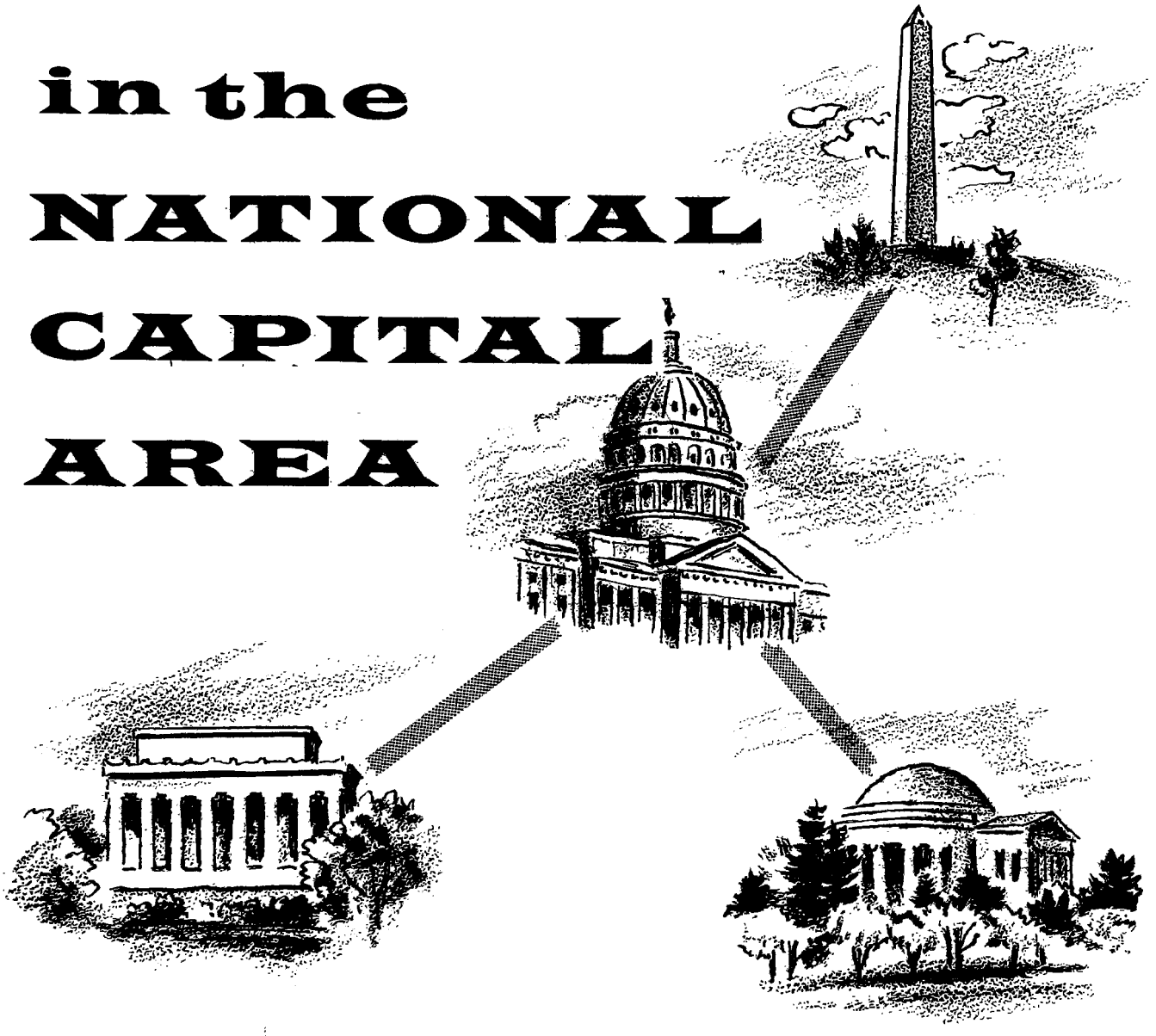
AIR POLLUTION in the NATIONAL CAPITAL AREA



U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

AIR POLLUTION IN THE

NATIONAL CAPITAL AREA

An appraisal made at the request of the
District of Columbia Department of Public Health

with the cooperation of the
Maryland State Department of Health and the
Virginia Department of Health

by

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U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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SUMMARY AND RECOMMENDATIONS

Air pollution in the Washington Metropolitan Area may be expected to increase rapidly, unless adequate control measures are taken. The Washington Metropolitan Area anticipates rapid and continued population growth, particularly in the urbanized areas adjacent to the District of Columbia, where sixty-two per cent of the Area's 2 million people already live. This growth rate - Area population more than doubled since 1940 - favors higher pollution levels in the future because of increasing pollutant emissions.

Despite topography and prevailing wind conditions generally favorable to dispersion of air pollutants, incidents of eye-irritating smog, visibility reduction, and plant damage have been experienced in the Area -- evidence that photo-chemical air pollution is becoming a serious problem. One or two prolonged periods of stagnating air masses, usually during late summer and fall, may be expected each year, with a subsequent accumulation of air pollutants.

Waste disposal operations such as incinerators, backyard burning, open burning dumps, the burning of leaves and wastes of construction and demolition are a significant contribution to the total air pollution problem, as are motor vehicle emissions, the combustion of coal and oil for heating, power generation, and industrial processes. And the use of natural gas, although lesser in magnitude, adds to emissions of certain gaseous pollutants present at levels higher than in some other cities of similar population. Even though previous studies indicate that the atmospheric particulate loading in Washington is lower than in most cities of comparable size, excessively high loadings do occur. All the named sources add to the total atmospheric burden and may be expected to become increasingly important as the Area continues to grow.

Enforcement of zoning laws in the Washington Metropolitan Area has not allowed the intermingling of residential, commercial, and industrial land uses and prevented some localized air pollution problems which otherwise would have occurred. This fact, along with the limited extent of manufacturing operations, has kept the industrial air pollution problem to a minimum. Nevertheless, each governmental jurisdiction has localized industrial areas that are significant from an air pollution standpoint. These small industrial areas are responsible for a large portion of the nuisance complaints made by the public to the respective governmental agencies, primarily concerning dusts, fumes, smoke, and odors from specific sources.

Local interest in air pollution already exists among officials and the general populace and to judge by newspaper reports is steadily increasing. Except for limited smoke abatement activities, the air pollution control program in the various local governmental jurisdictions is directed primarily toward investigation of nuisances and complaints. At the request of the District of Columbia Department of Public Health and with the cooperation of the Maryland State Department of Health and the Virginia Department of Health, the Public Health Service conducted an appraisal of factors relating to air pollution in the Washington Metropolitan Area. This appraisal was undertaken to determine the extent of the existing and potential air pollution problem and control activities, and to develop general recommendations for activities to meet present and future air pollution problems. This report is an analysis of information collected relating to sources of pollutants, indications of pollution levels, and status of local activities in the air pollution field.

Recommendations

The following recommendations are made on the basis of this appraisal and the general available knowledge relating to air pollution. A limited amount of data on atmospheric pollution levels was available from the National Air Sampling Network, from some limited studies conducted several years ago, and from a one-week pilot study that was recently conducted by the District of Columbia Department of Public Health and the Public Health Service.

The first section pertains to the District of Columbia and the second to the suburban areas of Maryland and Virginia that are adjacent to the District of Columbia.

The District of Columbia

1. Considering the nature and magnitude of the present and potential air pollution problem within the District of Columbia, it is recommended that a comprehensive air pollution control program be established. Such a program should provide not merely for smoke control, as at present, but for comprehensive air pollution control. The program should include:

a. Routine air quality monitoring to determine specifically the nature and extent of air pollution within the District.

b. An inventory of air pollution sources to provide current data on the quantity and types of air pollution emissions. Detailed sampling and evaluation of certain sources may be necessary to fully define specific emissions.

c. A public education program to disseminate complete and accurate information about the nature, effects, and costs of air pollution in the District.

d. A permit or registration system for the identification and control of non-combustion sources of air pollution. (Such a system exists for combustion sources.)

e. Investigation of air pollution complaints and, when indicated, initiation of appropriate abatement measures.

f. Implementation of additional air pollution abatement programs whenever new information indicates a need for them.

2. Necessary budget, personnel, and laboratory facilities should be provided to support the comprehensive air pollution control program outlined above.

3. A study and review should be made of existing regulations pertaining to air pollution control so that necessary revisions can be made.

4. Appropriate consideration should be given to planning and zoning activities to minimize the intermingling of industrial and residential areas.

5. An interdepartmental committee or council should be organized to coordinate the total air pollution program within the District of Columbia. This group should include representation from all of the District of Columbia governmental agencies directly concerned with air pollution control.

6. A Metropolitan Air Pollution Advisory Board or Council should be organized to provide leadership and cooperation for the development of coordinated efforts toward the study or control of air pollution in the Washington Metropolitan Area. This advisory group should include at least one representative from the agency responsible for air pollution control in the District of Columbia, in each of Montgomery and Prince Georges Counties in Maryland, and in Arlington and Fairfax Counties and the city of Alexandria in Virginia. Representatives of interested Federal and State governmental agencies should also be included.

The Suburban Areas

1. In view of the present and potential air pollution problems in the suburban areas of Maryland and Virginia that are adjacent to the District of Columbia, it is recommended that modest air pollution control programs be developed within the local governmental agencies. These programs should initially consider the following:

a. Investigation of air pollution complaints and initiation of abatement measures when indicated.

b. Public education activities to disseminate complete and accurate information about the nature, effects and costs of air pollution in the Washington suburbs.

c. Surveillance of air pollution problems

by means of periodic air sampling and identification of major air pollution sources.

d. Implementation of additional air pollution abatement programs whenever new information indicates a need for them.

e. Collaboration with other local governmental jurisdictions in the organization of a Metropolitan Air Pollution Advisory Board or Council for the coordination of efforts toward the study and control of air pollution in the Washington Metropolitan Area.

2. It is recommended that the individual programs develop long-range objectives for a comprehensive air pollution control program that would expand their activities to include:

a. Routine air quality monitoring.

b. Inventory and identification of air pollution sources.

c. Ordinances or regulations specifically for air pollution control.

d. Adequate budget, personnel, and laboratory facilities to support a comprehensive air pollution control program.

3. It is recommended that enabling legislation be obtained in Maryland and Virginia to allow the formation of interjurisdictional air pollution control districts. This would permit the establishment of a coordinated and unified air pollution control program in the Virginia portion of the Washington Metropolitan Area and another in the Maryland portion.

4. It is recommended that, contingent on the enactment of such legislation, the local governmental jurisdictions in Maryland and Virginia that are a part of the Washington Metropolitan Area seriously consider the formation of air pollution control districts within their respective States.

INTRODUCTION

The Area

Washington, D. C., capital of the United States and seat of the Federal Government, is situated between Northern Virginia and Southern Maryland on the east bank of the Potomac River about 100 miles above its mouth. The City of Washington is coextensive with the District of Columbia and has a total area of about 69 square miles, of which approximately 8 square miles are covered by water. (1) The altitude ranges from about 10 to 500 feet above sea level.

As defined by the U. S. Bureau of the Census, the Washington Standard Metropolitan Area consists of Washington, D. C., Montgomery and Prince Georges Counties in Maryland, Arlington and Fairfax Counties in Virginia, and the independent Virginia cities of Alexandria and Falls Church. (2) The term Washington Metropolitan Area, as used in this report, means the standard metropolitan area as defined above. Washington, D. C., and the immediately adjacent urbanized areas of Maryland and Virginia (Figure 1) comprise the area of particular interest because they contain practically all of the metropolitan area population and industry. The outlying areas of Montgomery and Prince Georges Counties in Maryland and Fairfax County in Virginia are primarily rural with a population density less than 1000 per square mile.

