CHAPTER II

AIR IMPACT

The quality of the air around us is measured in terms of the ground-level concentration of certain pollutants. Changes in this air quality is the result of several factors such as emission of pollutants, the atmospheric transport and dispersion of the pollutants, and chemical and mechanical processes acting on the pollutants. The impact of the pollutants on man and materials depends on frequency, duration, and level of exposure, and on the chemical reactivity of the pollutants, as well as the susceptibility of the receptors to damage. To protect man, primary air quality standards have been established while secondary standards protect against damage to materials. The interplay of these various factors is discussed in this Chapter.

In sections A to D, we will discuss the nature of power plant emissions, the health effects of the pollutants, standards protecting human health, and, finally, the present levels of pollution. Section E will focus upon emission control of SO_2, the major power plant pollutant. Mathematical modeling of pollutant plume dispersion, often a central factor in licensing procedures, is discussed in Section F. Finally, the provisions and implications of the Clean Air Act Amendments of 1977 are reviewed in Section G.

A. Sources and Nature of Emissions

Airborne wastes from power plant combustion include sulfur oxides (SO_x), possibly mixed with sulfates and sulfuric acid mist, nitrogen oxides (NO_x), particulates, and, to a lesser degree, hydrocarbons, carbon monoxide, flourides, carbon dioxide, and traces of organic and metallic compounds. The rate of release depends on the type of fuel, power level, the type of boiler firing, and the efficiency of pollution control devices such as precipitators and scrubbers.

During combustion, sulfur in coal and oil is almost completely converted to SO_2 and emitted through the stack, unless it is absorbed in a scrubber. The preponderance of NO_x emitted is due to reactions between O_2 and N_2 in the air at elevated temperatures. Thus, NO_x emission rates are sensitive to flame temperature and amount of excess air entering the furnace. Particulates, mainly non-combustible fuel residues (silicates, metal salts, sodium chloride) and incompletely burned organic materials, are often removed from the flue gas by precipitators.

Table II-1 shows Maryland area power plant (Figure II-1) emissions for 1974 and 1975 and the total state emission inventory (1) by source category as obtained from measurements and theoretical calculations. It can be seen that, of the five major pollutants emitted by all sources in Maryland, power plants contribute negligible amounts of carbon monoxide and hydrocarbons, about 30 percent of the NO_x, 32 percent of the particulate, and 69 percent of the sulfur oxides. Power plant contributions to ground-level concentrations of these pollutants are, however, much smaller than these emission data indicate (see Section D).

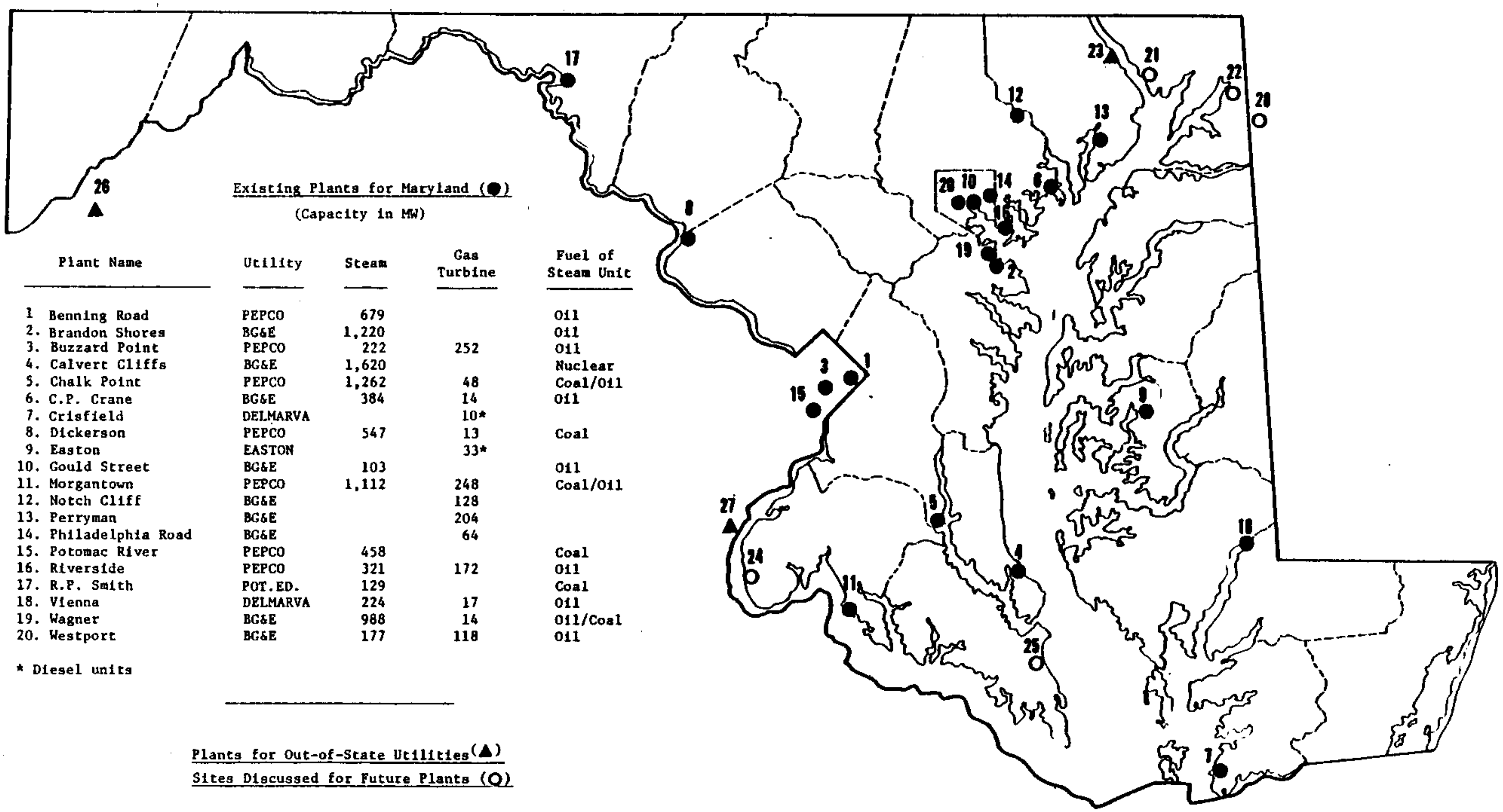
Table II-1. Statewide total emissions inventory, 1974 and 1975

	Heating		Power Plants		Mobile Sources		Process		Refuse		Total	
	1974	1975	1974	1975	1974	1975	1974	1975	1974	1975	1974	1975[a]
Particulate												
Tons/yr	12,200	9,900	47,500	27,300	17,600	18,600	22,000	27,700	4,300	1,500	103,500	85,400[b]
% of total	11.8	11.6	45.8	32.0	17.0	21.7	21.2	32.4	4.2	1.7		
Sulfur Oxides												
Tons/yr	62,200	60,000	248,800	283,500	18,100	26,600	45,500	39,300	800	400	375,500	409,900
% of Total	16.6	14.6	66.3	69.2	4.8	6.5	12.1	9.6	0.2	0.1		
Hydrocarbons												
Tons/yr	3,200	3,700	2,100	2,800	198,100	259,900	77,400	44,900	1,100	300	281,900	336,100[c]
% of Total	1.1	1.1	0.8	0.8	70,3	77.3	27.5	13.4	0.4	0.1		
Nitrogen Oxides												
Tons/yr	47,400	46,800	102,900	104,900	154,200	189,400	39,600	17,500	1,000	400	342,900	359,100
% of Total	13.7	13.0	29.8	29.2	44.7	52.7	11.5	4.9	0.3	0.1		
Carbon Monoxide												
Tons/yr	9,900	8,700	3,900	4,300	1,374,500	1,808,000	112,200	85,200	3,800	4,000	1,504,300	1,915,400
% of Total	0.6	0.5	0.3	0.2	91.4	94.4	7.5	4.5	0.2	0.2		

(a) Includes a miscellaneous category.

(b) These are "man-made" particulate emissions. Particulate "emissions" due to natural causes, e.g., wind blown dust and pollen, vary widely with place and time and can exceed man-made emissions by an order of magnitude.

(c) In addition, about 150,000 tons per year is released from asphalt roads in the State. This quantity can be reduced to 20,000 to 25,000 tons per year by current use of a different type of road tar. Emission from an asphalt surfaced road decreases significantly over a period of one to two years.



Existing Plants for Maryland (●)

(Capacity in MW)

Plant Name	Utility	Steam	Gas Turbine	Fuel of Steam Unit
1 Benning Road	PEPCO	679		Oil
2. Brandon Shores	BG&E	1,220		Oil
3. Buzzard Point	PEPCO	222	252	Oil
4. Calvert Cliffs	BG&E	1,620		Nuclear
5. Chalk Point	PEPCO	1,262	48	Coal/Oil
6. C.P. Crane	BG&E	384	14	Oil
7. Crisfield	DELMARVA		10*	
8. Dickerson	PEPCO	547	13	Coal
9. Easton	EASTON		33*	
10. Gould Street	BG&E	103		Oil
11. Morgantown	PEPCO	1,112	248	Coal/Oil
12. Notch Cliff	BG&E		128	
13. Perryman	BG&E		204	
14. Philadelphia Road	BG&E		64	
15. Potomac River	PEPCO	458		Coal
16. Riverside	PEPCO	321	172	Oil
17. R.P. Smith	POT.ED.	129		Coal
18. Vienna	DELMARVA	224	17	Oil
19. Wagner	BG&E	988	14	Oil/Coal
20. Westport	BG&E	177	118	Oil

* Diesel units

Plants for Out-of-State Utilities (▲)

Sites Discussed for Future Plants (○)

21. Bainbridge
22. Chesapeake City
23. Conowingo
24. Douglas Point
25. Elms
26. Mount Storm (VEPCO)
27. Possum Point (VEPCO)
28. Summit

Figure II-1. Power plants in the Maryland region

B. Health Effects

Numerous investigations have sought to document the health effects of exposure to air pollutants for concentrations normally encountered at ground level (2).

Scientific consensus on the interpretation of dose-response data has led to enactment of Federal and State Ambient Air Quality Standards, which include sufficient safety margins (as a hedge against uncertainty in the data) to protect even the most sensitive segments of the population (3). Emission standards and fuel use regulations have also been promulgated as a means of obtaining compliance with Ambient Air Quality Standards by regulating pollution at its source.

There is an increasing realization that few of the pollutants for which standards have been established act directly or alone in producing medical effects. Toxicological studies indicate that the chemical transformation products of SO_2, mainly sulfates, are more likely than SO_2 alone to be responsible for many of the adverse health effects associated with ambient sulfur oxides. In the absence of other pollutants, such as ozone and particulates, SO_2 is a mild respiratory irritant; but there is evidence that certain sulfate compounds (especially sulfuric acid aerosols) are more severe irritants (4).

