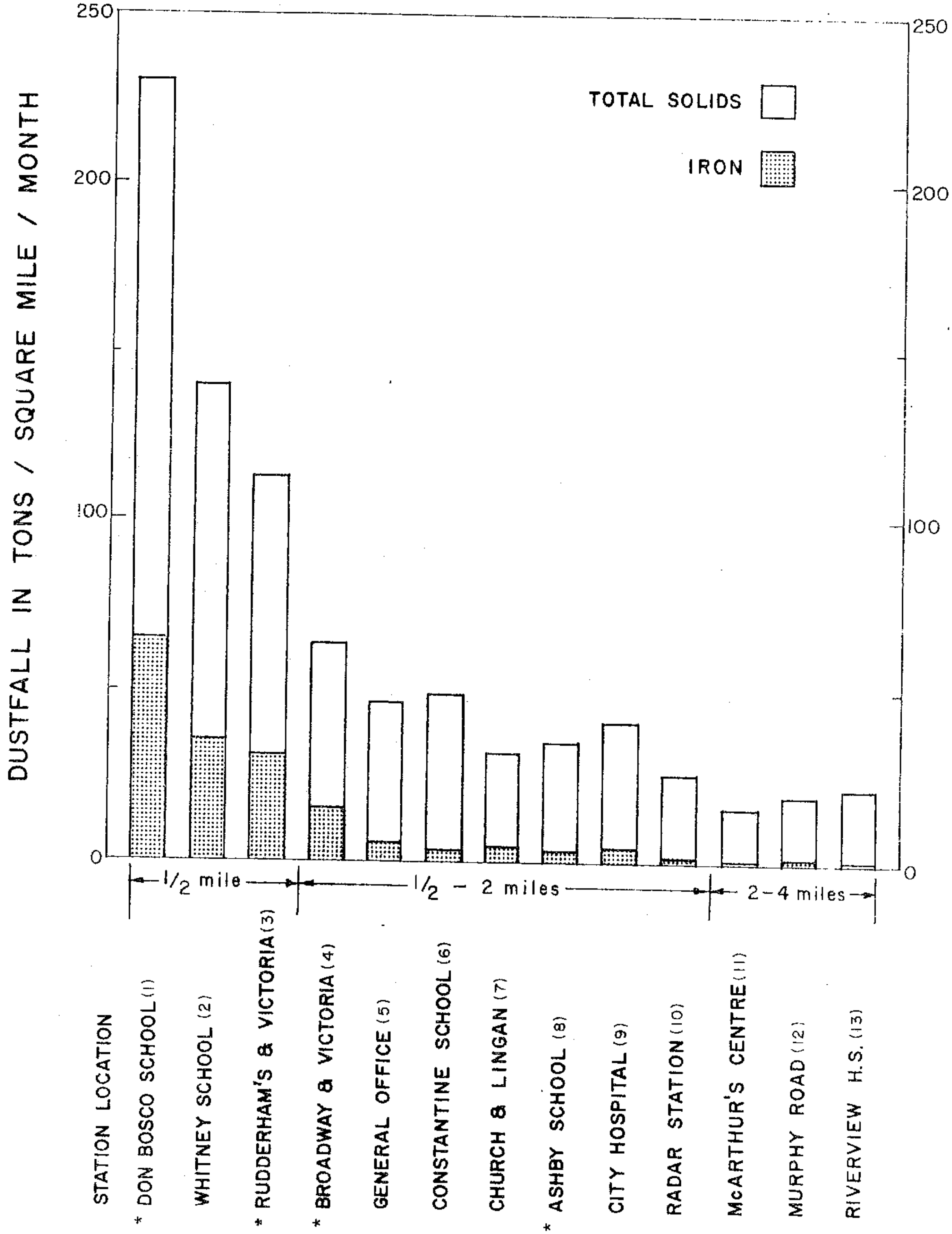


Fig. 3

DISTRIBUTION OF DUSTFALL AND IRON WITH DISTANCE FROM THE STEEL MILL FOR 13 SAMPLING STATIONS FOR 1965-1970 IN SYDNEY, N,S.

*DENOTES STATIONS DISCONTINUED IN MAY, 1968.