Local Interest in Air Pollution

During June 1959 the Washington Metropolitan Area experienced a four day episode of eye irritating smog. The following December a local newspaper published a series of five informative articles dealing with the air pollution problem, especially that due to automobile exhaust, in the Washington Metropolitan Area.

In May of 1960, the Engineer Commissioner for the District of Columbia and the Metropolitan Area Traffic Council organized an Automotive Nuisance Abatement Committee of that Council. This Committee was established to promote the control of obnoxious noises, smoke, and fumes from automotive equipment operated within the Washington Metropolitan Area. As a result of several committee meetings and other activities, the District of Columbia Board of Commissioners in July of 1960 proposed that the District of Columbia Fuel Burning Equipment Regulations and the Traffic and Motor Vehicle Regulations be amended to require reduction of air pollution from certain sources. Following public hearings, the Traffic and Motor Vehicle Regulations were amended in September 1960 and the Fuel Burning Regulations were amended in April 1961.

In July of 1960 the District of Columbia Department of Public Health requested that the Public Health Service Regional Office in Charlottesville, Virginia, conduct a study of the total environmental health problems and programs in the District of Columbia. The Technical Assistance Branch of the Division of Air Pollution completed that portion of the environmental health study pertaining to air pollution. It was later agreed that in addition to complying with the original request the air pollution study should be expanded to provide a general appraisal of the total air pollution problem in the Washington Metropolitan Area and general recommendations for the guidance of local officials.

The Study

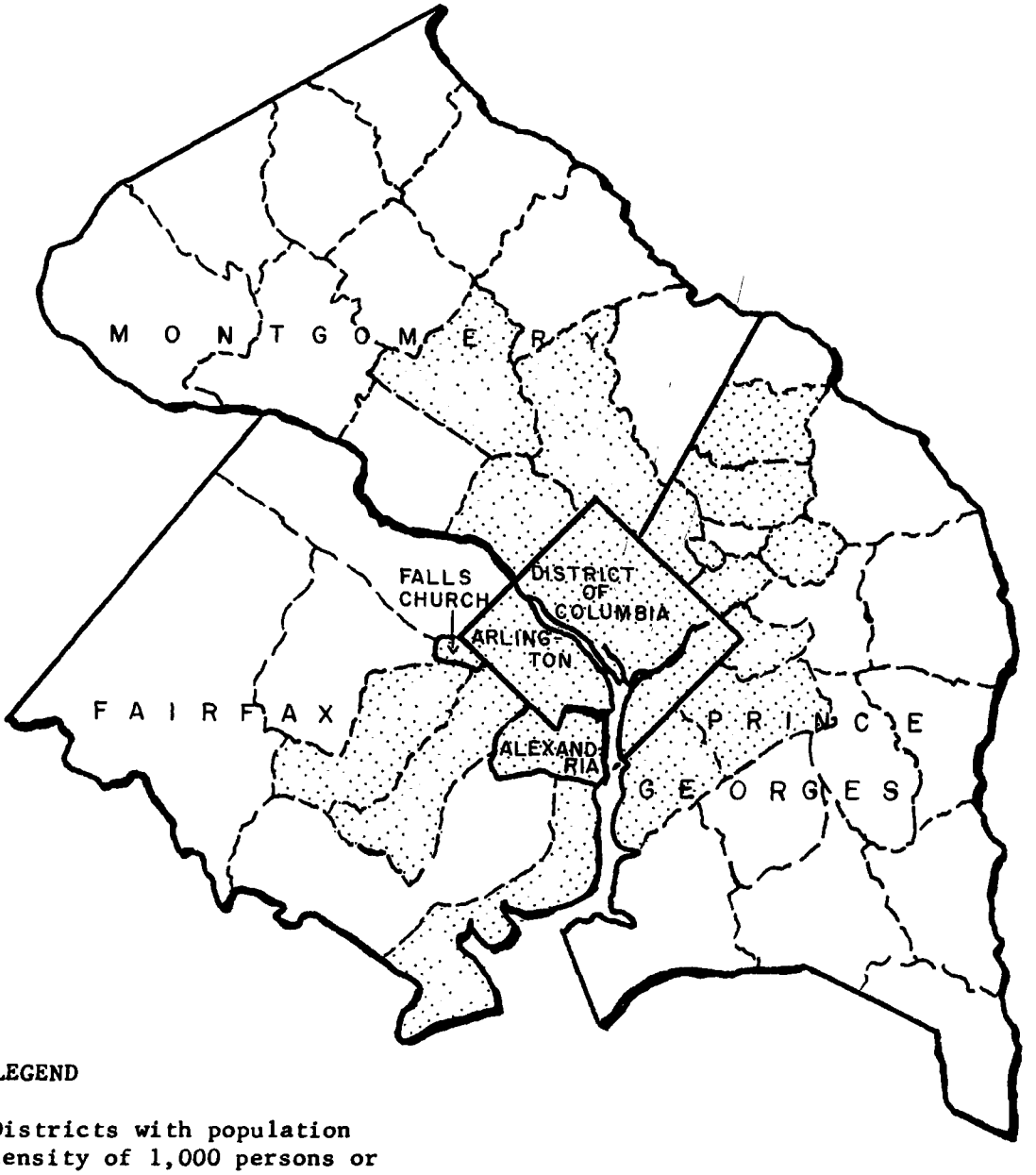
In accordance with the amended request, this appraisal of air pollution problems in the Metropolitan Washington Area had three objectives:

1) To review and evaluate the existing and potential air pollution problems of the Metropolitan Area.

2) To review briefly air pollution control activities presently being conducted by the respective local governmental agencies.

WASHINGTON METROPOLITAN AREA

URBANIZED DISTRICTS AS OF
1960 CENSUS(2)



LEGEND

Districts with population density of 1,000 persons or more per square mile shaded.

Figure 1

3) To develop recommendations for the guidance of local officials in meeting existing and future air pollution problems.

The scope of the study was limited to consideration of available information regarding air pollution, including: activities which cause pollution, evidence of pollution levels, meteorological and topographical influences on dispersion of pollutants, local air pollution control activity, and other relevant community characteristics. In view of these limitations this report should be considered a preliminary appraisal of air pollution problems in the National Capital Area.

An engineer from the Technical Assistance Branch, Division of Air Pollution, collected the data and prepared this report. Valuable assistance was given by personnel of various agencies of the District of Columbia Government, public health officials from suburban Virginia and Maryland, trade associations, official and unofficial business and industrial organizations, and interested agencies of the Federal Government. Specific acknowledgment is made to the Environmental Meteorological Research Projects of the U. S. Weather Bureau for their assistance in preparing the meteorological and climatological data for this report.

GENERAL FACTORS AFFECTING AIR POLLUTION

Air pollution levels in any community depend principally on the quantity, type, and rate of discharge of pollutants to the atmosphere and the ability of the atmosphere to disperse these pollutants. In addition, some air pollutants are the result of reactions that occur between contaminants in the atmosphere.

Population, general character of industry and employment, and land use are all general factors that are directly related to the discharge of pollutants to the atmosphere. The ability of the atmosphere to disperse the pollutants is directly related to certain meteorological and topographical factors.

Population

Daily activities of the general public are responsible for the emission of certain pollutants to the atmosphere. Activities such as combustion of fuels for space and water heating, cooking, transportation, and the burning of rubbish and other waste materials contribute a significant amount of pollution each day. The amount of air pollution contributed by any one individual is very small, but collectively, the total emissions may reach enormous proportions. In sparsely settled areas these emissions are dispersed into the atmosphere and readily assimilated, but as the population density increases more pollutants are discharged and it becomes increasingly difficult for the atmosphere to disperse them. Population estimates are an index of future pollution levels, since a population increase is accompanied by an increase in pollution emissions, both from the activities of the general public and the accompanying increased industrial-commercial activity.

The 1960 census reported the population of the Washington Standard Metropolitan Area as 2,001,897, a net increase of 537,808 over the 1950 census even though the population of the central city decreased about 5 percent. (2) Approximately 62 percent of the Metropolitan Area population lives outside of Washington, D. C. Population density for Washington, D. C., is high in comparison to other cities in the United States but the population densities for suburban Maryland and Virginia are relatively low. (Figure 1)

The Washington Metropolitan Area has shown a consistent growth over the last thirty years. Since 1930 population has approximately tripled, a growth rate surpassing all other metropolitan areas among the ten largest in the United States. (4) The growth of the Washington Metropolitan Area from 1940 to 1960 is shown by Table 1.

The suburban areas of Maryland and Virginia have shown tremendous growth in recent years. The population of Fairfax County, Virginia, has tripled in the last ten years and in Montgomery and Prince Georges Counties in Maryland the population has doubled in the last ten years. It is anticipated

TABLE 1

POPULATION GROWTH AND DENSITIES IN THE WASHINGTON METROPOLITAN AREA

1940 1960 (2)

YEAR	WASHINGTON D. C.	SUBURBAN MARYLAND	SUBURBAN VIRGINIA	TOTAL
1960 A/	763,956	698,323	539,618	2,001,897
1950 B/	802,178	358,583	303,328	1,464,089
1940 B/	663,091	173,402	131,492	967,985
POPULATION DENSITY 1960				
Land Area - sq. miles	61	979	448	1,488
Population density C/	12,525	715	1,205	1,345

A/ Final 1960 Census Figures

B/ U. S. Bureau of the Census, Census of 1940 and 1950

C/ People per square mile

that practically all of the future growth in the Washington Metropolitan Area will occur in the suburban areas of Maryland and Virginia. Estimates indicate a continued substantial growth for the Washington Metropolitan Area, with a population of about 2,750,000 by 1970 and 3,500,000 by 1980. (4) Air pollution levels will increase accordingly, unless steps are taken to control the emission of pollutants, because the greater the population the greater the activities that contribute to air pollution.

General Character of Employment and Industry

The business life of the Washington Area is determined largely by the fact that it is the location of the nation's Capitol. Also, the area is fast becoming one of the world's leading science centers with a larger portion of its population employed in scientific and professional effort than any other large metropolitan area in the United States. The area has limited manufacturing and other industry but does have a flourishing retail trade and ranks high as a retail trading center.

Table 2 shows the total employment in the Washington Metropolitan Area as of December 1960. (4) The limited manufacturing employment is offset by the high Federal Government employment in the area. The Federal, State, District of Columbia, and local governments and the military services accounted for approximately 40 percent of the employment in the Washington Metropolitan Area as of December 1960. As may be expected, the second highest percentage of the total employment is directed toward providing necessary goods and services.

TABLE 2

WASHINGTON METROPOLITAN AREA ESTIMATED EMPLOYMENT
DECEMBER 1960 (4)

INDUSTRY	WASHINGTON D. C.	SUBURBAN MARYLAND	SUBURBAN VIRGINIA	TOTAL
Federal Government (Civilian)	174,400	27,400	37,100	238,900
Wholesale and Retail Trade	83,697	33,252	28,482	145,431
Military Service	23,800	9,200	25,400	58,400
Construction	21,149	16,479	12,989	50,617
D. C., State, & Local Government	25,100	18,100	9,600	52,800
Professional Services & Organizations	42,500	4,000	3,300	49,800
Transportation, Communication, & Public Utilities	28,400	3,300	14,600	46,300
Personal Services & Domestics (Private Home)	28,300	9,500	6,300	44,100
Finance, Insurance, & Real Estate	25,632	7,251	5,444	38,327
Business, Repair, and Recreation Services	17,200	8,300	10,900	36,400
Manufacturing	20,684	10,159	4,319	35,162
Self-Employed	33,000	13,500	12,400	58,900
Miscellaneous	8,500	6,900	1,800	17,200
Totals	532,362	167,341	172,634	872,337

TABLE 3

EMPLOYMENT IN MANUFACTURING INDUSTRIES [6]
WASHINGTON METROPOLITAN AREA, OCTOBER 1958

INDUSTRY	TOTAL NUMBER PLANTS	NUMBER OF EMPLOYEES
Ordnance and accessories	1	125
Food and beverages	107	7,826
Apparel and other similar finished products	23	271
Lumber and products (except furniture)	62	858
Furniture and fixtures	46	731
Paper and allied products	9	975
Printing and publishing	339	12,646
Chemicals and allied products	32	1,212
Paving and roofing materials	11	398
Rubber and miscellaneous plastics products	6	144
Luggage	1	15
Stone, clay, and glass products	81	2,407
Primary metal industries	4	58
Fabricated metal products	78	2,715
Machinery (except electrical)	28	347
Electrical machinery	43	8,285
Transportation equipment	6	214
Scientific instruments	29	1,037
Miscellaneous	38	387
Totals	944	40,651

Note: Total not comparable with data in Table 2 due to changes in the Standard Industrial Classification Code.