For instance, epidemiological studies in several U.S. cities have associated high daily or annual sulfate levels with increased frequency of asthma attacks, intensification of symptoms in cardio-pulmonary patients, decreased ventilatory function in school children, and symptoms of acute and chronic respiratory disease in children and adults. Taken together, findings of the toxicological and epidemiological studies suggest that sulfate compounds may be the agents responsible for the observed excess mortality associated with high SO_2 levels (5).

Similarly, many hydrocarbons have been found not to be medically harmful, but they take part in a chain of photochemical reactions with NO_x and other atmospheric constituents to form oxidants, such as ozone (O_3), which are major irritants (6).

Thus, in many cases, the emitted pollutants are only precursors to the substances which actually constitute the health hazard. Since these relationships between precursors and their end products are complex and often poorly known -- even the origin of some of the precursors (e.g., hydrocarbons) is not well understood -- the Environmental Protection Agency (EPA) has found it premature to establish standards for "ultimate pollutants" such as sulfates. Until more is known about the reaction processes, it is considered sound and meaningful strategy to control the five major "criteria" pollutants: particulate matter, sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide, and hydrocarbons.

C. Standards

Ambient air quality is measured and defined as ground-level concentration of pollutants. Federal and State agencies are attempting to attain and maintain good air quality by regulation of: (a) pollutant ground-level concentrations, through ambient air quality standards, (b) source emissions, through source emission standards, and (c) the quality of fuels burned, through sulfur content standards.

Ambient Air Quality Standards have been established by the Federal Environmental Protection Agency for ground-level concentrations of certain pollutants.* The National Ambient Air Quality Standards (NAAQS) (7) are listed in Table II-2. The National Primary standards are designed to protect human health (i.e., medical effects of pollution), whereas the secondary standards are concerned with the protection of human welfare (i.e., the material and aesthetic effects of pollution).

Emission Standards were established by EPA in December, 1971 under authority of the Clean Air Act of 1970 for new sources, i.e., sources beginning operation after 1977 (8). To satisfy the requirements of the Clean Air Act Amendments of 1977, EPA has proposed new standards of performance for stationary sources (8). These standards would apply to utility steam generating units for which construction is commensed after September 18, 1978. Table II-3 compares these New Source Performance Standards (NSPS).

Fuel Standards have been imposed by the State in the form of limits on the sulfur content in coal and oil that can be used in specific power plants and in oil for home consumption (9).

In addition to the standards, a comprehensive body of guidelines and regulations have been developed at national and state level to control and maintain air quality. Several of these regulations will be discussed in subsequent sections.

D. Status and Trends in the Maryland Airshed

In general, all areas of the State are currently in compliance with the National Ambient Air Quality Standards, except for the hydrocarbon and photochemical oxidant standards which are violated throughout the State, and suspended particulate and carbon monoxide standards which are violated in part of the Baltimore area and part of the Potomac Valley (10) in Allegany County.

Trends in ambient air quality can be determined from analyses of ground-level concentration data from air quality monitoring stations. The national air quality trends presented below are based on data from the U.S. Environmental Protection Agency's National Aerometric Data Bank (NADB). These data are gathered primarily from State and local air pollution control agencies through their monitoring activities (11).

Maryland data are reported by the State's Bureau of Air Quality and Noise Control (BAQNC) which has stations throughout the State mainly in the urban areas (12). Because of the non-uniform distribution of stations, the ground-level concentrations reported may not be representative of the overall status

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* Maryland Ambient Air Quality Standards were repealed by HB 1146 in the 1978 legislative session. The National Ambient Air Quality Standards therefore apply to the State.

Table II-2. Federal ambient air quality standards

	National			
	Primary		Secondary	
	µg/m^3	ppm	µg/m^3	ppm
Sulfur Oxides				
Annual Arithmetic Mean	80	0.03		
24-hr Maximum(a)	365	0.14		
3-hr Maximum(a)			1,300	0.5
1-hr Maximum(b)				
Suspended Particulate Matter				
Annual Geometric Mean	75		60	
24-hr Maximum(a)	260		150	
Carbon Monixide				
8-hr Maximum(a), mg/m^3	10	9	10	9
1-hr Maximum(a), mg/m^3	40	35	40	35
Hydrocarbons (non-methane)		(carbon)		(carbon)
3-hr (6-9AM) Maximum(a)	160	0.24	160	0.24
Nitrogen Dioxide				
Annual Arithmetic Mean	100	0.05	100	0.05
Photochemical Oxidants		(ozone)		(ozone)
1-hr Maximum(c)	240	0.12	240	0.12

(a)Not to be exceeded more than once per year

(b)Not to be exceeded more than once per month

(c)The ozone standard was changed from 160 µg/m^3 and 0.08 ppm in January 1979 (regulations to be published in Federal Register week of February 5, 1979)

Table II-3. Existing new source standards of performance for fossil fuel fired steam generators (1971) and proposed standards (1978)

Pollutant	Old Standard	Proposed Standard
Particulate matter	0.10 lb per million BTU heat input, maximum 2-hr average.	0.030 lb/per million BTU heat input, maximum 2-hr average.
	20 percent opacity (6-min average); except that 40 percent opacity is permissible for not more than 2 min in any hour.	Same
Sulfur dioxide	0.80 lb per million BTU heat input, maximum 2-hr average when liquid fossil fuel is burned.	Same(a)
	1.2 lbs per million BTU heat input, maximum 2-hr average when solid fuel is burned.	Same(a)
		85 percent reduction of uncontrolled emission(b)
Nitrogen oxides	0.2 lb per million BTU heat input, maximum 2-hr average, expressed as NO_2, when gaseous fossil fuel is burned.	Same
	0.30 lb per million BTU heat input, maximum 2-hr average, expressed as NO_2, when liquid fossil fuel is burned.	Same
	0.70 lb per million BTU heat input, maximum 2-hr average, expressed as NO_2, when solid fossil fuel (except lignite) is burned.	0.60 lb per million BTU heat input, maximum 2-hr average, expressed as NO_2, from combustion of bituminous coal.
		0.50 lb per million BTU heat input, maximum 2-hr average, expressed as NO_2, from combustion of subbituminous coal, shale oil, or any solid liquid or gaseous fuel derived from coal.

(a) Except for 3 days per month; compliance to be determined on a 24-hr daily basis.

(b) Except for 3 days per month; when only 75 percent reduction is required. For sources emitting less than 0.20 lb/million BTU, the percent reduction requirement would not apply.

of air quality, but the trends, or changes, at these stations do indicate the state-wide trends. However, since many stations have been moved over the years and the measurement methods have changed, it is sometimes difficult to find stations with sufficient continuity to establish long-term trends.

Emission data are obtained from estimates of indicators such as fuel consumption, production rates, control efficiencies, and vehicle miles traveled. Average emission factors, which relate these indicators to emission rates for specific source categories, are used to derive total emissions (13).

In the following sections, national and State trends in air quality are discussed for the three main power plant pollutants.

Total Suspended Particulates (TSP)

The national trend for TSP ground-level concentrations shows considerable improvement from 1960 to 1975 at 95 urban stations throughout the nation (14). The urban composite average of the annual geometric mean decreased from about 110 $\mu g/m^3$ in 1960 to 72 $\mu g/m^3$ in 1975, just below the primary national standard of 75 $\mu g/m^3$. In a much broader sample of 2350 stations throughout U.S.A. (11) the recent trend, from 1970 to 1976 is shown in Figure II-2A.

Peak daily concentrations are shown in Figure II-2B for the same stations. Corresponding emission trends are shown in Figure II-2C. Additional particulate emission control is not expected to produce much improvement in air quality, since many areas have a high background concentration of natural origin (e.g., windblown dust and pollen).

There has also been a downward trend in TSP concentrations in Maryland over the last 10 to 15 years (12). Because of changes in locations and deletion and additions of stations, the trends may not be immediately evident from an inspection of the annual air quality data reports. Figure II-3 shows the number of stations violating state standards for annual arithmetic mean of TSP out of a group of 35 measuring stations which have been in operation at the same location for the six years, and where each station has had at least one violation in one of the six years. Improvement is indicated by decreasing violations. Figure II-3 shows the trends for these stations from 1971 to 1976, and the trend for all Maryland stations is shown in Figure II-4.

A closer inspection of the air quality data from the Bureau of Air Quality and Noise Control reveals that there are two general non-attainment areas: along the Potomac Valley from the Bloomington/Luke area to Cumberland, and in the southeastern part of Baltimore City. The importance of these non-attainment areas to the siting of future power plants will be discussed in Section G.

The problem in maintaining a satisfactory air quality in the greater Baltimore area has been investigated (15) through the use of an Air Quality Display Model (AQDM) (16). This model calculates ground-level concentration of pollutants using a Gaussian plume model with appropriate atmospheric stability and wind conditions established from 5 years of meteorlogical records. Discrete (e.g., industrial and commercial) and distributed (e.g., home heating) emission sources are used as inputs to the model. Vehicular emissions are also