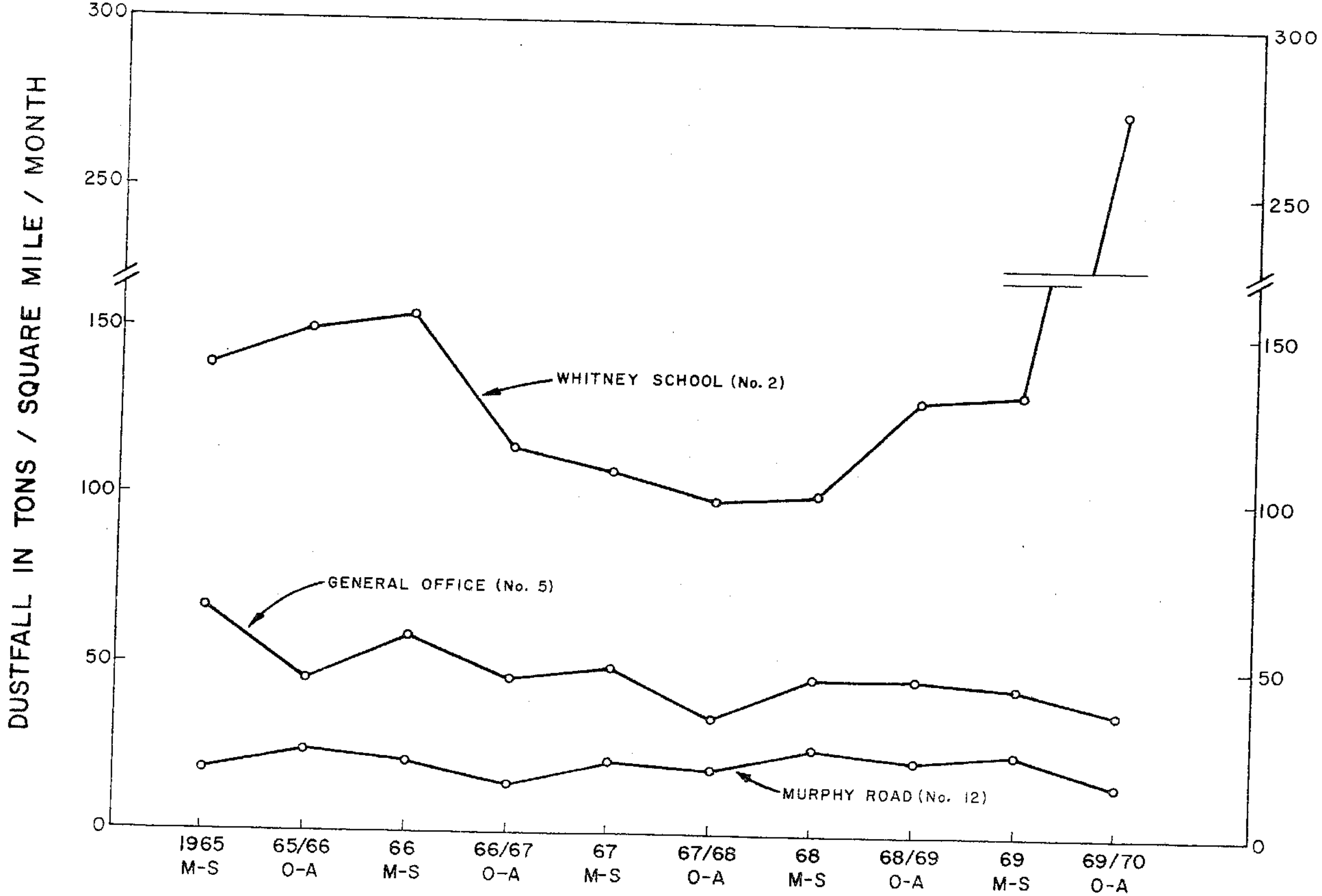
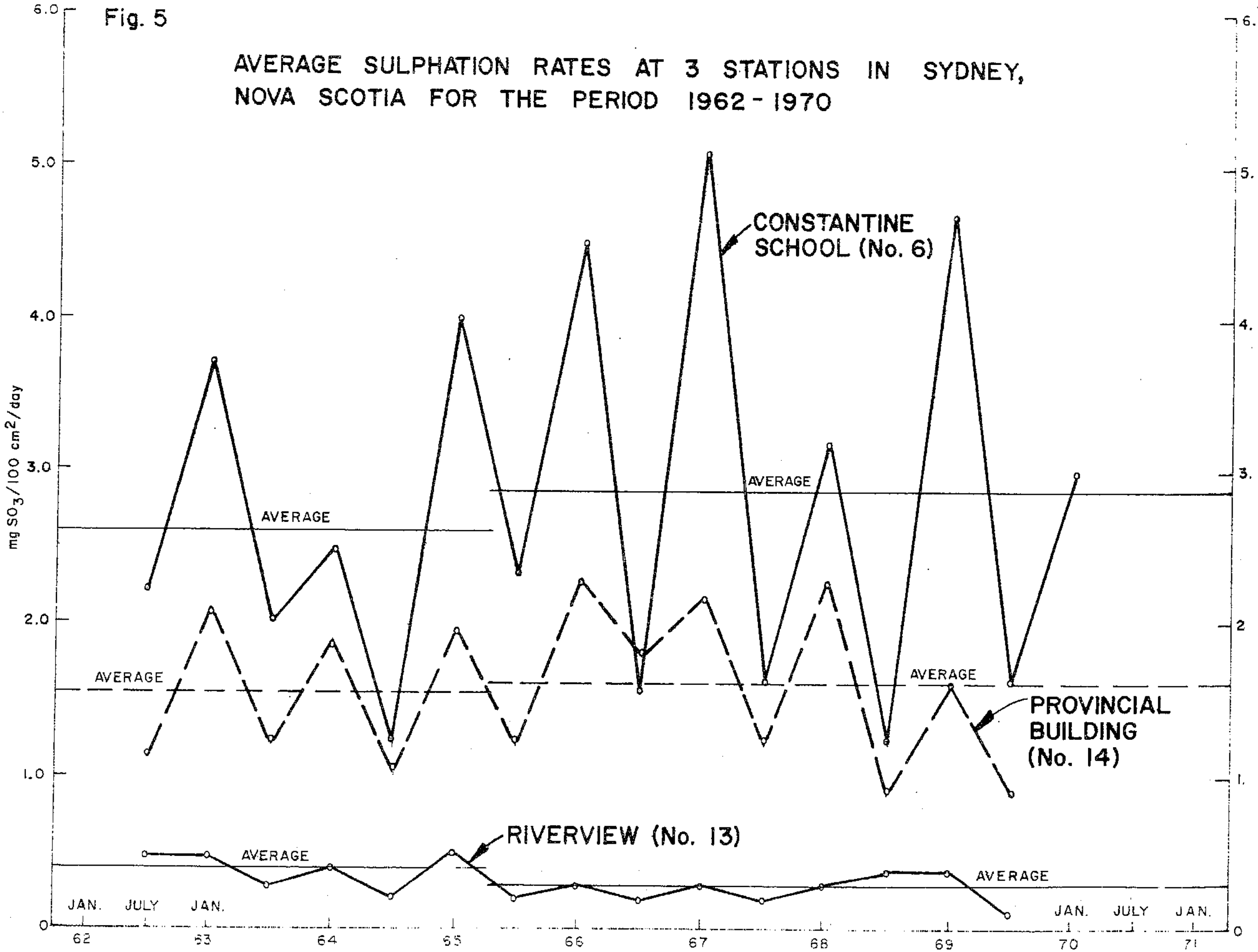