In 1954 there were 854 manufacturing establishments in the Washington Metropolitan Area (5), and in October 1958 there were 944, as shown by Table 3. (6) Principal industries are printing and publishing, electrical machinery, and food and beverages. Based on the 1958 data these three industry classifications account for 52 percent of the industrial plants and 71 percent of the industrial employees in the Washington Metropolitan Area.

Land Use

Most of the land in the Washington Metropolitan Area is useful. There is no great expanse of swampland or other waste-land. The land use pattern for the metropolitan area shows that the District of Columbia and the immediately adjacent portions of suburban Maryland and Virginia are primarily concentrated residential areas, with relatively large areas devoted to parks and governmental uses. (7) In 1955 more than 42 percent of the land area in the District of Columbia was owned by the Federal Government. (8) Although the exact proportion has not been determined, it appears that the Federal Government land ownership in suburban areas of Maryland and Virginia that are adjacent to Washington, D. C., may also approach this magnitude. In addition to the large areas of Federally owned land that are devoted to parks and recreational use, the State and local governments have also provided large areas of land for these purposes.

The industrial sections of the Washington Metropolitan Area are located primarily along the Potomac and Anacostia River water fronts, along the railroad tracks, and along the main North-South Highway. The main concentration of industries is located in the Alexandria-South Arlington area of Virginia and the Northeast sector of the District of Columbia. A wide variety of industries is present in the Washington Metropolitan Area, but in general they are classified as light industries.

Several new industrial parks are being developed in Suburban Maryland and Virginia as well as in the District of Columbia. Figure 2 shows the general location of the new industrial parks. They range in size from several acres to several hundred acres, and are generally located in outlying suburban areas. (9) All of these sites are generally protected by adequate zoning regulations as well as by restrictions and performance standards regarding the types of industries permitted.

In general, the land use pattern of the Washington Metropolitan Area has not permitted the intermingling of industrial and residential areas. In some cases, the development of industrial areas adjacent to residential areas preceded the development and enforcement of adequate zoning and land use planning. This appears to be the case in some of the older sections of the metropolitan area such as Georgetown and Alexandria. A land use pattern that permits the intermingling of industrial and residential areas promotes the occurrence of air pollution problems because it brings major pollution sources into close proximity with susceptible receptors.

DISPERSION OF POLLUTANTS

Topography

The Washington Metropolitan Area is located at the western edge of the middle Atlantic Coastal Plain, 35 miles west of the Chesapeake Bay and far enough inland from the ocean to escape the sea breeze effects that normally occur along the coast during the warmer months. The Blue Ridge Mountains, rising to an elevation of 3,000 feet or more, are about 50 miles west of the Washington Metropolitan Area, and the orographic effects of these mountains is one of warming and drying of westerly winds reaching the area.

The terrain to the east of the Washington area is generally flat, with elevations being less than 100 feet above sea level. To the west, gently rolling hills, with elevations of 200 to 500 feet above sea level, extend to the Blue Ridge Mountains. Consequently, the topography in the vicinity of the Washington area generally allows free air movement with little channeling effects.

Meteorological Factors in Air Pollution

Air pollution generally decreases with increasing wind speed, i.e., the volume of air

NEW INDUSTRIAL AREAS

WASHINGTON METROPOLITAN AREA

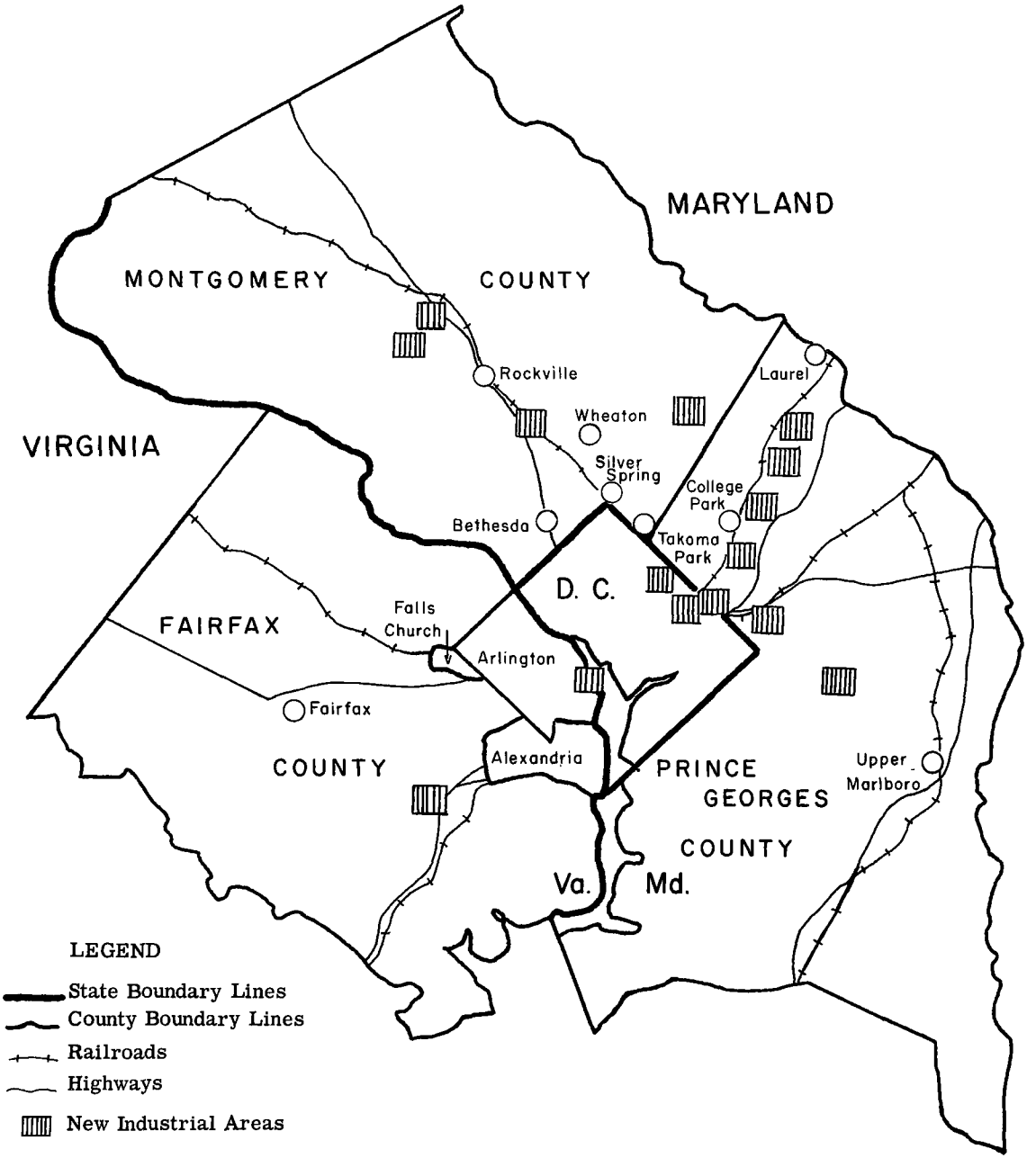


Figure 2

into which pollutants are emitted is directly proportional to wind speed and the concentration of airborne pollutants is inversely proportional to wind speed. However, high winds are not always beneficial, since local incidences of high pollution can result from aerodynamic downwash of stack effluents. In essence, wind speed and direction data yield an index to horizontal transport and diffusion of airbonre material, and thus indicate a rate of ventilation.

Of equal importance is the extent of vertical mixing in the atmosphere, implied by the temperature distribution with height. When there exists a large decrease of temperature with an increase in height, the air is unstable, and turbulence and vertical exchange of material occur readily; however, when there is a small decrease or increase (inversion) of temperature with an increase in height, the air is stable with little or no turbulence. The effect at the ground surface usually depends on whether the stable layer is at the surface or aloft. If aloft, pollutants may rise and accumulate under the temperature "lid," only to be brought to the ground surface in high concentrations when convective heating processes occur in a vigorous mixing of the air between the surface and the elevated stable layer. Such "fumigation" processes usually occur shortly after sunrise. If the stable layer extends from the ground surface upward, which is the usual situation for nocturnal inversions, diffusion of pollutants is restricted in the vertical so that they tend to spread horizontally. Such low-level stabilization is usually accompanied by calm or light winds, thereby giving rise to a condition of poor ventilation and limited vertical mixing and thus to a limited volume of air for pollutant dispersion.

In urban areas there are parameters to be considered which may promote some dilution. Heat sources such as buildings, automobiles, etc., can provide energy for convective mixing, and a light wind flow over the irregular surface of a metropolitan area can enhance vertical mixing. Hence, marked vertical stratification of polluted layers is probably more frequent in suburban and nearby rural areas than "downtown." Topographic features may influence diffusion processes; however, such influences are not necessary in order for stagnant weather conditions to occur. This can be exemplified by the Greater London smog episode of December 5-9, 1952. Because of their combined effect on temperature profile, air drainage, and radiation, valleys may influence the diffusion processes. Some of the river valleys in the Washington area may have local effects on atmospheric diffusion.

The effects of moisture content of the air and condensation processes on atmospheric pollution are not so direct. Since precipitation is usually associated with unstable weather regimes, and thus with good diffusion, the potential washout process is usually of no concern. The role of fog in air pollution is also indirect, since the meteorological circumstances which favor poor diffusion also favor the formation of radiation fog. To the extent that fog may attenuate solar radiation reaching the surface during daytime hours and thus restrict convective mixing processes, its presence may enhance poor diffusion.

Stagnant Weather Conditions

While short-duration diffusion anomalies are common to most areas and can cause pollution problems, the most dramatic and by far the most insidious community problems involving atmospheric pollution are those resulting from prolonged stagnant weather regimes, which are usually enhanced by topographic influences. Large scale atmospheric stagnation was responsible for most of the well-known disastrous episodes, such as those of the Meuse Valley, Donora, and Greater London. Although the simultaneous occurrence of light and variable winds, great stability in the lower atmosphere, and often fog, causing a build-up of high pollutant concentrations, is not unusual, the persistence of such weather conditions for several consecutive days rarely occurs in most areas, other than those dominated by semi-permanent high pressure systems, such as the Pacific High off the California coast.

In the United States, east of the Rocky Mountains, stagnation periods lasting for several consecutive days are generally associated with slowly moving or quasi-stationary high pressure systems. Subsiding air from aloft, associated with these high pressure systems, causes a warming of the air in its descent and an inversion is established at levels from about 800 to 3,000 feet

above the surface. This "subsidence inversion" persists throughout the day and night and acts as a lid to vertical mixing during daylight hours. The combination of light wind speeds at the ground and aloft gives rise to a low rate of ventilation and restricted vertical mixing. This results in a greatly reduced volume of air into which pollutants are emitted, causing pollution concentrations higher than usual.