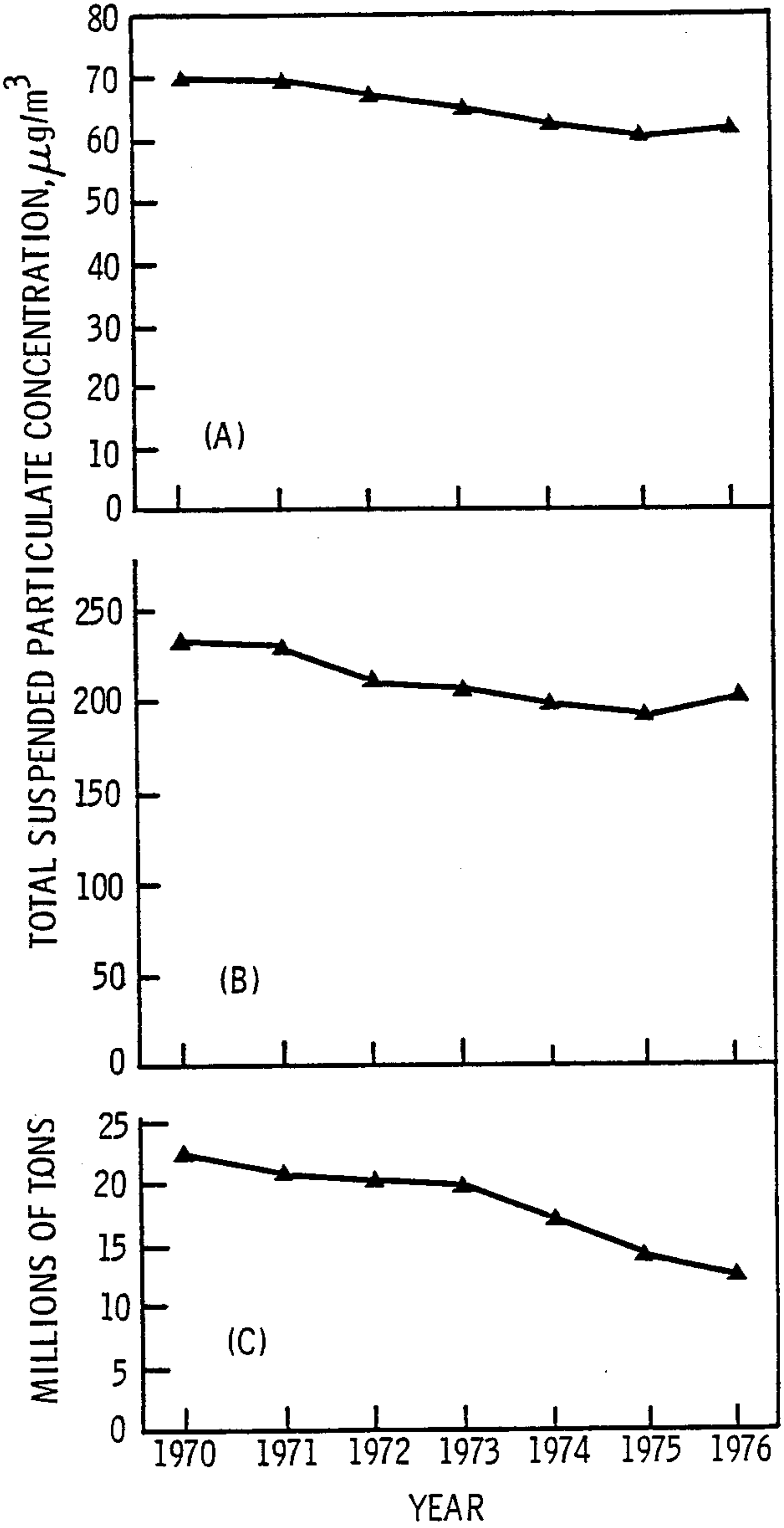

Figure II-2. (A) Composite average of annual mean total suspended particulate concentration at 2,350 U.S. sampling sites

(B) Composite average of peak daily total suspended particulate concentration at 2,350 U.S. sampling sites

(C) Total suspended particulate emission estimates for U.S.

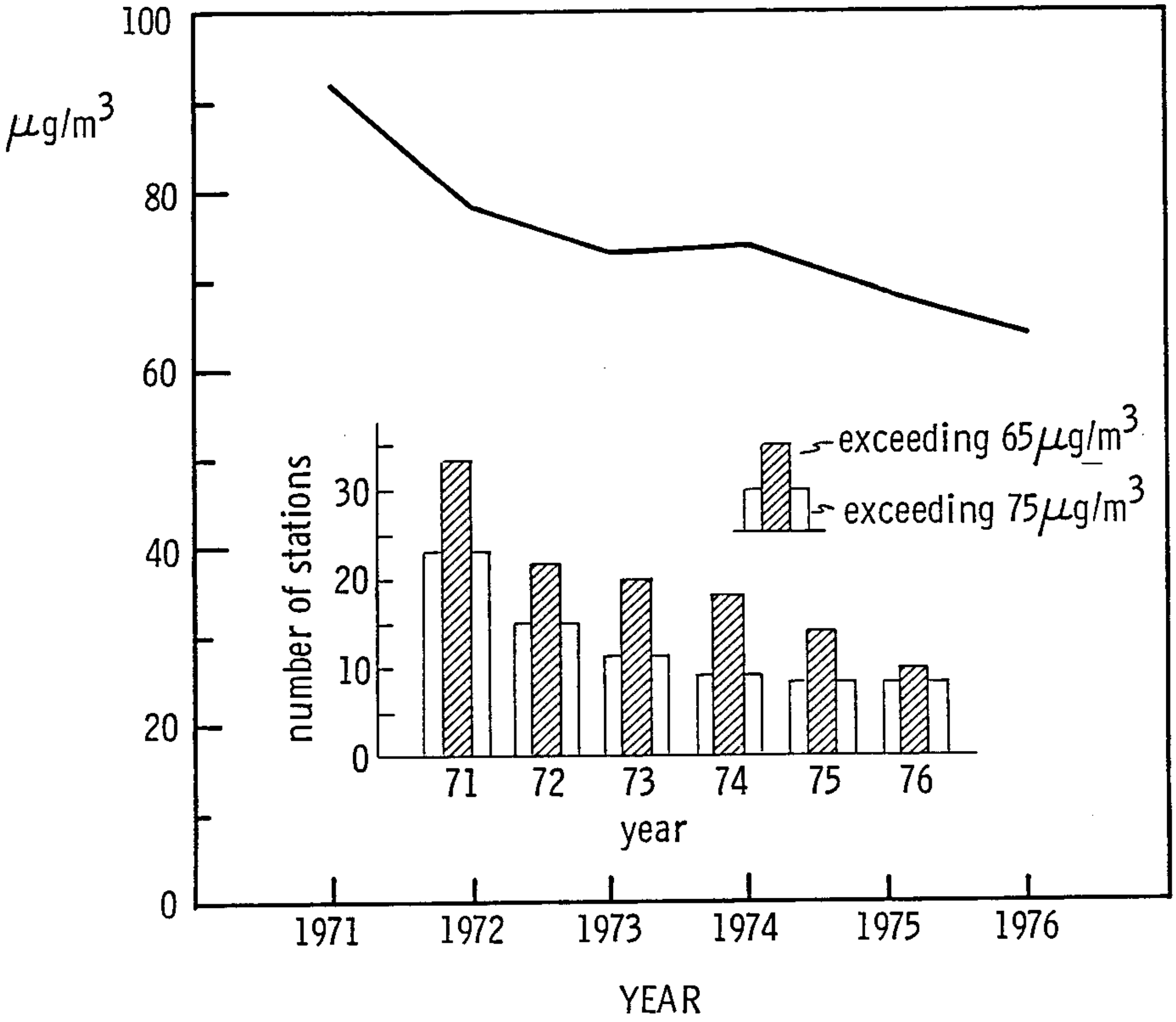

Figure II-3. The bar graph (insert) shows the number of violations of the State standards for total suspended particulates (TSP) for a set of 35 stations throughout Maryland. These stations have a continuous record since 1971 and exceeded one or the other of the "more adverse range" or "serious level" State standards at least once during this period. The graph on the top shows the composite means of the annual average of TSP for these stations. (The State Standards have since been replaced by Federal primary and secondary standards of 75 μg/m^3 and 60 μg/m^3, respectively.)

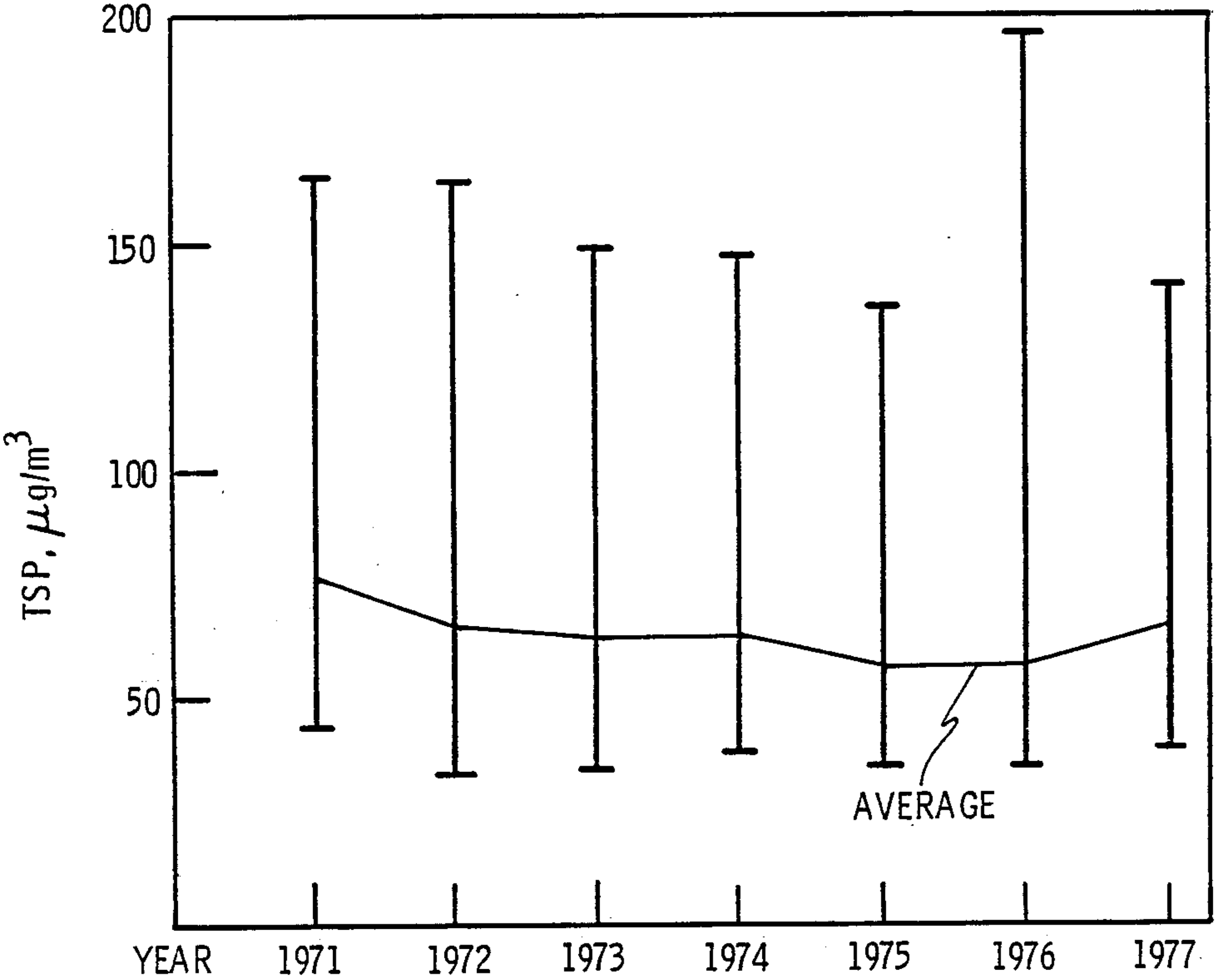

Figure II-4. Composite mean of the annual averages of total suspended particulates (TSP) for all Maryland stations with a continuous record for the six years shown. The bars indicate the range of values for the stations.

accounted for using known traffic density and emission rates per miles travelled. A set of baseline emission conditions have thus been established for 1973, and forward projections to 1985 have been made using expected rates of change in economic activities (including new power plants such as Brandon Shores) and population shifts, from Department of State Planning data.

The AQDM can only calculate ground-level concentrations under prevailing average conditions in a gross sense, and it does not account for localized effects (caused by conditions such as local wind patterns, detailed topography or any shielding effect) at any particular spot where measurements may be taken at a monitoring station. Although all known major emission sources are in the model, unknown small sources may be located near a monitoring station and affect its readings, although their impact on overall air quality may be negligible. Therefore, one must not expect a point by point agreement between calculated and measured value in any one area, particularly in an urban area. However, general overall distributions and trends should agree between the model and field measurements.