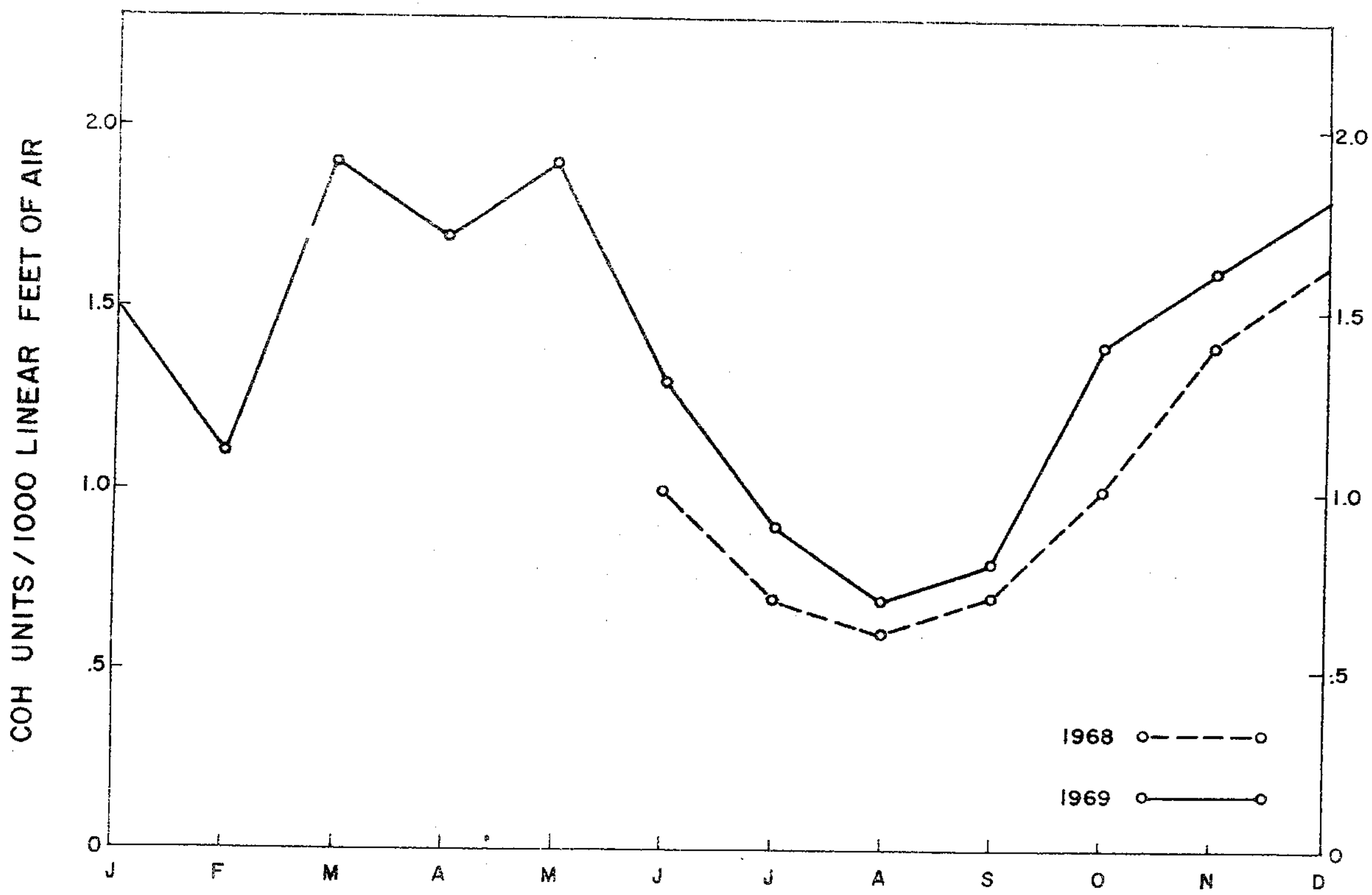
Fig. 4

AVERAGE DUSTFALL RATES FOR 3 SAMPLING STATIONS
FROM 1965 - 1970 IN SYDNEY, N.S.

Fig. 5

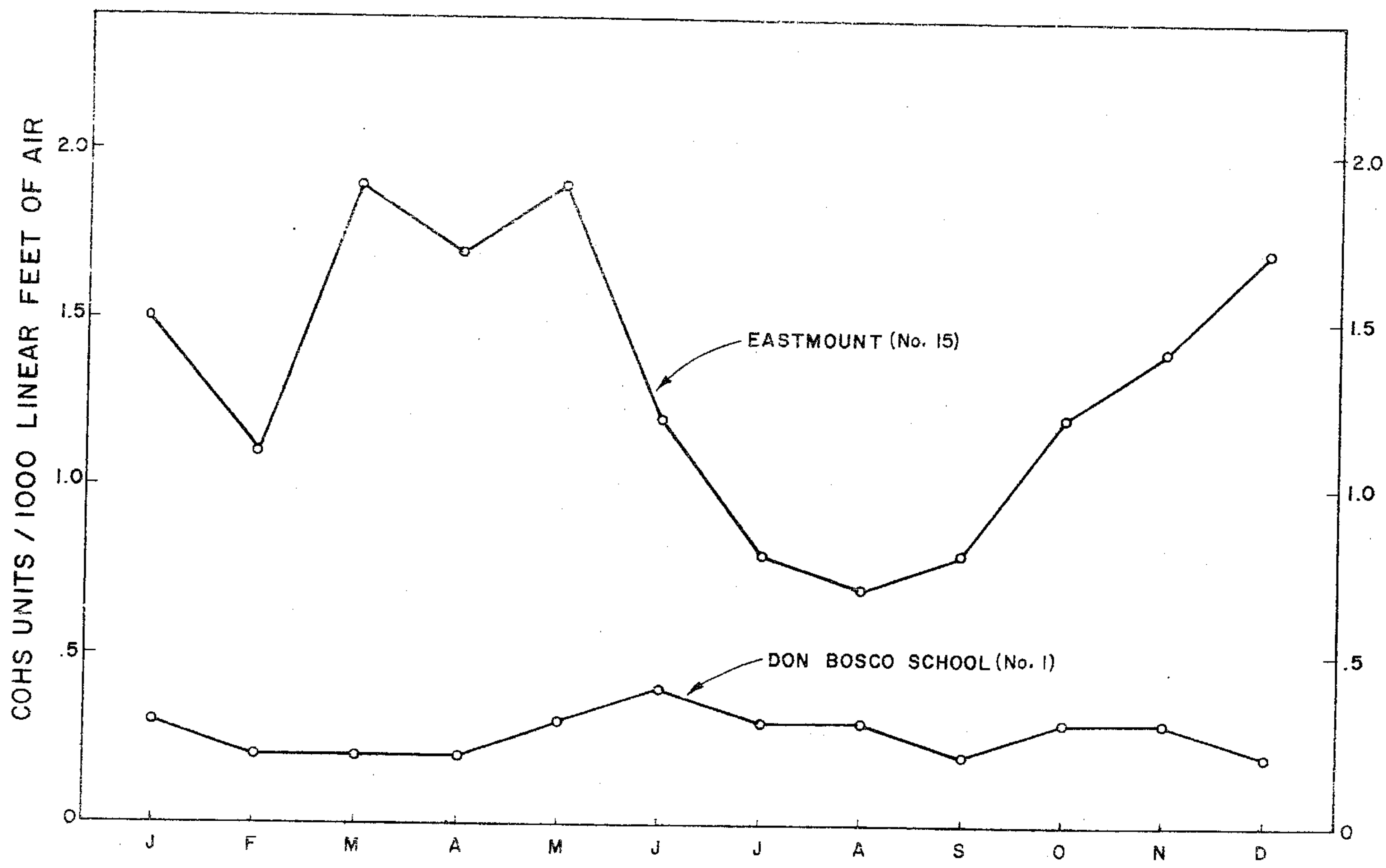
AVERAGE SULPHATION RATES AT 3 STATIONS IN SYDNEY, NOVA SCOTIA FOR THE PERIOD 1962 - 1970