Recent studies (10,11) of these stagnant episodes show that over a 21-year period the Washington area experienced 144 days of stagnation and 30 stagnation episodes with at least 4 consecutive days of stagnation. This averages about 7 stagnation days and 1.5 stagnation episodes per year. Such stagnation periods usually occur during the summer or fall months, with August, September, and October the months having the highest frequency in the Washington area.

General Climatology

The Washington area climate has the seasonal and daily variations characteristic of the eastern seaboard, with moderate winters and frequent intervals of high humidity and oppressive heat in the summer. The winter season is generally shorter and milder than in cities located to the north and west. This affords reduced heating requirement during the winter. During the summer, high temperatures may average in the upper eighties, but temperatures of 90° F to 100° F are not uncommon. (12,13)

The average annual precipitation is about 41 inches, with no pronounced wet or dry season. While the annual snowfall averages about 20 inches, greater amounts can be expected in nearby western and northern suburban areas.

Surface wind roses by months are shown in Figure 3. During the colder months of the year, winds from the northwest quadrant are most frequent, while winds from the south and southwest prevail during the summer season.

The frequent movement of cold polar and Arctic air masses into the Middle Atlantic States from Canada result in a prevailing northwest flow of unstable air in Washington from late November through April. The unstableness and relatively high wind speeds attending these air masses result in good atmospheric dilution conditions. These good diffusion regimes are interrupted for only brief periods, occasioned by nocturnal radiation inversions when skies are clear and winds subside, or by light southerly flow which brings warm moist air into the region preceding cold frontal passages. In general, the winter and spring months constitute the period of most frequent unstable weather in Washington, i.e., storminess and high winds, and thus result in good atmospheric dilution and good ventilation in the lower atmosphere.

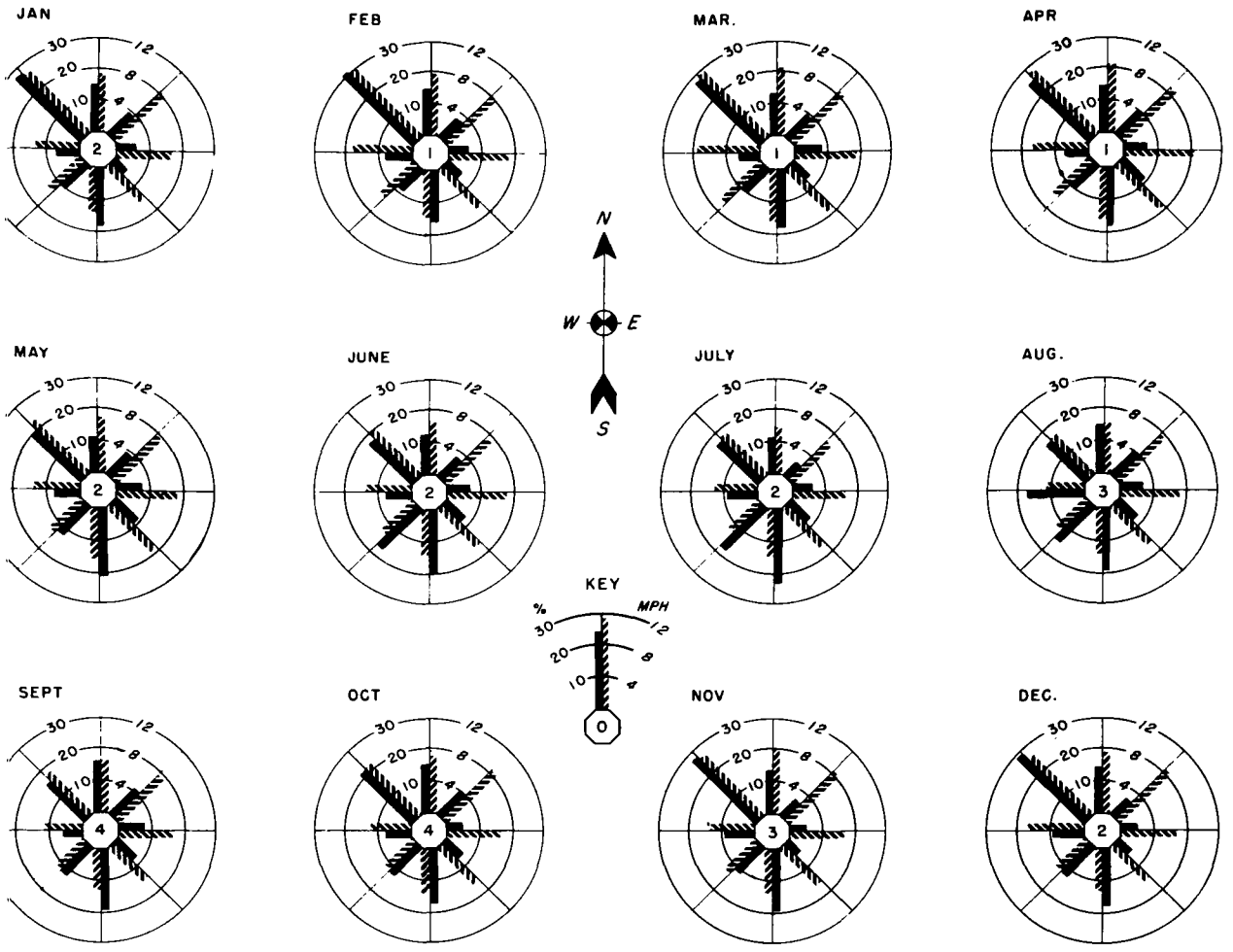
The summer and fall months are characterized by a reduction of wind speed and the prevalance of southerly winds. These months also have a higher frequency of cloudless and light wind conditions during nocturnal hours, permitting a higher frequency of radiational surface-based inversions to form. This is shown by the cloudcover and wind speed data for nighttime hours in Table 4. Consequently, the summer and fall seasons constitute the periods of lowest ventilation and highest potential for atmospheric stagnation for the Washington area.

As pointed out previously, atmospheric stability is an important aspect of air pollution. Vertical temperature gradient data, obtained from upper air soundings made twice daily at nearby Silver Hill, Maryland, give percent frequency values of inversions based below 500 feet above ground that are compatible with other stations in the Middle Atlantic Coastal Plain. In general, the Washington area has low-level stability on about 40-60 percent of the nights in any season, a frequency similar to most inland areas of the eastern United States.

The potential for atmospheric dispersion of pollutants can be generalized as follows: 1) The Washington area topography does not restrict the dispersion of airborne pollutants; 2) The area is too far inland to be directly influenced by the sea breeze effect; 3) The Washington area may experience several stagnant weather episodes a year, which may contribute to the buildup of airborne pollutants; 4) Stagnant weather

WASHINGTON METROPOLITAN AREA

SURFACE WIND ROSES BY MONTHS



LEGEND

The solid radial bars: ▬ show the average percentage of time the wind blows from each direction; the figure in the center shows the average percent of the time the wind is calm. The hatched radial bars: ▨ show the average wind speed from each direction, in miles per hour.

Figure 3

TABLE 4

SEASONAL PERCENT OF NIGHTTIME CLOUD COVER AND WIND SPEED [13]
WASHINGTON, D. C. 1950-1954

	WINTER	SPRING	SUMMER	FALL
LOCAL STANDARD TIME	1600-0600	1800-0500	2000-0400	1800-0500
Cloud Cover				
(0.3 or less of sky covered by clouds)	42.7	37.7	48.7	53.3
Wind Speed				
0 3 mph	14.0	13.3	21.7	21.3
0 - 7 mph	37.3	37.3	58.3	54.0

conditions, persisting 3 to 5 consecutive days, are most likely to occur during the summer and fall; 5) Unstable weather, and thus good atmospheric dispersion conditions, prevails much of the time during winter and spring; 6) Low-level nocturnal inversions occur on most nights having relatively clear skies and light winds, with higher frequency in the suburban and rural areas than over the central city. In general there is nothing particularly adverse about the diffusion climate of the Washington Metropolitan Area.

SOURCES OF POLLUTION

Pollution From Fuel Usage

Pollutants in the form of gases, solid particulates, and liquid droplets are released to the atmosphere by the combustion of fuel for heating, power generation, transportation, and industrial process needs. The type and quantity of pollutants are related to the type of fuels used, condition of the firing equipment, firing practices, load demands, and the use of pollution control measures.

Typical pollution rates from various fuel uses are given in the Appendix.

Coal -- During 1960, about 2,800,000 tons of coal were consumed in the Washington Metropolitan Area, broken down as follows: 1) about 2,190,000 tons for steam-electric generation; 2) about 360,000 tons used by the Federal Government primarily at central plants for space heating of Federal Buildings; and 3) about 250,000 tons for residential space heating and other commercial and industrial uses. (14)

Practically all of the coal is obtained from the bituminous coal regions of West Virginia, Pennsylvania, and Virginia. This coal generally contains about 20 to 40 percent volatile matter, 5 to 10 percent ash and 0.9 to 3 percent sulfur. (15,16) The two central heating plants operated by the Federal Government are equipped with underfeed stokers. Electrostatic precipitators and mechanical collectors are used to prevent dust emission. The Capitol Power Plant is equipped with spreader stokers and electrostatic precipitators for dust collection. The Naval Weapons Plant has both underfeed and spreader stokers with electrostatic precipitators provided on the spreader stoker units. (16)

The four steam-electric plants operated by the local utility company all feed pulverized coal. (15) Three of the plants are equipped with electrostatic precipitators and mechanical collectors. The fourth plant has only mechanical collectors.

The total coal consumption in the Washington Metropolitan Area should remain at about the same level in the future. The amount of coal used for space heating and

for commercial and industrial purposes is decreasing but this is offset by increases in the amount used for steam-electric generation.

Discharge of particulate matter from the combustion of coal may be reduced by using low volatile coal, changing combustion equipment and firing practices, or by installing high efficiency collection systems. Sulfur dioxide, a major gaseous pollutant from the combustion of coal, can be effectively reduced by using low sulfur content coal. Because most of the coal is consumed at several large installations, control of emissions should be easier than if there were a multitude of smaller plants.

Oil -- Consumption of fuel oil in the District of Columbia has been reported as 207,100,000 gallons for 1960, about evenly divided between distillate fuel oil and residual fuel oil. (17) It has been estimated that the suburban areas consumed about 100,000,000 gallons of fuel oil during 1960. (18) This would indicate a total fuel oil consumption of about 307,100,000 gallons in 1960 for the Washington Metropolitan Area.

The combustion of fuel oil releases aldehydes, oxides of nitrogen, sulfur oxides, organic acids, other organic materials, and ash. For the practically smokeless operation of oil burning equipment it is essential that the equipment be properly designed, adjusted, maintained, and operated.

The use of fuel oil in the Washington Metropolitan Area is gradually increasing, primarily in the residual fuel oils that are used for space heating in the larger office buildings, hotels, and apartments. (18) Fuel oil consumption in this area is not considered a major smoke problem, but it must be considered as a source of air pollution in the form of organic substances and sulfur and nitrogen oxides.

Gas -- Gas usage during 1960 amounted to 46,800,000 thousand cubic feet (MCF) (19) divided by general usage as follows:

Residential & Commercial with Heating	38,400,000 MCF
Residential & Commercial without Heating	7,150,000 MCF
Public Authorities	1,250,000 MCF

Industry uses practically no gas except for certain limited space heating requirements. About 55 percent of the total volume of gas used during 1960 was used solely for residential and commercial space heating purposes. (19) Nearly all new homes being built in the Washington Metropolitan Area are equipped for both gas space and gas hot water heating. In addition, gas cooking equipment is predominant in newly constructed homes and apartments. Since 1950 the total gas consumption in the Washington Metropolitan Area has increased by almost 250 percent. (19) It is anticipated that with the continued population increase and the availability of gas in the growing suburban areas the total gas consumption will continue to increase at the rate of about 20 percent per year.