Figure II-5 shows the expected distribution of annual average TSP for the Baltimore area in 1973, 1980, and 1985, based on model runs (15). Used as trend indicators, the model runs show that the air quality of the region will change little over the next 10 years, and that the existing pattern of violations of the annual average will continue unless control efforts are intensified.

Other calculations for the 24-hour average indicate that this standard also will be violated regularly throughout a sizeable part of Baltimore City and the suburbs surrounding the industrial area (Essex, Sollers Point, Lansdowne, and Glen Burnie) unless corrective measures are taken (15).

An additional problem with the TSP levels (not considered in the model runs) has resulted from the federal coal conversion program. At the present time, Morgantown, Dickerson, and Chalk Point Units 1 and 2, are burning 100% coal (as coal deliveries and emission constraints allow), as opposed to a coal /oil mixture. In the Baltimore area, Wagner Units 1 and 2, Riverside and Crane, are now burning oil and are under active consideration for coal conversion. The Department of Energy (DOE) is studying the impacts of these conversions and is expected to announce the results of its study by the end of 1979.

To meet State emission control limitations at these three plants would require substantial investment in precipitators. Recent estimates range from 18 to 30 million dollars per unit (17). Even with this equipment, the additional impact of coal burning on the Baltimore Airshed may be sufficient to warrant a negative decision for conversion of one or more of these plants. The DOE study will include an evaluation of this impact.

Two power plants, Chalk Point and Dickerson, are presently not in compliance with particulate emission limitations. The precipitators on the older units at these plants need to be upgraded to modern standards. Plans have been submitted that will achieve final compliance by July 1, 1979 in accordance with the Clean Air Act Amendments. The new Chalk Point #3 unit was recently damaged by fire. Final repairs and upgrading started in January 1978. No final compliance deadline has been set.

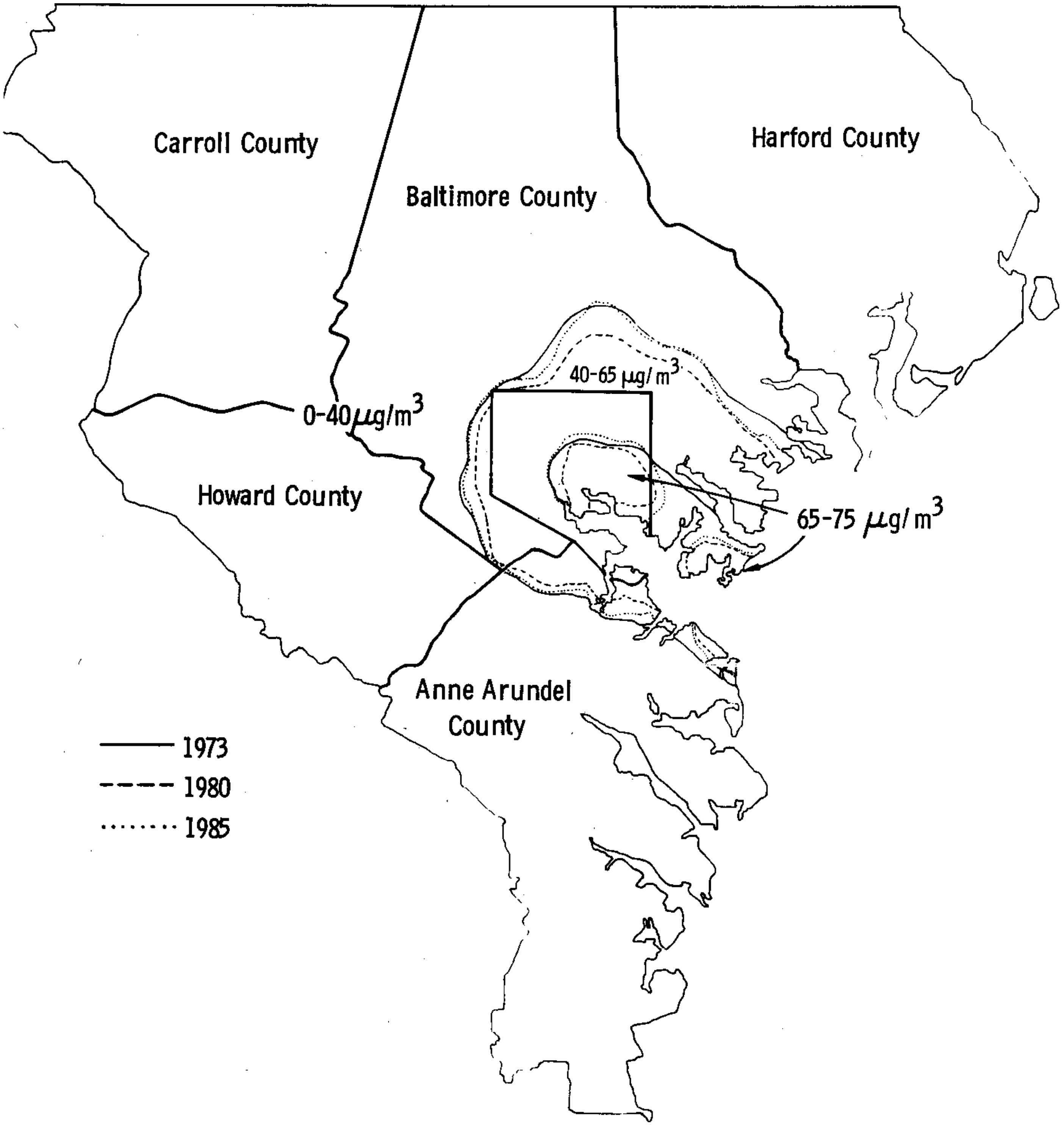

Figure II-5. Estimates of total suspended particulates ground-level concentrations by the Maryland Bureau of Air Quality and Noise Control

Sulfur Dioxide (SO_2)

From 1964 to 1975 there was a decrease of about 60 percent in the composite annual SO_2 arithmetic means from 32 stations throughout the U.S. (14). Most of the improvement (a 50 percent decrease in the composite mean) occurred between 1964 and 1971 and was much greater for the "dirty" areas than for the "clean" areas. In the industrial northeast, the "dirtiest" region, the annual mean fell from almost 90 $\mu g/m^3$ in 1964 to a little above 40 $\mu g/m^3$ in 1971.

Recent trends (1970-1976) are shown in Figure II-6 for a much broader sample of 722 stations throughout the U.S.A. (11). Plots of national emissions (Figure II-7) show that, during the period when SO_2 ground-level concentrations decreased by 50 percent (1964 to 1971), the total SO_2 emissions increased by more than 20 percent (27 to 33 million tons per year). This apparent inconsistency can largely be explained by the following considerations. First, most air quality monitoring stations are located in urban areas whereas large power plants, the most important source of the increase in emission (Figure II-7), are increasingly being located in rural areas. They contribute little to urban pollution levels because of distance, their tall stacks, and high buoyancy flux; all of which increase the SO_2 dispersion. Secondly, the SO_2 emissions in and around the cities have decreased markedly as clean fuels, such as low sulfur oil and gas, have replaced coal and high sulfur oil for space heating in residential and commercial establishments. The effect of this fuel replacement is small on national emissions but large on local air quality.

Maryland SO_2 data generally follow the national trends up to 1970 (12). Since 1972, there has been some improvement in SO_2 ground-level concentrations, which have been in compliance with the air quality standards. Figure II-8 shows the trend at several stations across the State since 1973. Figure II-9 shows a seasonal trend in the SO_2 concentration (measured by the flame photometric method). Higher levels in the heating months (first and fourth quarters) further indicates that a large contribution to the SO_2 level comes from local sources, primarily space heating units (most Maryland power systems have higher summer than winter loads, see Chapter I).

Predictions by the AQDM for 1973, 1980, and 1985 (see Figure II-10) indicate that the SO_2 air quality will change little through these years, and that no violations of current SO_2 standards are expected (15). As with TSP, the heaviest SO_2 pollution will be in the industrialized southeastern part of the city and the adjoining suburbs.

A special study was made using the AQDM to compare the contribution from BG&E power plants to the SO_2 level in this critical industrialized area of Baltimore to that from a group of 23 industrial sources (17). Table II-4 shows the calculations of the BG&E plants contributions to the SO_2 ground-level concentration. The detailed data (not shown here) reveal that, as a group, these power plants are either the second or third largest contributor at each of the receptor points shown. However, their total contribution to the ground-level concentration (about 17 percent) is far below their contribution to SO_2 emission (55 percent). In contrast, the 23 other industrial sources contributed 70 percent or more of the ground-level SO_2 concentration (at most of the receptor points) from only 31 percent of the total emissions. It appears that distributed sources, e.g., from home heating units, are not adequately accounted for in the

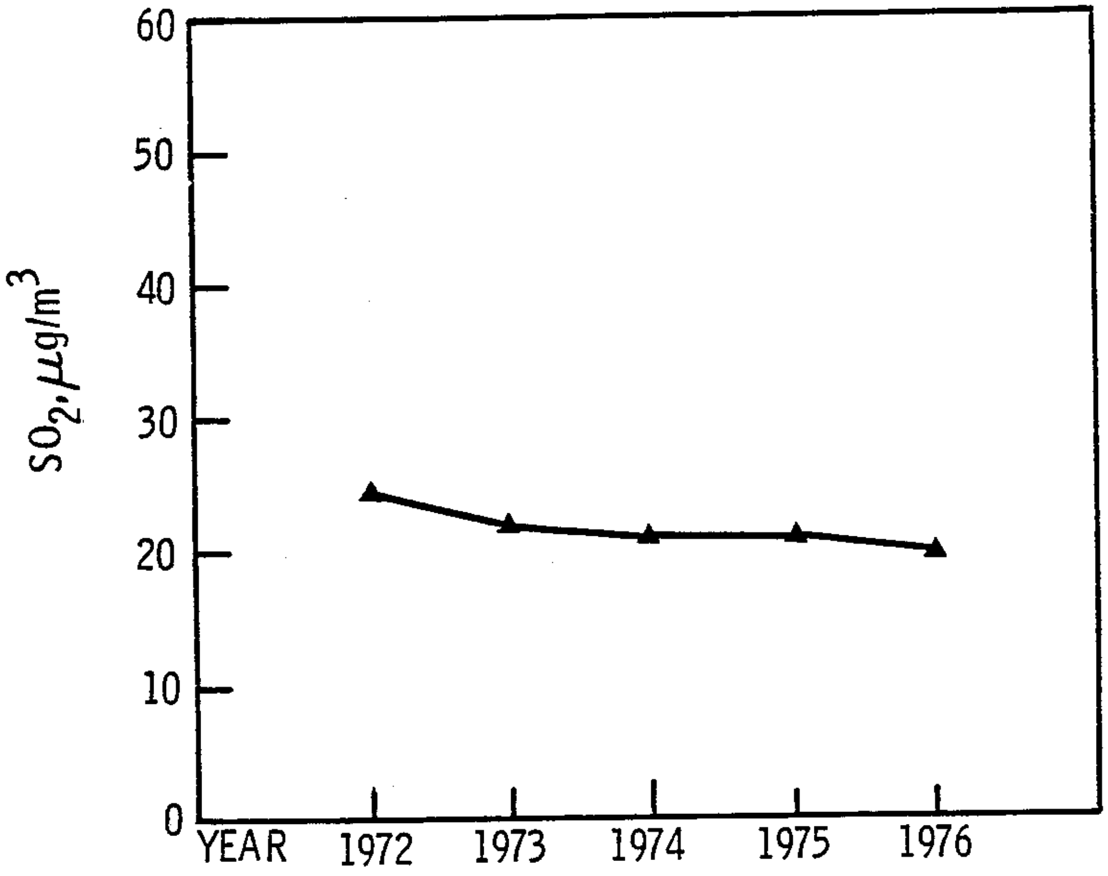

Figure II-6. Composite average of annual mean SO_2 concentrations at 722 U.S. sampling sites.