A COMPARISON OF AVERAGE SOILING INDEX DURING 1968
AND 1969 AT EASTMOUNT STATION IN SYDNEY, N. S.

Fig. 6



AVERAGE SOILING INDEX AT 2 STATIONS DURING 1968 - 69 IN SYDNEY, N. S.

Fig. 7

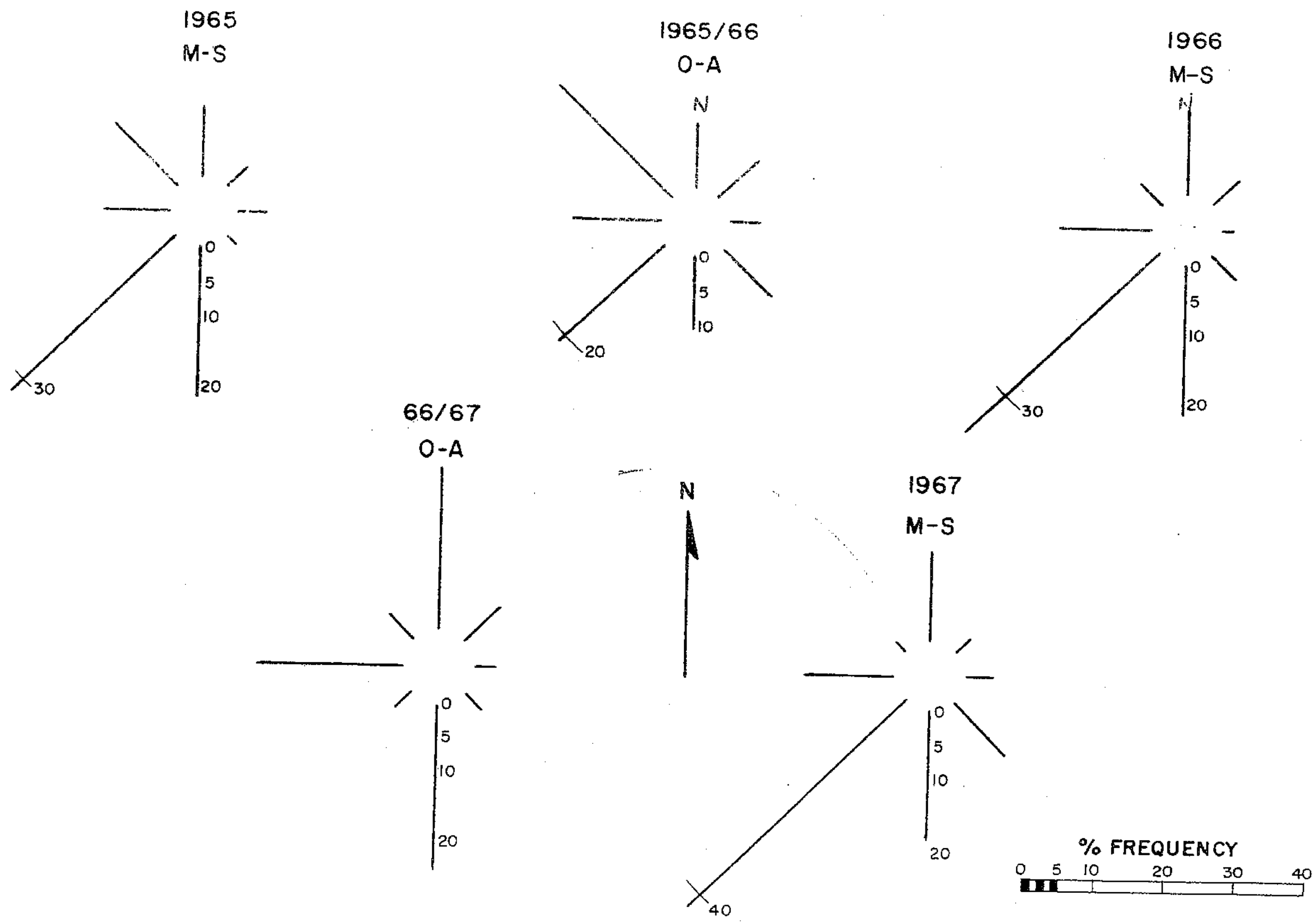


Fig. 8

WIND ROSES FOR SYDNEY AIRPORT FOR 1965-1967

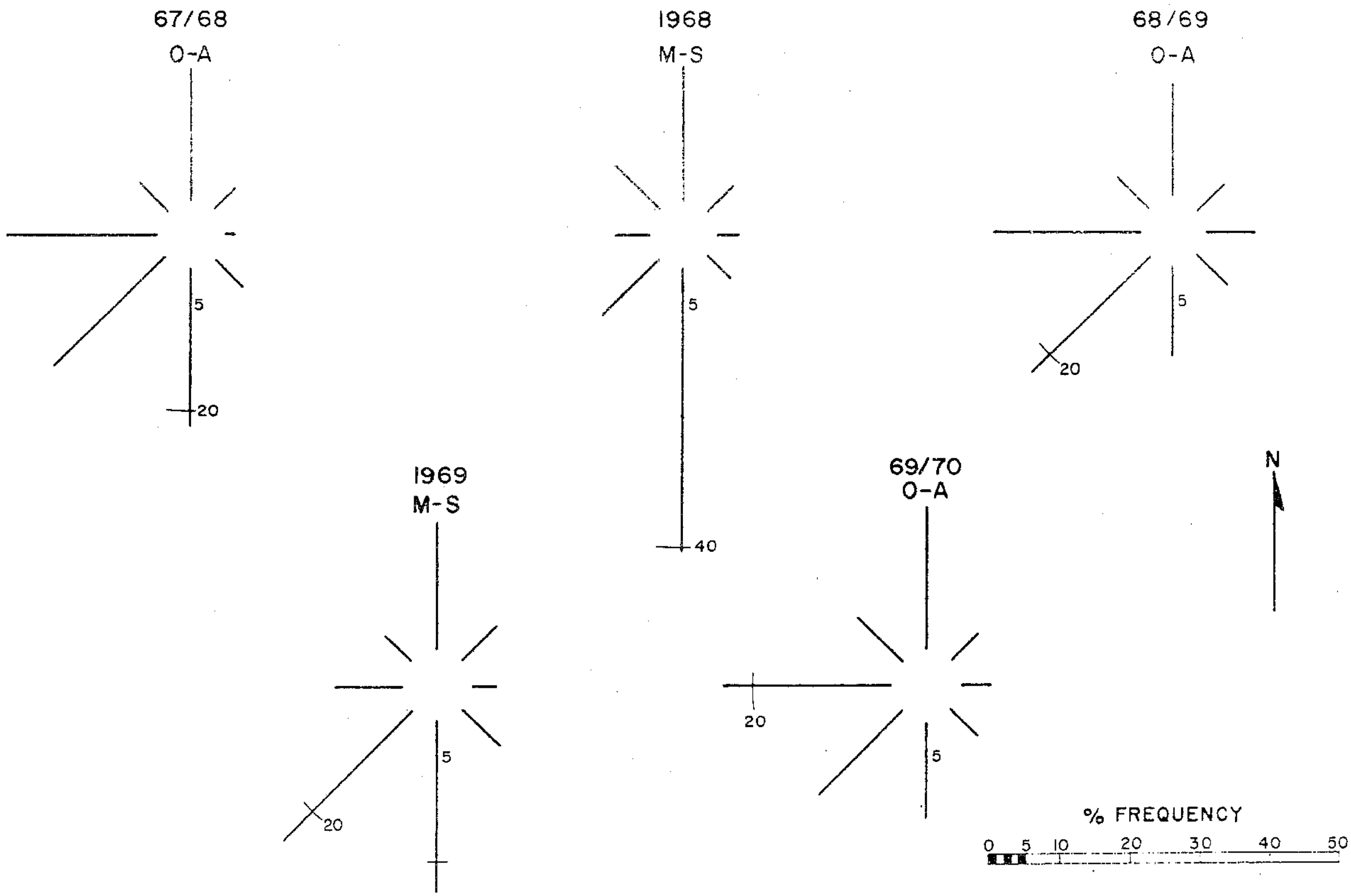


Fig. 9 WIND ROSES FOR SYDNEY AIRPORT FOR 1967-1970

	STEEL	IRON	SINTER	COKE
M-S 65	75.7	51.2	18.2	30.1
O-A 65/66	57.7	43.7	19.0	30.5
M-S 66	68.3	48.2	20.7	36.4
O-A 66/67	48.9	35.8	14.6	25.5
M-S 67	49.9	38.0	15.8	27.1
O-A 67/68	66.4	52.2	21.3	37.2
M-S 68	68.4	53.5	21.0	40.0
O-A 68/69	83.6	67.2	12.9	47.8
M-S 69	82.8	65.0	19.9	53.7
O-A 69/70	87.1	68.2	10.0	51.1

PRODUCTION FIGURES OF STEEL, IRON, SINTER AND COKE
(MONTHLY AVERAGES IN THOUSANDS OF TONS)
FOR HEATING AND NON-HEATING SEASONS 1965-1970