The combustion of gas does not produce visible smoke, but it does produce pollutants such as aldehydes, nitrogen oxides, organic acids, and other organics which add to the total atmospheric pollution.

Residential Use of Fuel -- In 1950 the predominant fuels for residential heating in the Washington Metropolitan Area were oil 37.8 percent, coal 30.8 percent, and natural gas 25.5 percent. (20) Since 1950 the use of coal has declined and the use of gas has greatly increased until present estimates indicate that fuel usage, excluding coal for steam-electric generation and that used by the Federal Government principally for central heating plant operation, may be summarized as approximately 59 percent natural gas, 39 percent oil, and 2 percent coal (on a potential BTU basis). The general trend has been toward the use of fuel oil for heating the larger apartment buildings and gas for the individual residences, along with the conversion in older buildings from coal to either fuel oil or natural gas.

It is not expected that the increased use of gas and oil for residential fuel will create a major smoke problem. It should be realized that the use of fuel oil at the larger apartments, office, and hotel buildings may create a smoke problem unless the firing equipment is properly maintained and operated. The principal air pollution contribution from gas and oil is in the form of organic substances and oxides of sulfur and nitrogen.

Seasonal Variation in Fuel Consumption -- The use of fuel for space heating purposes is related to the heating degree days (Table 5). Approximately 73 percent of the space heating contribution to air pollution occurs during a four month period, December through March.

Because a large percentage of the gas is used for heating purposes the monthly consumption varies markedly. During August 1960, 1,510,000 MCF of gas were used, primarily for cooking, hot water heating, air conditioning, and commercial uses. (21) During December 1960, 8,700,000 MCF of gas were used, largely for heating purposes. (21)

Because of its fuel use pattern, the Washington Metropolitan Area does not have a great problem of smoke and fly ash such as is normally associated with the widespread use of coal for heat and power. This does not mean that the combustion of oil and gas for heating purposes is not a part of the community air pollution problem, on the contrary, it must be considered a significant part of the total air pollution problem.

Pollution from Transportation

Motor Vehicles -- Motor vehicles are considered a very significant source of air pollution in large communities throughout the country. Motor vehicles discharge significant quantities of hydrocarbons, carbon monoxide, and nitrogen oxides and relatively smaller quantities of aerosols, oxides of sulfur, aldehydes, ammonia, organic acids, and other organic compounds. Gasoline additives such as tetraethyl lead, boron, and phosphorous compounds as well as motor oil and their additives also cause specific air pollutants. (See Appendix.)

In 1960 there were about 185,000 automobiles, 19,000 trucks, and 1,800 buses registered in the District of Columbia. In addition, it is estimated that about 24,000 automobiles, owned by military personnel and other Federal employees, are located and operated in the District of Columbia but are registered in other States. This indicates a total of about 230,000 motor vehicles owned and operated by people living in the District of Columbia. (24)

In 1960 there were about 280,000 motor

TABLE 5

NORMAL MONTHLY AND ANNUAL DEGREE DAYS FOR WASHINGTON METROPOLITAN AREA, 65° F BASE (1921-1950) (22)

Month	Degree Days	Percent of Heating Load
January	871	20.6
February	762	18.0
March	626	14.8
April	288	6.8
May	74	1.8
June	0	0
July	0	0
August	0	0
September	33	0.8
October	271	5.2
November	519	12.2
December	834	19.8
Total	4,224	100.0

vehicles owned and operated in suburban Maryland and about 175,000 in suburban Virginia. (25) This indicates that a total of about 685,000 motor vehicles are owned and operated in the Washington Metropolitan area.

A 1959 traffic survey indicated that about 667,000 motor vehicles entered or left the District of Columbia during an average 24-hour period, 263,000 going to or from Virginia and 404,000 going to or from Maryland. It has been estimated that the number of motor vehicles entering or leaving the District of Columbia has more than doubled in the last 10 years. A certain percentage of the motor vehicles entering or leaving the area is due to through traffic on U.S. Highways 1, 29, 50 and 240, especially on U.S. Highway 1, a main north-south truck route, passing directly through the District of Columbia. Of the motor vehicles operating in the District of Columbia on an average day, about 49 percent are registered in the District of Columbia, 24 percent are registered in Maryland, 19 percent registered in Virginia and 8 percent registered in other States, including through truck and tourist travel. (25)

The movement of more than half a million motor vehicles per day into and out of the District of Columbia emphasizes the need for a metropolitan area approach for the reduction of emissions from motor vehicles. Improvement of highways and bridges, along with continual population growth, will certainly increase the volume of motor vehicle movements in the Washington Metropolitan Area. Because of the many governmental jurisdictions involved, however, reduction of motor vehicle emissions may prove difficult.

In the District of Columbia, motor vehicle registrations have shown an increase from 195,000 in 1950 to 206,000 in 1960. (26) During the same period of time motor vehicle registrations in suburban Virginia have increased from 100,000 to 175,000 and in suburban Maryland motor vehicle registrations have increased from 190,000 in 1955 to 280,000 in 1960. (24) It is anticipated that the number of motor vehicle registrations in the Washington Metropolitan Area will continue to increase, probably at a relatively slow rate in the District of Columbia and at a rapid rate in the suburban areas of Maryland and Virginia. This of course will increase air pollution in the Washington Metropolitan Area. It is certainly possible that the number of motor vehicles operated in the Washington Metropolitan Area will approach 1,000,000 by 1970.

Approximately 195,307,000 gallons of gasoline were sold in the District of Columbia and about 295,500,000 gallons were sold in suburban Maryland and Virginia during 1960. (23) This indicates that a total of about 490,807,000 gallons of gasoline were sold in the Washington Metropolitan Area during 1960.

About 15,500,000 gallons of diesel fuel were sold in the District of Columbia during 1960, about 6,200,000 gallons were for on highway use and the remainder for railroads vessels, military and other miscellaneous uses. (17) Actual figures for diesel fuel sales in suburban Maryland and Virginia were not readily obtainable but it has been estimated that they are at least equal to those reported for the District of Columbia. This would indicate that approximately 30,000,000 gallons of diesel fuel were sold in the Washington Metropolitan Area during 1960.

Internal combustion engines make a significant contribution to the overall air pollution problem in the Washington Metropolitan Area. While emissions from motor vehicles and other pollution sources may not create a condition as severe as exists in Los Angeles, it should be recognized that the potential for a problem of that type but of lesser intensity does exist in the Washington Metropolitan Area. In fact, past episodes of eye irritation and photochemical smog in the Washington Metropolitan Area have shown that the problem may already exist to a limited degree.

Based on limited observations and spot checks, about 5 to 15 percent of the motor vehicles operated within the District of Columbia emit excessive visible exhaust smoke. (23) This is evidence that the engines are in bad adjustment or a poor state of repair. In either case, these engines emit more unburned hydrocarbons, carbon monoxide, and visible smoke than engines that are properly adjusted and maintained.

Odorous materials emitted from diesel powered trucks and buses are a cause of public complaints. The increasing use of diesel fuel will lead to more complaints regarding the odors created. This will be especially true at bus terminals and along heavily used bus and truck routes.

Shipping -- The port of Washington, D. C. handles about 2,000,000 tons of freight per year and the port of Alexandria, Virginia, handles about 330,000 tons per year. (27) In addition, a number of U. S. Navy ships ply the waters adjacent to the Washington Metropolitan Area. Most of these ships are oil fired and, considering the overall air pollution picture, the total contribution from shipping is believed to be relatively minor.

Rail -- Seven railroads serve the Washington Metropolitan Area. About 145 daily passenger trains carry an estimated 35,000 passengers per day to and from the Nation's Capital. (3) In addition a great number of freight trains operate through Washington, which is a strategic rail crossing of the Potomac, to provide direct service between the Northeast and Southeast. Most of the trains are diesel powered, although some are electric powered. A diesel unit (usually 3 or 4 units are used per train) burns about 2 gallons of fuel per mile, while diesel switch units burn about 8 gallons of fuel per hour of operation. While diesel locomotives do not contribute significantly to the dust fall problem, the combustion of diesel fuel does release pollutants to the atmosphere (Appendix). Proper operation, maintenance, and adjustment of diesel units is essential to prevent smoke. The contribution of diesel locomotives to the overall air pollution loading in the Washington Metropolitan Area is considered to be minor.

Airlines -- Washington, D. C. ranks third among United States cities in the number of air passengers. National Airport, which is located across the Potomac River, about four miles from the heart of the city, handles over 20,000 passengers per day, with an average of about 800 arriving and departing flights per day. (3) One of the world's largest and finest airports is scheduled to open in late 1962, 20 miles west of Washington. It is anticipated that this new airport will be handling 4 million passengers per year by 1965 and 7 million by 1970. There are also three military air fields; Andrews Air Force Base, Bolling Air Force Base, and Anacostia Naval Air Station. Emissions from all of these sources are considered a minor portion of the total air pollution problem of the Washington Metropolitan Area.

Pollution From Waste Disposal Operations

Refuse Disposal -- The method used for refuse disposal is an important factor in controlling air pollution. The burning of refuse on open dumps or on private premises is the poorest method of disposal. Incomplete combustion of refuse results in production of a wide variety of gaseous and particulate matter including odors, smoke, aerosols, aldehydes, organic acids and other pollutants (Appendix).

The District of Columbia Division of Sanitation burns about 1600 tons of rubbish each day, about 1200 tons at three incinerators and about 400 tons at an open dump. (28) The open dump burning operation has been used for quite a few years, due to inadequate incinerator capacity. It is anticipated that a new 500 ton per day incinerator will be operated during 1962; this will provide adequate capacity so that operation of the open burning dump may not be necessary.

Some problems were encountered several years ago with the Georgetown incinerator, due to fly ash and other emissions. This particular incinerator is located lower than, but very near to, residential areas so that the top of the stack is at about the same elevation as the surrounding residential areas. Through a very carefully controlled operating procedure the fly ash and other emissions have been reduced until practically no complaints are received.

Most of the garbage from within the District of Columbia is used for hog feeding. Some of the garbage, which is not suitable for hog feeding, along with incinerator residue, street sweepings, ashes, and other non-combustibles is hauled to a transfer station, located a few thousand feet from the Capitol Building, where it is loaded in large tractor-trailor units and gondola railroad cars for transport to sanitary landfills. In passing enabling legislation authorizing this installation, Congress wrote

a proviso into the law that the structure be equipped for odor and dust control because of its proximity to the Capitol. This resulted in a system of cyclones, fiberglass filters, and carbon absorption canisters which has been reported as 95 percent efficient in removing odors and very effective in controlling the dust problem. (29)

In the suburban areas of Maryland that are a part of the Washington Metropolitan Area approximately 100 tons of refuse are incinerated per day. The only incinerator in this area is operated by the Washington Suburban Sanitary Commission and serves about 60,000 people. (30) Most of the other residential, commercial, and industrial refuse is disposed of at sanitary landfills located at various sites in Montgomery and Prince Georges Counties and operated by respective towns, cities, special taxing districts and the county. (31) These operations are periodically inspected by the county health agencies to enforce the respective county regulations that prohibit burning at open dumps or landfills.

In the suburban areas of Virginia that are a part of the Washington Metropolitan Area approximately 400 tons of refuse are incinerated each day (300 in Arlington County and 100 in the City of Alexandria). (32) In addition, some refuse from Arlington County and the City of Alexandria, as well as all of the refuse from Fairfax County and the independent City of Falls Church, is disposed of at sanitary landfills located within their respective areas. (32, 33) In all of these areas, close supervision has minimized the amount of burning at the landfill sites.