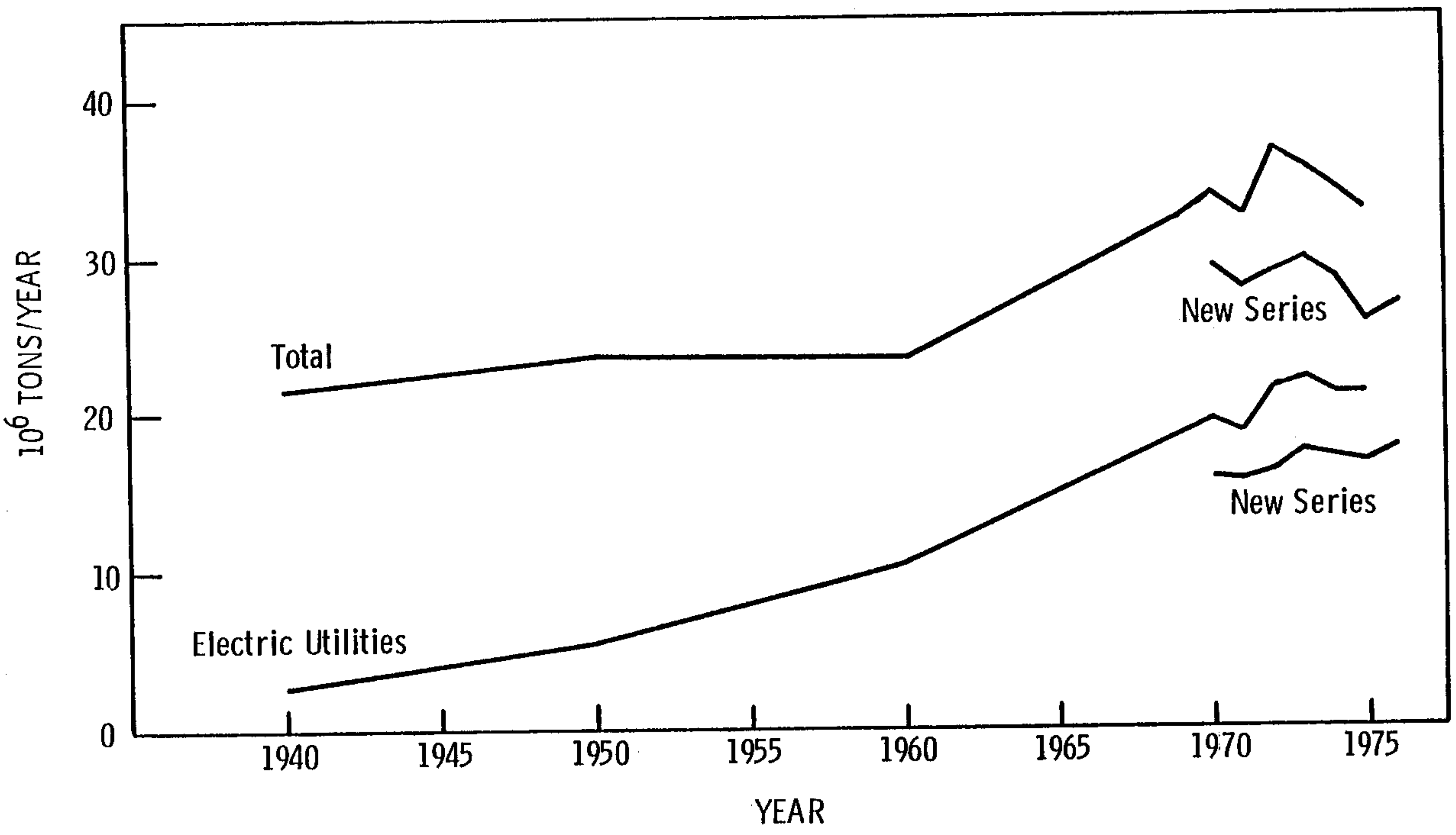

Figure II-7. Long-term trends in U.S. SO_2 emissions. New Series starting in 1970 are based on improved estimating techniques.

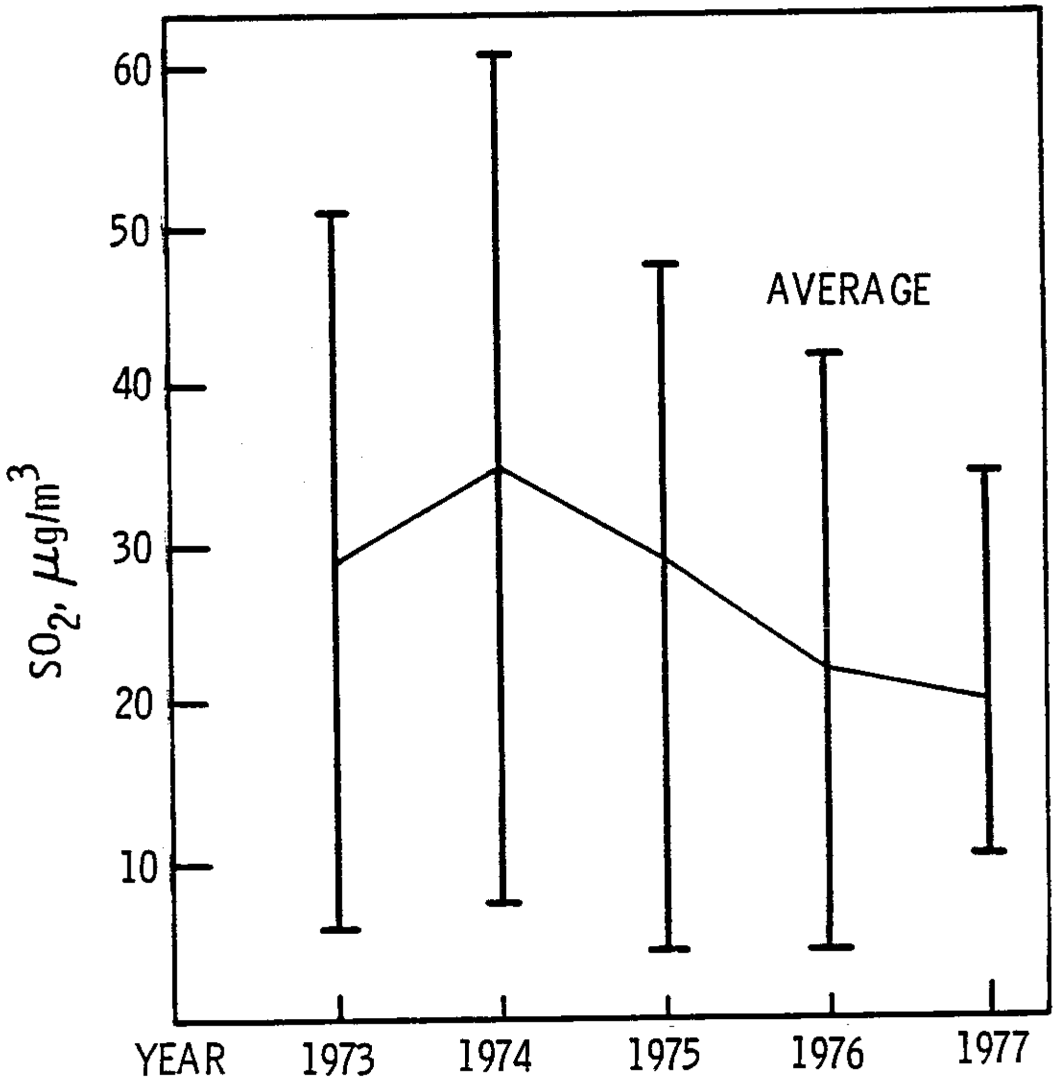

Figure II-8. Composite mean of annual arithmetic averages of SO_2 for those stations in Maryland with complete data for entire year. Measurements are by the flame photometric method, which was introduced in 1972, and has full-year coverage since 1973. Ranges of values indicated by the bars.