Fig. 10

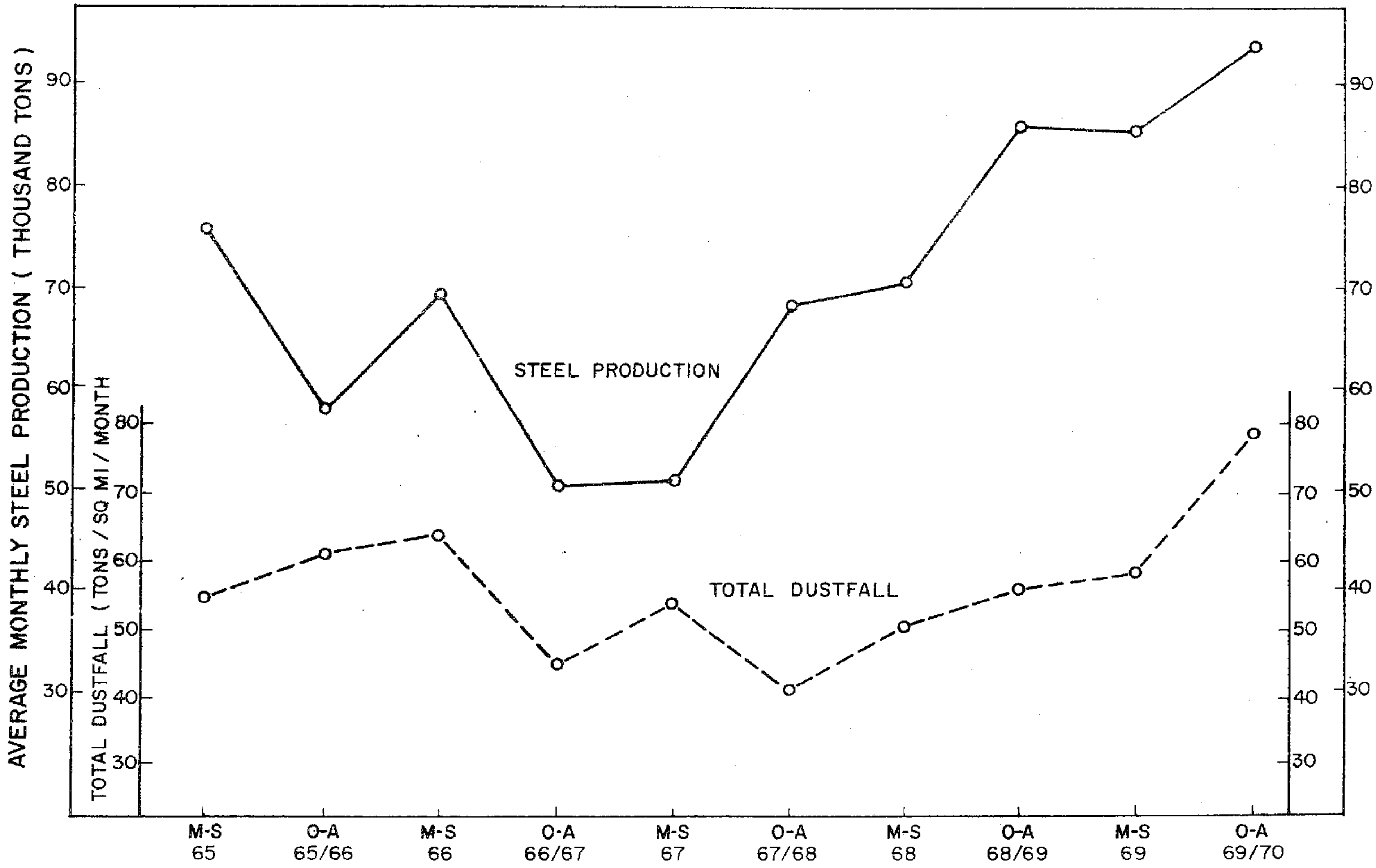


Fig. 11 MONTHLY AVERAGE STEEL PRODUCTION AND TOTAL DUSTFALL FOR 1965-1970

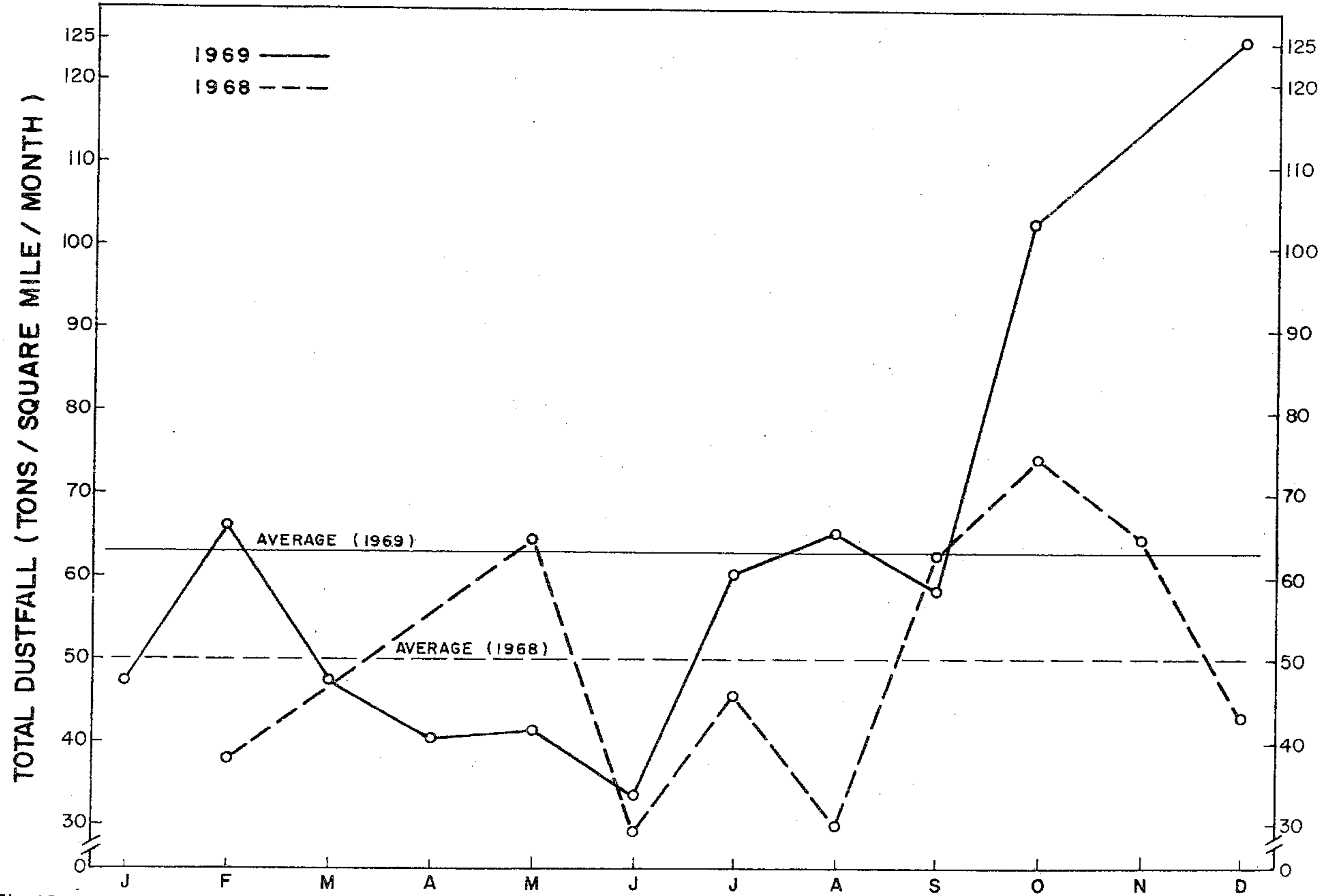


Fig. 12

AVERAGE MONTHLY DUSTFALL AT 5 STATIONS IN