Burning of combustible refuse in individual backyard trash burners has been prohibited in the District of Columbia for years. This practice, which results in the discharge of large quantities of gaseous and particulate pollutants to the atmosphere, is permitted in the suburban areas of Maryland and Virginia. Backyard burning is restricted to after 4 p.m. in Prince Georges and Fairfax Counties during the spring months and in Montgomery and Prince Georges Counties during the fall months. Except as indicated above, open burning in the suburban areas of Maryland and Virginia is permitted during the daylight hours. Although restriction of backyard burning to the hours after 4 p.m. may be desirable for fire prevention, this is the normal period of light wind speed and poor ventilation during the fall months, hence the least desirable period for burning from an air pollution standpoint.

The many trees in the Washington Metropolitan Area produce great quantities of leaves that are usually disposed of by open burning. This results in the discharge of large quantities of gaseous and particulate pollutants to the atmosphere during the season of the year in which most air stagnation episodes are experienced. The open burning of a single pile of leaves is, not of course, a major source of air pollution. However, this practice should be seriously questioned when it is conducted on a large scale. Even though the burning of leaves is prohibited in the District of Columbia and restricted to certain daylight or evening hours in other areas, dense smoke from burning leaves may be experienced throughout the entire Washington Metropolitan Area during the fall months.

Practically all new apartment houses in the Washington Metropolitan Area are equipped with single- or multi-chamber incinerators for the disposal of combustible rubbish. In addition, many of the newer commercial and industrial establishments are also equipped with single- or multi-chamber incinerators. Recent amendments to the District of Columbia Fuel Burning Regulations require that multi-chamber incinerators be installed in the District of Columbia after October 1961. Single-chamber incinerators, which produce greater quantities of air pollutants per pound of material burned than multi-chamber units, are still permitted in other portions of the Washington Metropolitan Area.

Because of the many construction projects for new buildings, highways, and residential areas the quantity of waste materials from construction and demolition activities in the Washington Metropolitan Area has reached enormous proportions. Most of these waste materials are disposed of by opening burning. This produces significant quantities of gaseous and particulate air pollutants. Open burning of construction and demolition wastes in Alexandria is done under a permit system; however, this does not prevent the open burning of these

materials. Recent amendments to the District of Columbia Fuel Burning Regulations prohibit open burning unless a very definite need can be established and there is no other practical method of disposal available. In such cases a permit may be issued. These new restrictions should greatly reduce, if not eliminate, open burning of construction and demolition wastes in the District of Columbia.

The District of Columbia Department of Highways burns dead, diseased trees, and trimmings from its own activities and for the National Capital Parks at the Poplar Point Nursery grounds. Even though diseased elm trees must be burned as a part of the disease eradication program this activity must be considered as contributing to the total air pollution problem.

In summary, the Washington Metropolitan Area disposes of about 1700 tons of refuse per day at municipal incinerators and about 400 tons per day at an open burning dump. The remainder of the Metropolitan Area refuse, consisting of several hundred tons per day, is disposed of by back-yard burning, apartment house incineration, and sanitary landfills. In addition, quantities of leaves, trees and waste materials from construction and demolition activities are disposed of by open burning in the Washington Metropolitan Area. These activities result in the discharge of a considerable amount of atmospheric pollutants each day and are considered a significant contribution to air pollution in this area. Table 6 shows a general summary of the waste disposal practices.

Sewage Disposal -- Complaints of odors have come from the immediate vicinity of some sewage treatment plants, especially during the summer months when the daytime temperatures and relative humidity are quite high and there is little or no air movement. In most cases, these odor problems are experienced only in areas immediately adjacent to the sewage treatment plants.

About 1,000,000 cubic feet of sewage sludge gas is produced each day by the various sewage treatment plants in the Washington Metropolitan Area. (34) This gas is used as fuel for certain types of engines or for heating purposes, or is wasted by flaring. The combustion or burning of the sludge gas produces aldehydes, oxides of nitrogen, oxides of sulfur, and other gaseous pollutants that contribute to the total community air pollution problem.

Sewage disposal operations in the Washington Metropolitan Area are considered a contributor to the total air pollution problem, but they are not considered of major importance.

Industrial and Commercial Emissions

Emissions to the Washington Metropolitan Area atmosphere from industrial processes contribute to the total air pollution situation. Metropolitan Washington is not a heavy industrial area and the emissions from industrial operations are of the type and quantity generally associated with light industry and manufacturing and service operations. Because exhaust stack sampling and plant inspections were not undertaken as a part of this evaluation, the following discussion and Table 7 are of a general nature. However, air pollution problems normally associated with specific types of industry are indicated.

Table 7 gives a summary of the major industries and their contributions to the community air pollution problem. Some are of minor significance, some are of a localized nature, and others are considered significant contributors. This indicates that industries in the Metropolitan Washington Area are an important part of the total air pollution problem even though they are not the most significant group of pollution sources.

Dust arising from construction operations, particularly highway construction, is a frequent source of public complaint. Complaints about commercial operations are usually associated with emissions such as hydrocarbons from petroleum bulk storage and retail filling stations, smoke and odors from scrap or salvage yards, odors from restaurants and markets, and smoke and odors due to laundries and dry cleaning establishments. The last are especially important in the Washington area because of the great number of small laundry and dry cleaning plants. Hydrocarbon losses from petroleum handling and storage also contribute to the overall pollution load on

TABLE 6

SUMMARY OF REFUSE DISPOSAL PRACTICES
WASHINGTON METROPOLITAN AREA

Area	Amount Incinerated Tons/Day*	Open Burning Dump Tons/Day	Sanitary Landfill	Backyard Residential Area Incinerators	Other Residential Area Burning	Construction & Demolition Waste
District of Columbia	1200	400	Yes	No	Prohibited	Burning (Permit)
Montgomery County Maryland	100	None	Yes	Yes	Limited (Leaves)	Burning
Prince Georges County Maryland	None	None	Yes	Yes	Leaves	Burning
Arlington County Virginia	300	None	Yes	No	Limited (Leaves)	Burning (Limited)
Fairfax County & City of Falls Church, Va.	None	None	Yes	Yes	Leaves	Burning
City of Alexandria, Virginia	100	None	Yes	Yes	Leaves	Burning (Permit)

*Does not include quantities incinerated at apartment houses or commercial or industrial installations.

TABLE 7

SUMMARY OF METROPOLITAN WASHINGTON MAJOR MANUFACTURING INDUSTRIES AND THEIR CONTRIBUTIONS TO THE AIR POLLUTION PROBLEM

Industry	Total Plants	Contributions to Air Pollution Problem
Food & Kindred Products	107	Odors coffee roasting and animal rendering plants - localized complaints minor contribution
Lumber & Wood Products	62	Burning wood wastes, saw dust, spray paint mist, and creosote odors - millwork, prefabrication, and container manufacturing · localized complaints - minor contribution
Printing & Publishing	339	Solvent odors printing processes - localized complaints minor contribution
Chemical & Allied Products	32	Dusts, sulfuric acid mists, fluorides and odors - fertilizer, insecticide, and paint manufacturing - localized complaints significant contribution
Petroleum & Coal Products	11	Dust and oil fumes - asphalt paving plants - many localized complaints - significant contribution
Stone, Clay & Glass Products	81	Dusts ready-mixed concrete and concrete or allied products - localized complaints significant contribution
Fabricated Metal Products	78	Gases and dusts - spray painting, degreasing, and grinding aluminum doors & windows, structural and ornamental steel products - no complaints minor contribution
Electrical Machinery	43	Gases and dusts - spray painting, degreasing and grinding no complaints minor contribution
Primary Metals	4	Gases and particulates steel tube production and gray iron castings - localized complaints minor contribution

the atmosphere. Factors for estimating losses from gasoline handling operations are given in the Appendix.

Certain Federal Government operations such as the Naval Weapons Plant, Government Printing Office, and the Bureau of Printing and Engraving are considered as industrial operations. Several years ago there were emissions from the Naval Weapons Plant due to metal plating and forging. Present emissions from the plant are due to steam electric generation, incineration of combustible wastes and occasional open burning of certain scrap products. The Government Printing Office and the Bureau of Printing and Engraving are basically printing, engraving and publishing operations. These activities generally do not produce significant quantities of air pollutants, other than some solvent odors. Altogether, the industrial type activities conducted by the Federal Government in the Washington Metropolitan Area contribute to the total air pollution problem, but they are considered of minor significance.

Miscellaneous sources of air pollution are common to most metropolitan areas and no attempt was made to evaluate their individual contributions to the Washington area air pollution problem. Their total contribution is considered of minor significance in the total air pollution problem.

Geographic Distribution of Industrial Sources

The Metropolitan Washington Area is relatively free of major industrial air pollution sources. The problems encountered are usually due to nuisances from specific odors or dusts in limited areas. Most of the industries are located along the Potomac and Anacostia Rivers, and along the railroad tracks and major highways. The industrial areas are dispersed and generally separated from residential sections. These factors, along with the nature and limited extent of the industries help to minimize the effect of industrial pollutants on the total air pollution problem.

INDICATIONS OF AIR POLLUTION LEVELS

Past Investigations

In 1931-1933, atmospheric pollution was studied in 14 of the largest cities of the United States, including Washington, D. C. (35) This study reported dustfall rates for Washington, D. C. as 26 tons per square mile per month during the winter, 24 tons per square mile per month during the summer, and 24 tons per square mile per month for the entire year. The study also reported that the average amount of suspended matter in the air during the winter months in the 14 cities was 510 micrograms per cubic meter of air. The Group III cities, which included Washington, D. C., averaged 350 micrograms per cubic meter. The study indicated that if the degree of atmospheric pollution during the winter months for all of the cities combined was taken as 100, the Group III cities would have a value of 56. Thus it would appear that in 1931-1933 the air pollution situation in Washington, D. C., was better than that in many other large cities in the United States.

During 1953-54, oxidant and sulfur dioxide were measured in 10 cities, including Washington, D. C. (36) Sampling was done for only a few days in each city, but a variety of weather conditions occurred, including a few days of smog. The Washington, D. C. oxidant level, as measured by the potassium iodide method, ranged from a high of 0.078 ppm (parts per million parts of air) to a low of 0.003 ppm, with an average of 0.039 ppm. Although atmospheric oxidant measurements usually include all oxidizing substances, ozone is one of the most important oxidants found in the air. Ozone is a highly reactive, unique form of oxygen that may be produced in the atmosphere by the action of sunlight on organic material in the presence of nitrogen dioxide. Sulfur dioxide concentrations ranged from a high of 0.12 ppm to a low of less than 0.01 ppm, with an average of 0.04 ppm as measured using the alkaline iodine

method. Total sulfate concentrations ranged from a high of 0.35 ppm to a low of less than 0.01 ppm, with an average of 0.09 ppm. Table 8 shows the values for Washington, D. C. and the maximum and minimum values for all 10 cities included in the study. The results indicate that oxidant concentrations in Washington were higher than the average for the 10 cities, in fact Washington was third highest in this respect, and the sulfur dioxide values were about average.

Plant Damage

As is true with many large metropolitan areas, symptoms of smog injury to vegetation have been found in the Metropolitan Washington Area. Such occurrences indicate the existence of an air pollution problem. Although estimates of economic losses in the Washington area due to plant damage by smog have not been made, it is known that economic losses in tens of millions of dollars have been experienced in other areas. No attempt has been made to complete a frequency-severity survey of plant damage in the Washington area.