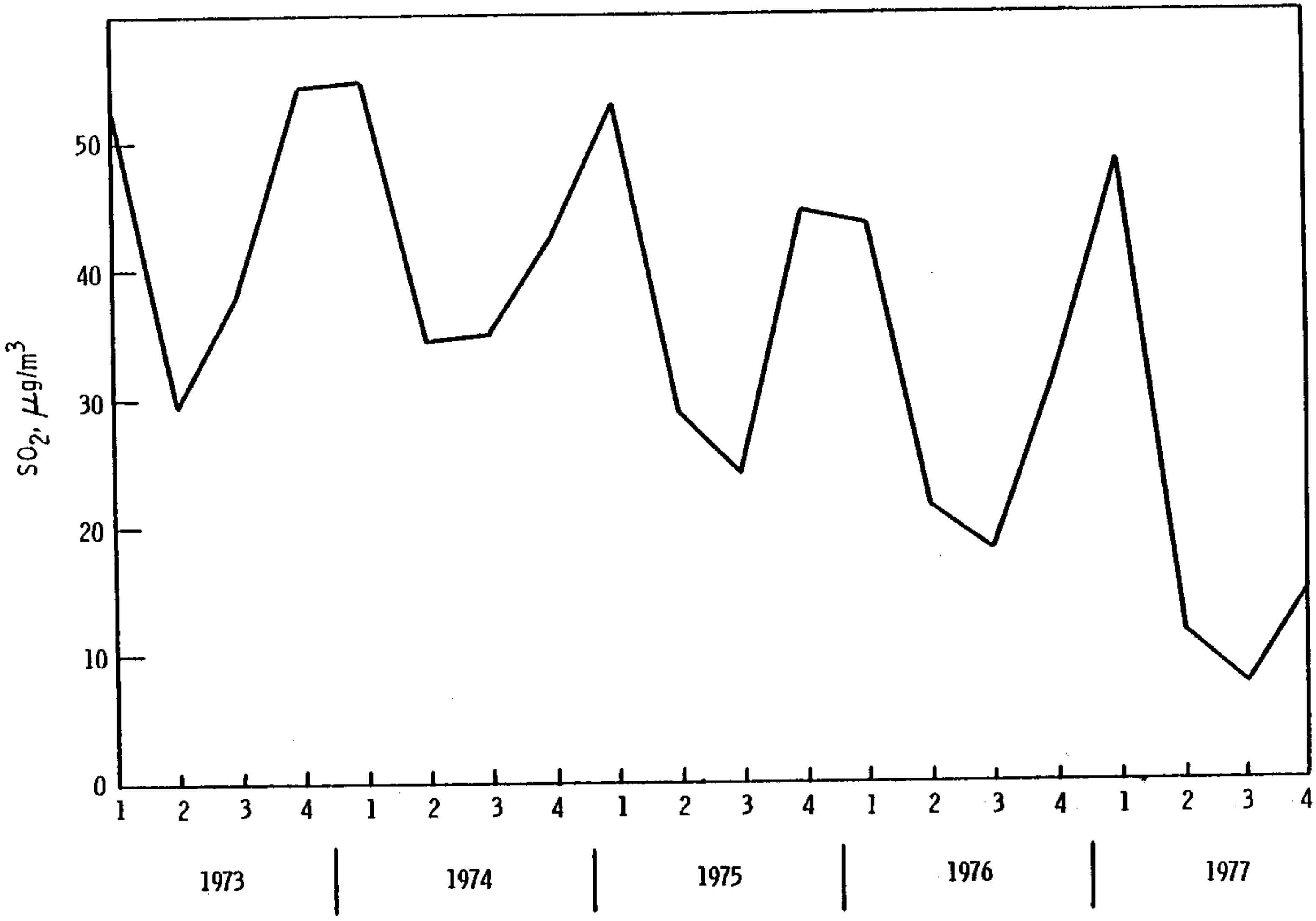

Figure II-9. Seasonal trend in SO_2 ground-level concentration. Average for all Baltimore City and County stations (Flame Photometric Method).

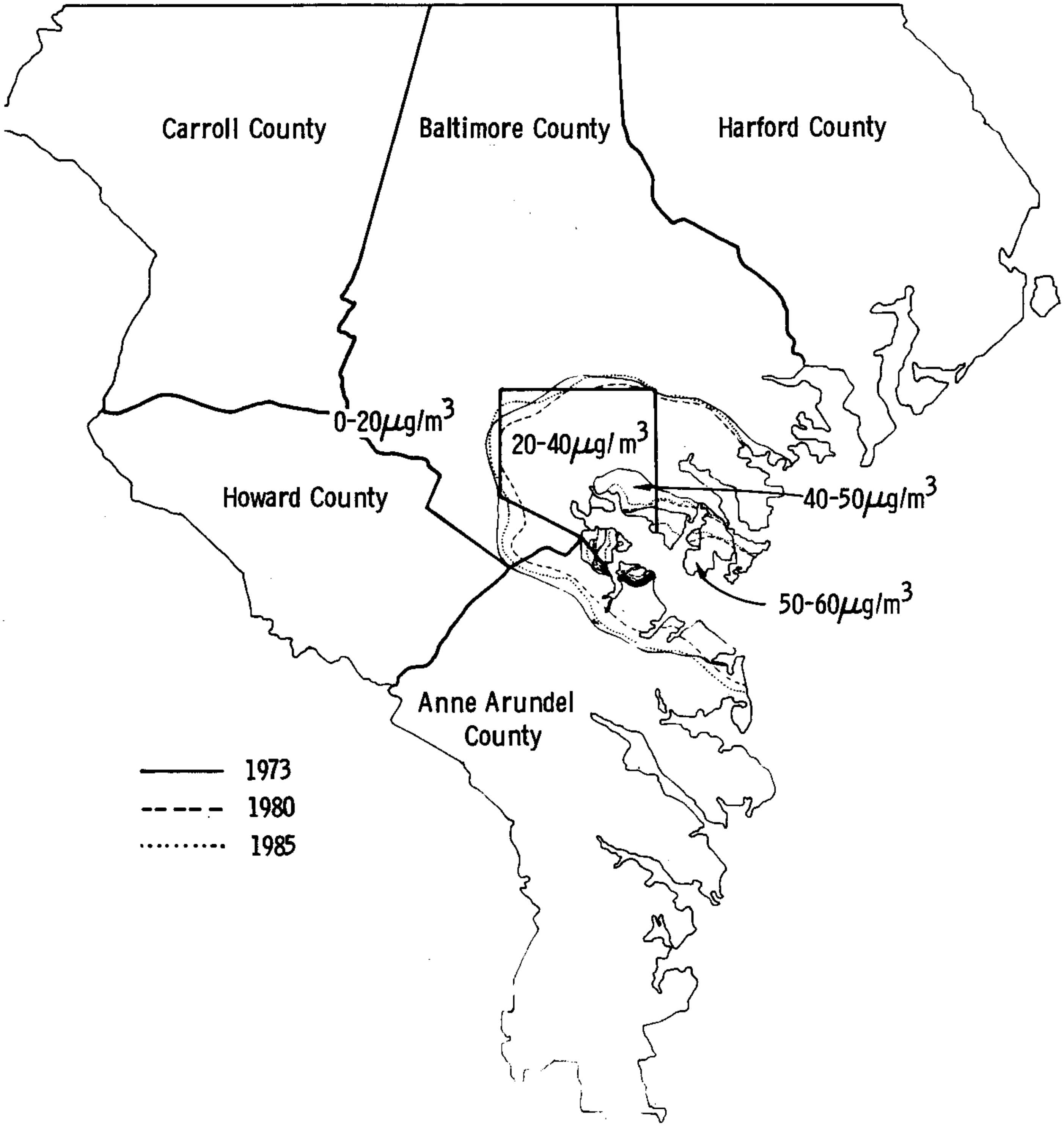

Figure II-10. Estimates of SO_2 ground-level concentrations by the Maryland Bureau of Air Quality and Noise Control

Table II-4. Calculate contribution to SO_2 ground-level concentrations from BG&E power plants compared to contributions from 23 other industrial sources at various receptor points in greater Baltimore.

Receptor Point	Percentage Contribution from BG&E Plants[a]	Percentage Contribution from other named Pollution Sources[b]
	1973 Conditions	
Sun and Chesapeake	15	73
Fort McHenry	18	70
Patapsco Sewage Treatment Plant	12	79
Reed Street	21	75
Essex	18	69
Sollers Point	12	79
Riviera Beach	27	64
Fort Howard	14	79
Sparrows Point High School	17	76
Sandy Plains	18	70
Cleaners Hangers	13	70
Fire Department #22	15	70

(a) The plants are: Crane, Riverside, Westport, Gould and Wagner. Calculations are rounded to nearest percentage point. These plants emitted 71,300 tons SO_2 in 1973.

(b) A total of 23 individual sources, which emitted 40,800 tons SO_2 in 1973.

calculations, since the total contributions shown in Table II-4 from the named sources adds up to about 90 percent of the GLC.

Nitrogen Oxides (NO_x)

Nitrogen oxides are formed in the power plant combustion process primarily by interaction of atmospheric nitrogen and oxygen at high temperature. There has been a national trend toward increasing ground-level concentrations of both nitric oxide (NO) and nitrogen dioxide (NO_2). Historical data for these pollutants is extremely limited. The Federal Continuous Air Monitoring Program (CAMP) shows increases of 13, 6, and 9 percent in NO, NO_2, and total NO + NO_2 ground-level concentrations, respectively, for the period 1964 to 1971 at the five urban CAMP sites (14).

The NO_x emissions from both power plants and motor vehicles have shown an increasing trend, but since 1976 the emissions from motor vehicles have stabilized because the increase in miles travelled has been offset be decreased emissions due to automotive pollution control devices (18).

Figure II-11 shows the trends in Maryland for the annual average ground-level concentration of NO_2 (12). It is difficult to separate power plant contributions from those of other sources.

Other Pollutants

Particulate Constituents. There are national and state standards for suspended particulate matter and state standards for settleable particulate matter. Because particulates are known to cause disease and discomfort, several constituents of particulates are being monitored, although there are no specific standards for their concentration level. One group of such constituents is the benzene soluable organic (BSO) portion (about 3 to 5 percent) of total suspended particulate matter in the ambient air. Polycyclic aromatic hydrocarbons, many of which are present in the BSO fraction, have been linked to cancer in animals, and one of them, Benzo-a-pyrene (BaP), is believed to be potentially carcinogenic in humans (19,20).

Power plants have relatively low hydrocarbon emissions because of their efficient combustion process, and the main sources of BSO are probably burning coal for space heating. A decrease of 50 percent of this activity from 1960 to 1970 (see Figure II-12) was probably the major reason for the declining trend in BSO and BaP (20). Controls on automotive combustion may be another factor. Since power plant coal consumption doubled from 1960-70 (Figure II-12) while the BSO level decreased, it is evident that power plants must have a minor effect on urban BSO levels. A definite seasonality in the BSO ground-level concentrations is also evident.

Sulfates. The sulfur emitted into the atmosphere is ultimately removed primarily by precipitation and dry deposition on the ground. Most of the SO_2 is converted to sulfate, either before or during this removal process. Global mass balance estimtaes yield atmospheric residence time for sulfur compounds in the range of 1 to 8 days, suggesting that long-range transport of sulfate is