SYDNEY, N. S. FOR 1968 AND 1969

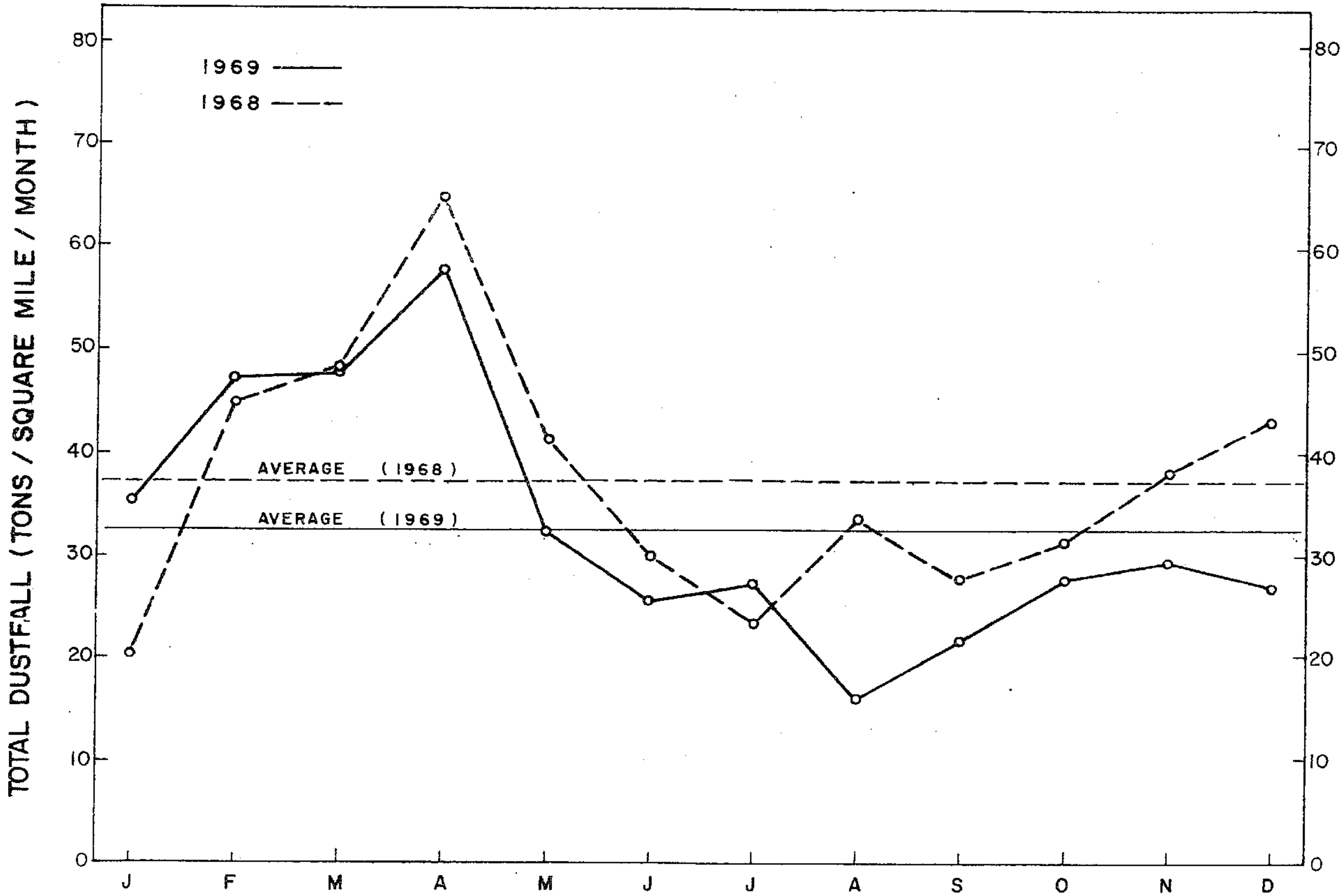


Fig. 13

AVERAGE MONTHLY DUSTFALL AT 12 STATIONS IN HAMILTON ONTARIO FOR 1968 AND 1969

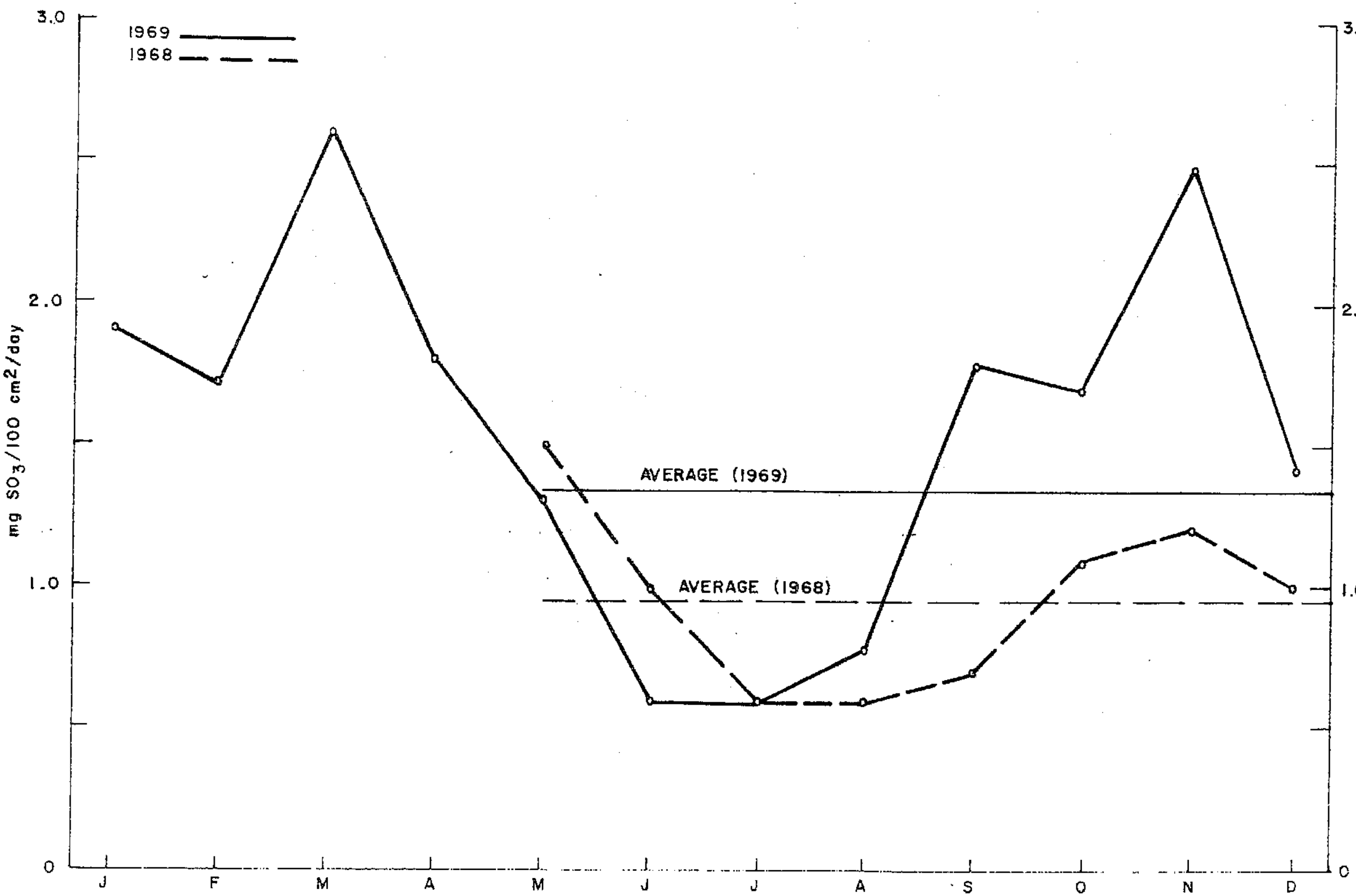