The occurrence of plant damage in the Washington Metropolitan Area has received considerable attention in the last few years. It has been shown that the "weather fleck" injury to tobacco plants at the U. S. Department of Agriculture Plant Industry Station, Beltsville, Maryland, was probably the result of atmospheric ozone, which is one of the most important atmospheric oxidants. (37) It has also been postulated that the high ozone levels (peak values of 0.31 to 0.50 ppm as measured by the buffered potassium iodide method) observed at Beltsville, which may have caused the plant damage, were the result of air pollution from the Washington Metropolitan Area. (38) Studies of the ozone injury problem are continuing and the severity of fleck in the tobacco at Beltsville continues to correlate with atmospheric ozone levels. Studies done in fumigation chambers at Beltsville using known ozone concentrations have confirmed the idea that fleck can be caused by ozone. Ozone levels required to produce the injury correlate with the atmospheric ozone concentrations found on days when flecking of tobacco occurs in plants exposed to ambient air.

The general symptoms of ozone injury on other crops has been reported. (39) Studies at Beltsville indicate that ozone injury symptoms on grape, spinach, tomato, and other crops correlate with tobacco fleck occurrences and atmospheric ozone levels.

There is little doubt that the Washington Metropolitan Area is the source of at least one phytotoxicant with a potential for inducing serious economic loss in vegetation. While a complete assessment has not been made, it is evident that vegetation damage does occur and deserves serious attention.

The National Air Sampling Network

Washington, D. C. has participated in the National Air Sampling Network of the Public Health Service since 1953. Samples of air are collected for a 24 hour period, using a high-volume sampler, on a predetermined schedule, by representatives of the District of Columbia Department of Public Health. The samples are sent to the Public Health Service's Sanitary Engineering Center in Cincinnati, Ohio, where they are analyzed. Data are available from 1953 through 1959 for suspended particulate matter, organic pollutants, reflectance, beta radio activity, and certain inorganic pollutants. (40,41)

Since 1953 four separate sampling locations have been used, including areas classified as commercial, residential, and a combination of commercial-residential (Table 9). The results reflect conditions in the different areas.

Particulate Matter Washington, D. C. had an average particulate pollution loading of 132 micrograms per cubic meter of air during the period of 1953-1959. Table 9 shows the results for the four separate sampling sites that have been used during the six-year period and the total results for this period. The values obtained during 1955-1956, which are higher than for other years, were probably influenced by dusty play fields and other activities at the high school, public recreation center, university, and large stadium that are all located nearby. Table 10 shows a comparison of suspended particulate matter concentrations results for Washington, D. C. and several other large cities. These results indicate that Washington's particulate pollution levels are less than the national average but higher than some other large cities; however, it also shows that the

TABLE 8

CONCENTRATION OF OXIDANT AND SULFUR DIOXIDE, 1953-1954 STUDY [36]

	Oxidants by Potassium Iodide Method ppm	Sulfur Dioxide by Alkaline Iodine Method ppm	Sulfur Dioxide Calculated from Total Sulfate after trapping in Alkali ppm
Washington, D. C.			
Maximum	0.078	0.12	0.35
Minimum	0.003	< 0.01	< 0.01
Average	0.039	0.04	0.09
10 Cities Studied			
Maximum	1.180	0.38	1.22
Minimum	0.000	< 0.01	< 0.01
Average	0.026	0.06	0.10

TABLE 9

SUSPENDED PARTICULATE POLLUTION IN WASHINGTON, D. C.
AS MEASURED IN THE NATIONAL AIR SAMPLING NETWORK, 1953-1959 [40,41]

Site	Type Area	Years	No. of Samples	Micrograms Per Cubic Meter		
				Min.	Max.	Ave.
No. 1 HEW-North	C-R	19 53-54	44	66	276	129
No. 2 Cardoza High School	C-R	19 55-56	70	70	459	171
No. 3 Health Center	R	19 56-57	40	41	258	97
No. 4 District Bldg.	C	19 58-59	51	38	231	107
TOTAL		1953-59	205	38	459	132

C - Commercial Area

R - Residential Area

TABLE 10

COMPARISON OF SUSPENDED PARTICULATE POLLUTANTS
FOR SEVERAL URBAN STATIONS, - 1957 - 58 (40,41)

1960 Area & Population	No. of Samples	Micrograms Per Cubic Meter		
		Min.	Max.	Ave.
Washington, D. C. 2,001,897	50	61	258	102
Baltimore, Md. 1,727,023	51	65	301	138
Los Angeles, Calif. 6,742,696	45	89	361	138
San Francisco, Calif. 2,783,359	51	22	253	80
St. Louis, Mo. 2,060,103	49	89	332	177
Cleveland, Ohio 1,796,595	51	69	314	175
Pittsburgh, Pa. 2,405,435	49	78	534	184
Portland, Ore. 821,897	50	26	334	99
Total NASN Stations	5340	11	978	131

maximum concentrations in Washington are lower than in most of the cities listed.

Reflectance The average light reflectance value of the Washington, D. C. high volume filter samples is 16 percent. Reflectance is used as a measure of the soiling properties of the collected pollutants. The lower the reflectance value the dirtier or grimier is the particulate matter in the air. Variation in reflectance readings can occur due to variations in composition of the particulate matter collected on the sample as well as variations in the amount of material.

Inorganic Pollutants - The National Air Sampling Network samples have been analyzed for a wide variety of inorganic solids. Many of these inorganic materials can be related to specific industrial processes and operations and they can sometimes be used to determine sources of pollution. The results of these analyses pertaining to Washington, D. C. for 1953-1957 have been published and, therefore, a detailed review will not be undertaken in this report. (40) Average values for specific inorganic solids found in the Washington air samples are about the same as the national average values.

Seasonal Variation If the year is divided into a "heating season" (November through April) and a "non-heating season" (May through October) a significant difference is noted in the atmospheric pollutants measured at the network station (Table 12). The primary reason for this difference is ascribed to the increased use of fuel for space heating. Pollution levels are higher in winter even though, as previously pointed out, the meteorological conditions are generally more favorable for atmospheric dispersion of pollutants during the November-April period.

Pilot Sampling Project

In December 1960 a seven day pilot air sampling project was completed by the District of Columbia Department of Public Health and the Public Health Service. The maximum values obtained during this period were: 0.25 ppm oxidant (which includes ozone), 0.40 ppm nitrogen dioxide, 0.70 ppm nitric oxide, 6.7 ppm carbon monoxide, 5.5 Cohs per 1000 linear feet for "smoke" (small sized particles, largely from combustion operations), and 445 micrograms per cubic meter for suspended particulate material. (42) The significant values obtained for oxidant, nitrogen dioxide, and nitric oxide indicate that photochemical smog is a problem in Washington. The values obtained for "smoke" and suspended particulate material were also significant. The maximum oxidant level of 0.25 ppm equalled the level at which some people experience eye irritation; in fact, several cases of eye irritation were reported during the study. This study indicates that among others, "smoke" and motor vehicle emissions are two major factors in the Washington air pollution problem.

Past Episodes

Photochemical air pollution is characterized by eye irritation, visibility reduction, cracking of rubber products, and results from the oxidation of hydrocarbons (primarily gasoline vapors) in the presence of nitrogen dioxide and sunlight.

The Washington Metropolitan Area has recently experienced three separate episodes of eye-irritating smog, June 8-11, 1959, September 23-27, 1960, and December 5-6, 1960. The 1959 episode occurred when a high pressure air mass existed and the 1960 episodes during atmospheric temperature inversions. A portion of the population experienced eye-irritation and other discomforts during these episodes, visibility was noticeably reduced, and numerous complaints were made to local governmental agencies. These recorded eye-irritating, visibility reducing, smog episodes are a definite manifestation of the photochemical air pollution problem of the Washington Metropolitan Area and warn of more serious future problems.

Complaints

The public certainly is not without cause for complaints concerning odors, smoke, and dusts from certain industrial operations which cause nuisance conditions. Some complaints regarding vegetation damage and glass etching have been received in certain areas of the Washington Metropolitan Area. To a great extent the complaints involve air pollution due to odors, dust, fumes, or smoke in the area immediately adjacent to a specific source of the air pollutant.

TABLE 11

SEASONAL VARIATION OF PARTICULATE POLLUTANTS
IN WASHINGTON, D. C. 1953 - 1959 [40,41]

Season	Months	Percent of Degree Days	Total Particulates (1)	Acetone Soluble Organics (1) *	Benzene Soluble Organics (1) **	Percent Reflectance ***
Heating	Nov.-Apr.	92.2	147	32.1	15.1	11
Non-heating	May-Oct.	7.8	107	21.5	9.3	21

(1) Micrograms per cubic meter.

* Prior to July 1, 1955, results reported as Acetone soluble organics.

** After July 1, 1955, results reported as Benzene organics.

*** The lower the reflectance value the dirtier the air.

Potential Health Effects

Apart from the specific findings of this survey, continuing research conducted or sponsored by the Public Health Service is adding steadily to the body of circumstantial evidence which links air pollution to certain cardio-respiratory diseases such as chronic bronchitis, asthma, emphysema, and lung cancer. For example, close correlations have been found very recently between atmospheric levels of sulfur dioxide and the frequency and severity of asthmatic attacks. Of course, the avoidance of needless risks to human health adds a most cogent reason to those developed in this report for a more efficient and more comprehensive air pollution control program in the Washington Metropolitan Area.

STATUS OF LOCAL ACTIVITY IN AIR POLLUTION

District of Columbia

In 1935 Congress enacted Public Law 279, District of Columbia Smoke Law, which prohibits the discharge of dense smoke from any building, stationary or locomotive engine, or motor vehicle, place or premises within the District of Columbia. This law also requires that all ashes, cinders, rubbish, dirt, and refuse be removed to a proper place and that cinders, dust, gas, steam, or offensive or noisome odors shall not be discharged from any building or place to the detriment or annoyance of other persons. The law further authorized the Commissioners of the District of Columbia to promulgate, alter, amend, or rescind regulations as they deem necessary. Enforcement of the law was made the responsibility of the Commissioners of the District of Columbia. They may direct the police department, health department, or any other officer or employee of the government of the District of Columbia to perform such services as necessary for enforcement of the smoke law. Limited modifications and revisions have been made to the smoke law, but for the most part it is basically the same as it was when originally enacted.

The Department of Licenses and Inspections is responsible for administration of the Smoke Law. This responsibility includes: (1) Examination of building plans for the construction, installation, reconstruction, alteration or repair of stacks, incinerators, boilers or furnaces; (2) issuance of permits and certificates for installations; (3) maintenance of records regarding applications, permits, plans, violations and complaints; and (4) investigation of complaints, observation of smoke conditions, and inspection of all equipment for which a permit has been issued. In general, single family homes are about the only installations that are not covered by the regulations.

The smoke abatement activities of this department are conducted by two different sections. The plan review portion is handled by the Engineering Branch of the department and all of the field inspections are handled by the Smoke and Boiler Section. Only three smoke inspectors are presently employed although authority exists for five smoke inspectors. Because of budget limitations, the low starting salary, and the lack of available candidates, difficulties have been experienced in hiring and retaining competent smoke inspectors. This has resulted in fewer smoke observations and inspections being made, thus reducing the effectiveness of the smoke abatement program.

During 1959 three smoke inspectors made 6,379 smoke inspections and 771 observations of smoke, and handled 237 complaints and 322 smoke violations. Insofar as possible, complaints are given priority and are followed up, by the smoke inspector who personally contacts the individual who made the complaint. Most of the smoke violations are due to improper operating procedures. Necessary corrections are usually brought about by a discussion between the smoke inspector and the equipment owner or operator of the reasons for the violation.