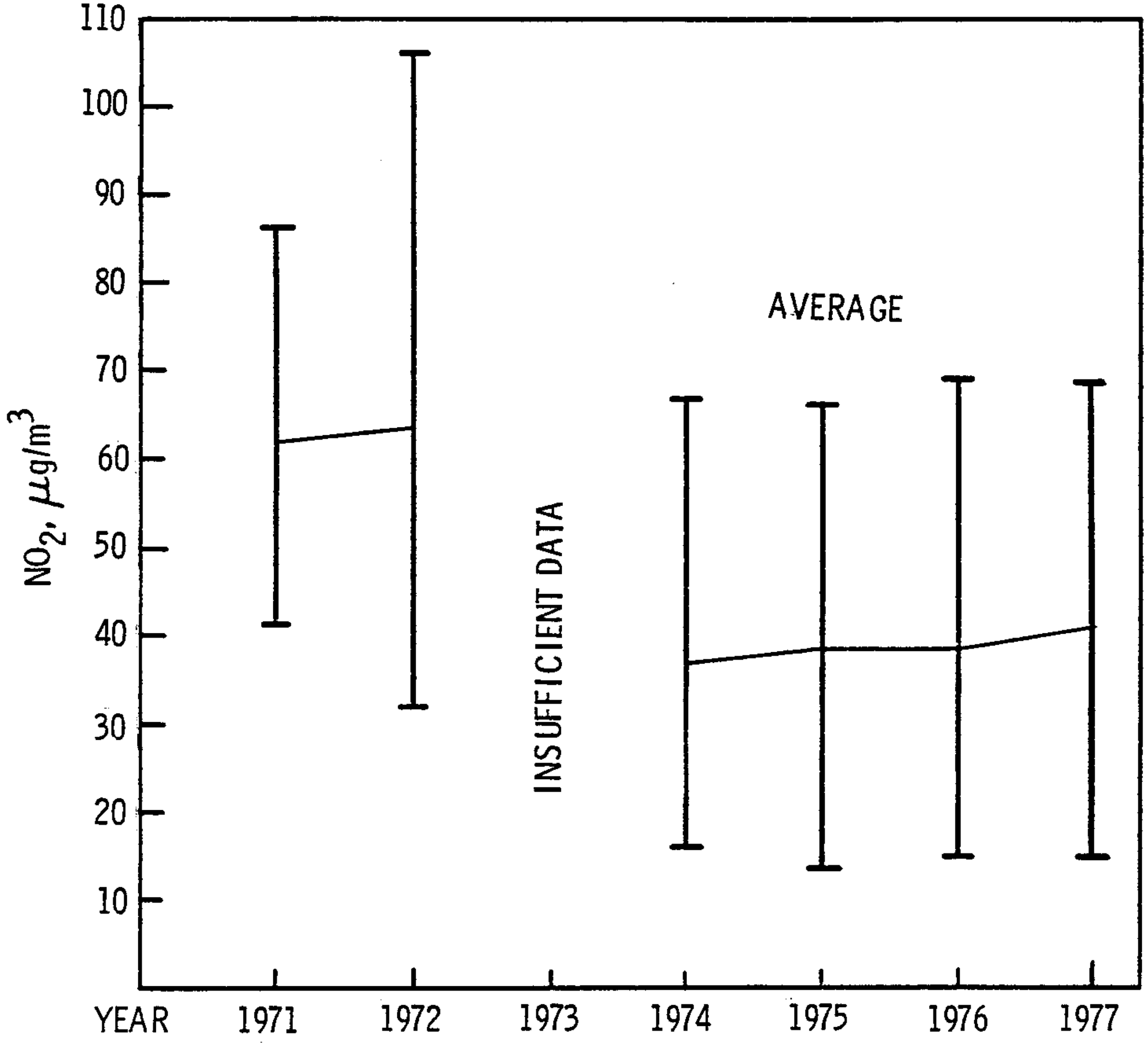

Figure II-11. Composite mean of annual arithmetic averages of NO_2 concentrations (measured by 24-hr gas bubbler) for Maryland since 1971. Ranges of values are indicated by the bars.

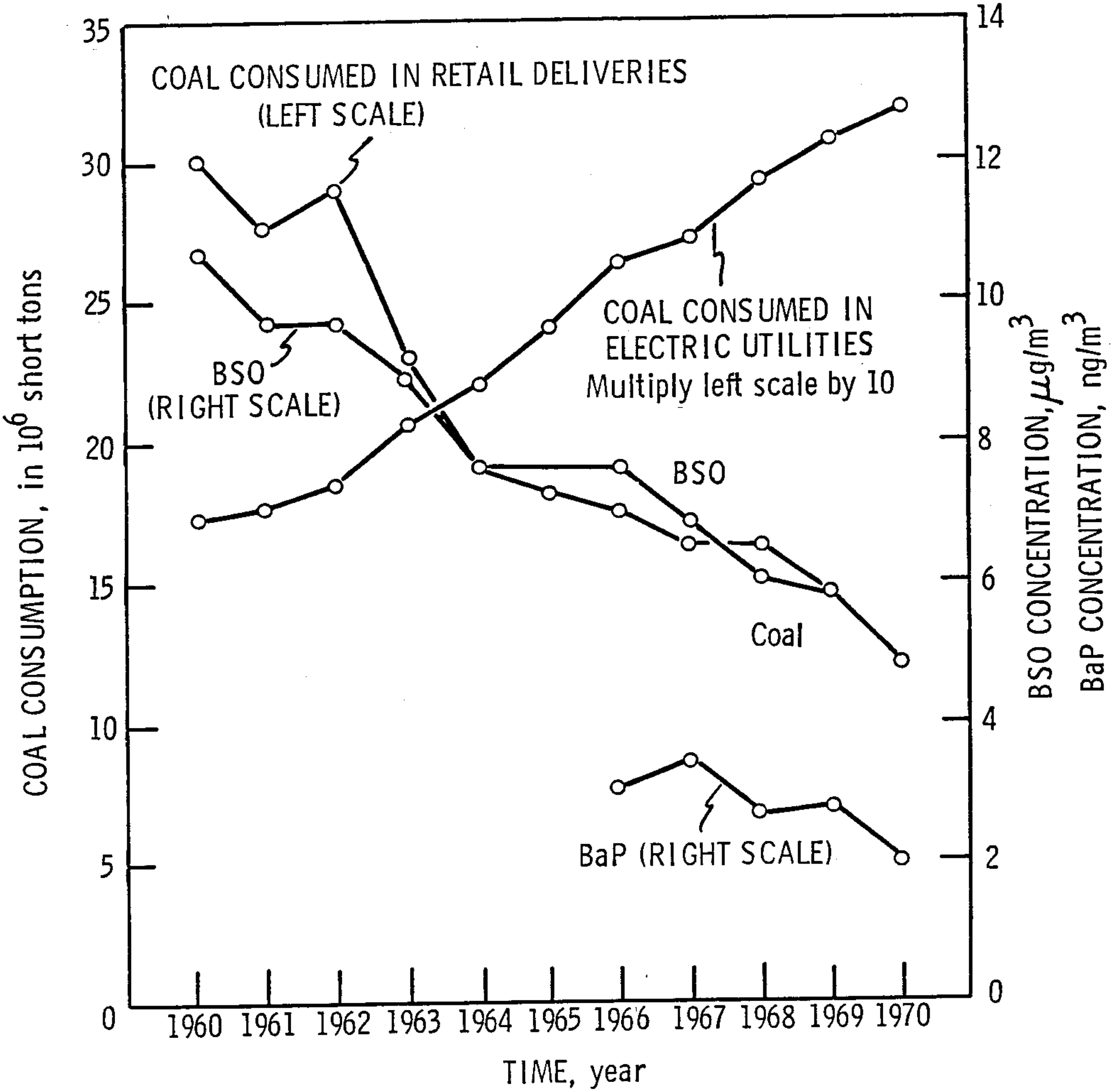

Figure II-12. Trends in national power plant and retail coal consumption, and in BSO and BAP annual averages. Utility coal consumption annual cumulative growth rate is approximately 7.2 percent from 1961 to 1971.

possible (21). A major concern is the possibility of long-range transport from the industrialized midwest into Maryland.

The various mechanisms for sulfate formation are poorly understood. The oxidation of SO_2 and its ultimate transformation into sulfates involve several reactive agents, such as fine particulates, ammonia, catalytic metals, and photochemical reactants. Sulfate formation rates are usually enhanced by high humidity and temperature. Rates of SO_2 oxidation in the ambient air are thought to range between 0.035 and 11.7 percent per minute (22).

It has been observed that SO_2 oxidation rates in power plant plumes for distances of up to 30 miles are 1 to 2 percent per hour for coal-fired plants and 10 to 20 percent per hour for oil-fired plants (23). This difference is explained as follows. In oil-fired plants, more metallic catalysts (e.g., vanadium) are present and accelerate the oxidation. Additionally, in the coal-produced plumes, SO_2 oxidation is originally inhibited by high concentrations of NO (nitric oxide), which will be preferentially oxidized to NO_2 by background oxidants. However, as the plume progresses downwind, several other factors enter into the oxidation process: NO is depleted as more ambient oxidants are encountered, NO_2 participates in a photochemical process leading to oxidation of SO_2, and ammonia (possibly of rural origin) in the ambient air acts to control one of the more important conversion mechanisms. Thus, the extent of SO_2 oxidation can depend more on concentrations of other precursors than on the concentration of SO_2 itself. Therefore, a reduction in ambient SO_2 level may not always produce a corresponding decrease in sulfate production, if these precursors are limited (24).

Nationwide, there has been a general decrease in urban SO_2 levels of more than 50% between 1960 and 1970, but there is no consistent trend for urban sulfates (14). A combination of long-range transport and the complex precursor relationship may account for this. The decreased SO_2 emissions in the cities reduce the local sulfate component, whereas the increased rural emissions, mostly from power plants, may have caused an influx of transported sulfates off-setting the decrease in the locally formed sulfates. Figure II-13 shown a comparison of Maryland quarterly averages of SO_2 and sulfates from 1976, when the sulfate measurements began (12).

Although there is mounting evidence of health hazards, no sulfate ground-level concentration standards have been established. EPA's current position is that not enough is known about sulfate formation and its health effects to warrant immediate establishment of standards (25). While standards are being formulated, control of sulfates will be attempted through maintenance of control of the precursor pollutants: SO_2 and particulates. Enforcement of state implementation plans for control of SO_2 and particulates, and increasing application of new source performance standards to power plants are thus relied on to reduce the rate of increase in the ambient sulfate levels.

Photochemical Oxidants and Hydrocarbons. Photochemical oxidants, mainly ozone (O_3), are pollutants of increasing concern. The mechanism of ozone formation in the atmosphere is not completely understood. There is complex relationship between precursor pollutants, particularly non-methane hydrocarbons (NMHC) and NO_x, possibly transported over considerable distances, and the creation of O_3 (26). In this respect, the situation is analogous to the SO_2-sulfate