Fig. 14 AVERAGE MONTHLY SULPHATION RATES AT 6 STATIONS IN SYDNEY, NOVA SCOTIA FOR 1968 AND 1969

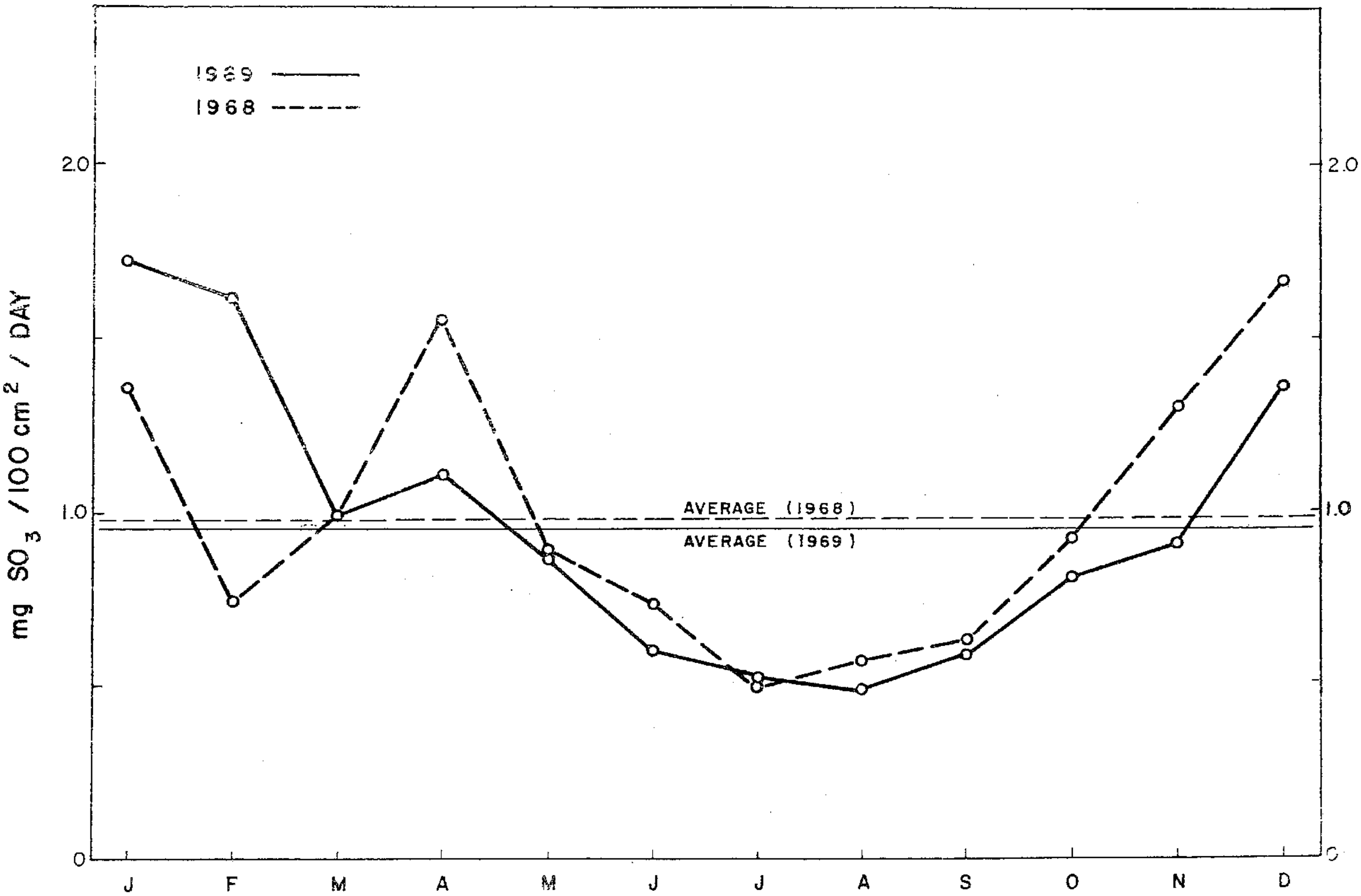


Fig. 15 AVERAGE MONTHLY SULFATION RATES AT 12 STATIONS IN HAMILTON ONTARIO FOR 1968 AND 1969