Since 1936, this program, through its inspection of plans and issuance of permits for fuel burning equipment, has had a great influence on the abatement of smoke and improvement of conditions which might cause nuisances. Through its adherence to proper engineering design and installation practices, the smoke abatement program has assured that, with proper operation, fuel burning equipment installations would not create nuisances or violate the smoke law. This has been very important during the past 25 years, when thousands of new or modified installations have been completed.

The Police Department recently entered the field of air pollution control through enforcement of amendments to the Traffic and Motor Vehicle Regulations. These regulations prohibit motor vehicle exhaust emissions darker than Ringelmann No. 2. Operators of motor vehicles producing excessive smoke are given a police notice to appear at one of the Department of Motor Vehicle Inspection Stations for further observation. Those found in violation of the regulation are given 10 days to obtain necessary repairs or face court action. In addition, the Department of Motor Vehicle Inspection Stations check for excessive exhaust smoke as a part of the required annual inspection of all motor vehicles registered in the District of Columbia. These combined activities should tend to reduce the number of motor vehicles that emit excessive exhaust smoke and thus contribute more than their proportionate share of the total air pollution load.

Under Reorganization Plan No. 5 of 1952, as amended, the District Department of Public Health was given responsibility for supervising adherence to proper standards of hygiene for occupations, work places, work material, work conditions, and related matters concerning city planning; heating, lighting, ventilation, aerial pollution, noise, and public health nuisances related to vacant land, occupations, and work places; and health hazards associated with work material and conditions. In addition, under various sections of the amended Health Ordinances, the District Department of Public Health has authority to investigate and have corrected nuisances due to noisome odors or noxious gases.

The District Health Department is responsible for (1) the investigation of air pollution complaints of a non-combustion nature; (2) operation of the Public Health Service National Air Sampling Station; and (3) the issuance of permits for the fumigation of buildings and facilities. This program is handled on a part-time basis by regular employees who are primarily responsible for other activities. The National Air Sampling Network Station activity consists of periodically collecting samples of particulate and gaseous materials and forwarding them to the PHS Sanitary Engineering Center at Cincinnati for analysis and tabulation. Complaint investigations are primarily concerned with localized situations that involve odors or dusts from a specific source and in past years have numbered about 5 to 10 per year. The fumigation permit issuance activity requires periodic inspections but does not require any appreciable professional time.

The District of Columbia Commissioners recently delegated authority to the Department of Public Health for developing an air survey and monitoring program to determine the extent and causes of air pollution. The D. C. Health Department was also directed to work with other departments in preparing specific proposals that will provide the necessary organization and budgetary arrangements to effect a sound air survey and monitoring program that would lead to an air pollution control program for the District of Columbia.

Suburban Maryland

In Montgomery County, air pollution control activity is handled by the health department and primarily consists of investigation of complaints. If possible, the complaints are handled by the health department staff but, if complex problems are encountered, assistance may be obtained from the Maryland State Department of Health. It was reported that about 20 air pollution complaints are investigated each year. The County does not have a smoke abatement program but the County ordinances and regulations establish performance standards for all incinerators and prohibit open burning of leaves and other combustibles during certain hours of the day.

In Prince Georges County a very limited air pollution control program is conducted by the health department. This program primarily consists of investigating complaints. It was reported that about 20 complaints are investigated each year, excluding numerous complaints pertaining to the open burning of leaves and rubbish. The health department normally handles the air pollution complaint investigations but may obtain assistance from the Maryland State Department of Health on special studies or complex complaints. The County does not have a smoke abatement program but county regulations establish performance standards for all incinerators and prohibit open burning at dumps and sanitary landfills.

Suburban Virginia

In Arlington County the limited air pollution activities are handled by the Department of Inspections. These activities are primarily directed toward the inspection and licensing of boilers and incinerators. It was reported that one or two air pollution complaints are received each year and they are referred to the Virginia Department of Health for investigation. Reports are sent back to the local department. County regulations limit the times when leaves and other combustibles may be burned in the open.

In Fairfax County and the City of Falls Church all the air pollution control activities are under the supervision of the Virginia Department of Health. It has been reported that no complaints regarding air pollution have been received in years. The County recently passed a zoning ordinance which established performance standards for the emission of smoke and other air pollutants.

In Alexandria, the local health department investigates complaints and makes some limited investigations of specific problems, with assistance from the Virginia Department of Health. It was reported that about 5 air pollution complaints are investigated each year. The smoke abatement activities are handled by the smoke and boiler inspector. Activities include plan review and inspection of boilers, stokers, and incinerators. Individual backyard incinerators are permitted and private open burning of leaves and other combustibles is allowed. Disposal methods for construction and demolition wastes is controlled by a permit system.

Table No. 12 gives a summary of local air pollution control activities in the Washington Metropolitan Area. The lack of air pollution control programs in this area is evident.

Zoning Regulations

Zoning provisions are often used as a means of controlling air pollution, either by establishing performance standards or by separation of industrial and residential areas. In general, the respective zoning ordinances in the Washington Metropolitan Area have prevented many major air pollution problems. In some of the older areas of Washington, and to some extent Alexandria and Arlington, the industrial areas were developed adjacent to residential areas prior to the establishment of effective zoning requirements. These situations account for a large proportion of the air pollution complaints received in the specific areas. The zoning regulations in effect in the various local governmental areas, through the use of performance standards and the separation of major air pollution sources and residential areas, have minimized the extension of air pollution problems into rural areas and prevented the intermingling of industrial and residential properties.

The District of Columbia Zoning Regulations prohibit the discharge of objectionable amounts of cinders, dust, fly ash, or noxious, toxic, or corrosive fumes or gases from buildings or structures located in manufacturing districts. Periodic surveys of commercial and industrial areas are conducted by the Department of Licenses and Inspections to determine compliance with provisions of the zoning regulations that pertain to external effects and the discharge of objectionable materials. This has tended to eliminate some potential air pollution problems.

TABLE 12

LOCAL AIR POLLUTION CONTROL ACTIVITIES
WASHINGTON METROPOLITAN AREA

Area	Smoke Control	Other Air Pollution Control	
		Complaint Investigation	Comprehensive Program
Washington, D. C.	Yes	Yes	No
Montgomery County, Maryland	No	Yes	No
Prince Georges County, Maryland	No	Yes	No
Arlington County, Virginia	Limited	No	No
Alexandria (City), Virginia	Limited	Yes	No
Fairfax County, Virginia	No	No	No

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APPENDIX

Examples of Pollution Emission Rates

The data presented in this appendix are of value only as general information on the composition and magnitude of pollution from several activities. They should not be applied to any specific situation without due consideration of the many factors which affect pollution emissions.

Estimates of Products of Combustion from Fuel Burning Operations
(Emissions in Lbs./Lb. of Fuel Fired) (43)

Pollutant	Fuel		
	Coal	Fuel Oil (a)	Natural Gas (b)
Sulfur Dioxide	1.7 x S*	1.8 x S	1.8 x S
Sulfur Trioxide	0.2 x S	0.2 x S	0.2 x S
Hydrogen Sulfide	0.004 x S	n.a. **	n.a.
Oxides of Nitrogen (as NO_2)	0.010	0.013	0.005
Total Hydrocarbons	0.010	0.005	0.0015
Inorganic Chlorides (as HCl)	0.002	n.a.	(c)
Fluorides (as HF)	0.002	n.a.	(c)
Organic Acids (as CH_3COOH)	n.a.	0.015	0.0012
Aldehydes (as CH_3CHO)	n.a.	0.0018	0.0004
Ammonia	n.a.	0.000006	0.000006
Particulates	See Tables A-2 & A-3	0.00025	(c)

* S = lbs. sulfur/lb. fuel

** Not available

(a) Weight of No. 2 fuel oil may be taken as 7.16 lb./gal.

(b) Weight of natural gas may be taken as 0.04575 lb./cu. ft.

(c) Negligible

Estimates of Particulates from Industrial Coal Burning;
According to Firing Method (43)
(Emissions in Lbs. per Lb. of Fuel Fired)

Firing Method	Solids*
Underfeed Stoker	0.15 A**
Travelling Grate	0.15 A
Cyclone Furnace	0.15 A
Spreader Stoker - Dust Reinjection	1.00 A
Spreader Stoker - No Dust Reinjection	0.60 A
Pulverized Coal	0.75 A

* Ash and unburned fuel.
** A = Lbs. ash per lb. of fuel

Estimates of Particulates from Domestic and Commercial Coal Burning; According to Firing Method (43)
(Emissions in Lbs. per Lb. of Fuel Fired)

Firing Method	Carbon and Tars		Ash
	$< 1\mu$ *	$> 1\mu$**	($> 1\mu$)
Hand Fired Furnaces	0.006	0.004	0.002
Stoker Fired Furnaces and Stoves	0.0025	0.0015	0.0015
Hand Fired Stoves	0.014	0.010	0.003

*Less than 1 micron in size.

**Greater than 1 micron in size.

Pollution Emissions from Gasoline and Diesel Engines
(highly variable)

Pollutant	Emissions in pounds per gallon of fuel used	
	Gasoline engines[44] (a)	Diesel engines[45]
Hydrocarbons	0.332	0.18
Aldehydes ketones	0.004	0.01
Other organic gases	0.005	n.a.
Carbon monoxide	2.91	0.06 (b)
Oxides of nitrogen	0.113	0.10
Sulfur dioxide	0.009	0.04
Aerosols	0.011	0.11

(a) Includes blowby emissions but not evaporation losses.

(b) Reference 44 used.

Pollution Emissions from Single and Multiple Chamber Incinerators

Gaseous compound or group	Pollution emission in pounds per ton of refuse burned	
	Single chamber incinerator[46]	Multiple chamber incinerator[47]*
Methanol	9-23	< 0.05
Ethylene	8-61	< 0.05
Acetone	> 8	< 0.05
Methane	23-150	< 0.05
Acetylene	< 4-73	< 0.05
Alpha olefins (as propylene)	< 6	< 0.05
Carbonyl sulfide	>3	< 0.05
Benezene	>3	< 0.05
Acids (as acetic)	>4	< 0.05
Phenols (as phenols)	>8	< 0.05
Aldehydes (as formaldehydes)	5-64	∽ 0.3
Ammonia	0.9-4	< 0.05
Oxides of nitrogen (as NO_2)	< 0.1	∽ 2.1
Carbon monoxide	197-990	< 0.05
Solid and liquid emissions	Single chamber incinerator[47]	Multiple chamber incinerator[47]
Solids, gr./SCF, @ 12% CO_2	0.9	0.11
Volatiles, gr./SCF, @ 12% CO_2	0.5	0.07
Total, gr./SCF, @ 12% CO_2	1.4	0.19
Total, lbs./ton of refuse burned	23.8	3.5

*Losses listed as < 0.05 lbs./ton were below the detectable limit.

Estimated Contaminants Discharged from Burning Dumps (48)

Pollutants	Pounds per day per 100,000 persons using refuse disposal
Sulfur Oxides	180
Nitrogen Oxides	90
Ammonia	345
Aldehydes	600
Organics	42,000
Organic Acids	225
Solids	7,000
Total	50,400

Estimated Hydrocarbon Losses from Gasoline Handling Operations [45]
(Emission in Lb./10,000 gal. of Gasoline Handled) [a]

Operation	Temperature						
	40°F	50°F	60°F	70°F	80°F	90°F	100°F
Marketing [b]	28	37	50	67	89	120	152
Filling Service Station Tanks	18	24	32	43	57	77	98
Filling Auto Tanks	21	28	38	51	68	91	116
Evaporation from Auto Tanks and Carburetors	124	163	222	297	393	530	674
Totals	191	252	342	458	607	818	1040

(a) As an approximation of the vapor pressures of gasoline, the vapor pressures of n - heptane were used.

(b) Marketing is the handling of gasoline at the bulk plants.

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