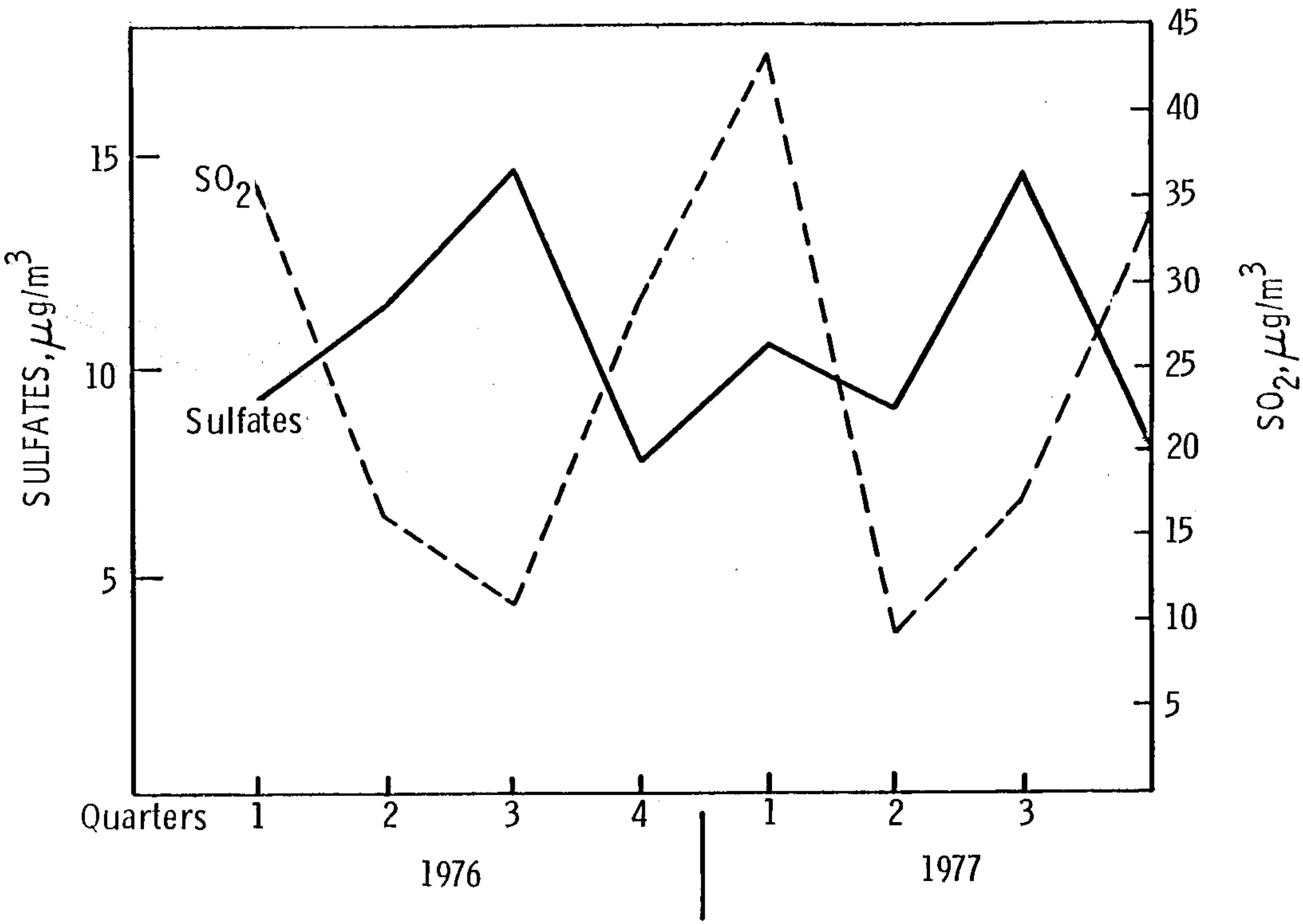

Figure II-13. Composite quarterly means of sulfate ground-level concentration since first quarter of 1976 when measurements began in Maryland. Also shown is the composite means of SO_2 for all stations using the flame photometric method.

relationship. Ambient air quality standards exist for both photochemical oxidants (measured as ozone) and hydrocarbons. The hydrocarbon standards are not based on any direct adverse effect of hydrocarbons, but rather on an empirical relationship, based on measurements, between hydrocarbon concentrations in the morning (the 3 hour period from 6 am to 9 am EST is the determining period in the Maryland Standards) and oxidant concentration occurring later during the same day. The hydrocarbon standard is designed primarily to achieve the standard for photochemical oxidants. In view of the lack of an exact quantitative relationship between the two constituents, and because hydrocarbons are difficult to identify and measure, the levels specified for hydrocarbons should be considered as guidelines only.* The standards are therefore not enforced. Both the oxidant and the hydrocarbon standards are consistently violated throughout the U.S., and Maryland is no exception. EPA is presently in the process of formulating a policy for control of photochemical oxidants. One of the major concerns is ozone formation in rural areas, caused by heavy influx of hydrocarbons transported from large population centers. Since a 1000 MW power plant typically emits 250 tons of non-methane hydrocarbons per year, any regulation of hydrocarbon could have a significant impact on power plant siting (see also Section G).**

E. Pollution Control

Ambient air quality can be improved by reducing emissions of pollutants from power plants (via emission control, conservation, cleaner fuel, or switching to alternatives such as solar or nuclear) or by enhancing dispersion. At present, emission controls are necessary for fossil-fueled power plants.

The need for emission control can be assessed by comparing emission factors to allowable emissions under the new source performance standards (NSPS). Table II-5 relates the new source performance standards to the emissions resulting from burning coal, oil, or gas without any emission control. Although it appears from the table that the new source performance standards for NO_2 cannot be met without additional emission control for any of the three fuels, it is possible to control combustion in a modern power plant boiler so that the NO_2 standard can be met.

Table II-5 shows that natural gas is the only fuel for which particulate emission control is not needed in order to comply with NSPS. For coal with an ash content of 15 percent, precipitators with an efficiency of about 99.7 percent would be necessary for plants using this fuel. Modern precipitator technology has progressed to the point where efficiencies exceeding 99 percent can be obtained (29), however, these efficiencies are often critically dependent on fly ash composition and sulfur content and must be carefully monitored.

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* There is considerable dispute on the ability of hydrocarbon control alone to reduce photochemical oxidant levels (27).

** Based on EPA emission factors (13). These factors are now under revision and may be reduced significantly (28).

Table II-5. Comparison of new source performance standards (NSPS) for emissions (in pounds per million BTU) and emission factors (in the same units) for combustion in utility boilers

POLLUTANT	PARTICULATE MATTER			SULFUR DIOXIDE			NITROGEN DIOXIDE		
FOSSIL FUEL AND FURNACE TYPE	STANDARD Old	STANDARD New	EMISSION FACTOR	STANDARD Old	STANDARD New*	EMISSION FACTOR	STANDARD Old	STANDARD New	EMISSION FACTOR
Coal	0.10	0.03		1.2	1.2		0.70	0.60 (0.50)	
Pulverized:									
general			0.67A			1.58S			0.75
wet bottom			0.54A						1.25
dry bottom			0.71A						0.75
cyclone			0.08A						2.29
Fuel Oil	0.10	0.03		0.80	0.80		0.30	0.30	
Tangentially fired			0.055			1.08S			0.34
Other									0.72
Natural Gas	0.10	0.03		No std.	0.80		0.20	0.20	
Tangentially fired			0.014			0.00055			0.27
Other									0.64

Note: The old standards did not apply to lignite. The new NO_x coal standard of 0.60 applies to bituminous coal, and 0.50 applies to subbituminous coal, shald oil, or any solid, liquid, or gaseous fuel derived from coal. There is no SO_2 NSPS for natural gas. A is ash content of coal in percent by weight. S is sulfur content in percent by weight.

Emission factors have been converted from the weight and volume units to BTU's using the following conversion, which approximates Maryland conditions:

Coal: 12,000 BTU/lb = 24 x 10^6 BTU/ton
Oil : 145,000 BTU/gal = 145 x 10^6 BTU/thousand gals
Gas : 1,100 BTU/cu ft = 1,100 x 10^6 BTU/million cu ft

Emission factors are only approximate guidelines and may be on the conservative (high) side. The emission factor of 1.58S for sulfur dioxide assumes that 95 percent (by weight) of the sulfur in the coal is released as sulfur dioxide.

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* The new NSPS also requires a reduction (presumably by scrubbing) by 85 percent of the uncontrolled SO_2 emissions from solid, liquid, and gaseous fuel.

The old (1971) NSPS could be met through use of clean (or cleaned) fuels. For example control of SO_2 emission was not needed for gas. Oil could meet the emission standards, provided that the sulfur content was about 0.8 percent or lower. Attainment on this level presents no technical problem, although there may be a related economic penalty (see Table II-7). SO_2 emission control for coal-burning power plants could potentially be met by:

- use of coal of inherently low sulfur content (< 0.8 percent)
- cleaning of coal
- conversion of coal to cleaner fuels
- advanced combustion systems (fluidized bed combustion)

Extensive research programs funded by private and public interests, are underway in these areas as discussed below. The requirement of the new (1978) NSPS that all power plant effluents must be scrubbed for SO_2 reduction may remove much of the economic incentive for development of these technologies, although credit for pre-cleaning of the fuel will be given in the form of an easing of the SO_2 percent reduction requirements. The technologies discussed below will probably be commercially available for power plant operations in the 80's (30). Many of these technologies are not complicated for some small scale uses but are difficult to transfer to the scale of power plant fuel consumption and large volume of effluents.*

Use of Low Sulfur Coal

Table II-6a shows the estimated measured and indicated reserves of coal by sulfur content (18,31). Although reserves of Eastern and Western coal are roughly equal, it is seen that the preponderance (86 percent) of the "clean" coal (S < 1 percent) is in the West. In the East (Table II-6b) the preponderance of this clean coal is in West Virginia (53 percent) compared to Maryland's share (0.6 percent).

Coal demand by U.S. utilities by 1980 is projected to be about 620 million tons (32), of which about one half will have a sulfur content low enough to comply with the NSPS of 1.2 lb SO_2 emission per million BTU. This compares to a 1974 consumption of 390 million tons, again with one half conforming to the current new source emission regulations. Availability of low sulfur coal, and the desirability of using it for burning in power plants, depend on several economic and energy-policy considerations. The price differential between low-sulfur and high-sulfur coal in the Washington area in 1975 is shown in Table II-7 (32). A change in demand and point of origin of the coal can shift these costs considerably. The capital cost of converting a plant from high-sulfur to low-sulfur coal also varies considerably. One recent estimate is $20 per kW, which

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* A high efficiency 500 MW unit burns about 190 tons of coal per hour, 1.3×10^6 tons per year at 80% utilization, and will exhaust 1.16×10^6 cubic feet of air per minute (at 20% excess air), assuming 38 percent efficiency (9,000 BTU/kWh) and 12,000 BTU/lb.

Table II-6a. Estimated in-place coal reserves in millions short tons

Sulfur Content in % S by Weight	S < 1	1 < S < 3	3 < S	Unknown	TOTAL
Eastern States					
Deep Mine Reserves	21,200	48,461	65,992	25,811	161,464
Strip Mine Reserves	5,302	6,822	15,434	4,936	32,494
TOTAL	26,502	55,283	81,426	30,747	193,958
Percent of Regional Total	13.7	28.5	42.0	15.8	
Percent of U.S. Total	6.2	12.9	19.0	7.2	
Western States					
Deep Mine Reserves	99,457	10,757	7,727	13,216	131,157
Strip Mine Reserves	67,866	26,774	3,516	5,106	103,262
TOTAL	167,323	37,531	11,243	18,322	234,419
Percent of Regional Total	71.4	16.0	4.8	7.8	
Percent of U.S. Total	39.0	8.8	2.6	4.3	

Table II-6b. Estimated in-place coal reserves in millions short tons for eastern states with major reserves.

Sulfur Content % S	<1	1<S<3	3<S	Unknown	Total
Maryland					
Deep Mine	106	624	171	0	902*
Strip Mine	29	67	16	35	146
Pa., Ky., Va., W. Va.					
Deep Mine	18,787	32,319	17,571	12,086	78,186
Strip Mine	4,988	3,466	2,608	3,265	14,336
Other Eastern States					
Deep Mine	2,327	15,518	48,250	13,726	82,428
Strip Mine	285	3,289	12,810	1,637	18,029
TOTAL					
Deep	21,220	48,461	65,992	25,812	161,516
Strip	5,302	6,822	15,434	4,937	32,511

* The Maryland Geological Survey estimates 855 million tons recoverable in Maryland of which an estimated 100 million tons could be recovered by surface mining techniques. Maryland production in 1975 was about 2.5 million tons. Peak production (1907) was about 5.5 million tons. Conventional underground mining allows recovery of 50-60 percent of coal in place.