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GUIDELINE FOR PUBLIC REPORTING OF DAILY AIR QUALITY--POLLUTANT STANDARDS INDEX (PSI)

U.S. ENVIRONMENTAL PROTECTION AGENCY

Office of Air Quality Planning and Standards

Research Triangle Park, North Carolina

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GUIDELINE FOR PUBLIC REPORTING OF DAILY AIR QUALITY--POLLUTANT STANDARDS INDEX (PSI)

OAQPS Number 1.2-044

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Prepared by

EPA Working Group to Develop an Air Quality Index

Contributing Agencies

U.S. Environmental Protection Agency
Office of Research and Development
Office of Air and Waste Management
Office of Planning and Management

National Oceanic and Atmospheric Administration

PREFACE

The U. S. Environmental Protection Agency's recommended "Pollutant Standards Index" (PSI) is the result of a joint effort on the part of EPA's Offices of Research and Development, Air and Waste Management, and Planning and Management. The guideline was prepared by the EPA Working Group to Develop an Air Quality Index in response to a request from the Federal Interagency Task Force on Air Quality Indicators of which EPA is a member. The Federal Task Force, chaired by the Council on Environmental Quality, was created as a result of a joint EPA/CEQ report[1] which pointed out existing problems resulting from the present diversity of indices used in the United States and Canada.

This guideline suggests the use of the Pollutant Standards Index (PSI) for those local and state air pollution control agencies wishing to report an air quality index on a daily basis. The PSI places maximum emphasis on protecting the public health; that is, it advises the public of any possible adverse health effects due to pollution. In order to err on the side of public safety, the index stresses reporting on the basis of the stations with the highest pollutant concentrations and assumes that other unsampled portions of the community will also experience high concentrations. In addition, its emphasis is upon acute health effects occurring over very short time periods (24 hours or less) rather than chronic effects occurring over months or years. It is not intended for, and should not be used for, ranking urban areas in terms of the severity of their air pollution problems. Such rankings require the use of many other kinds of environmental data not incorporated in this index.

Finally, Appendix A discusses the meteorological information needs of forecasting relative index changes. This was prepared by personnel from the National Oceanic and Atmospheric Administration.

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1. EXECUTIVE SUMMARY

This guideline suggests the use of the Pollutant Standards Index (PSI) for those local and state air pollution control agencies wishing to report an air quality index on a daily basis. The document also includes appropriate monitoring and reporting guidance. The guideline is the result of an earlier study[1] showing that of all the air quality indices in use today, no two are exactly the same. A potentially serious problem of public confusion can occur in regions where neighboring states and cities use different indices. The PSI also responds to the request of several state and local agencies that the U. S. Environmental Protection Agency provide them with a recommended uniform air quality index.

The recommended index incorporates five pollutants--carbon monoxide, sulfur dioxide, total suspended particulate, photochemical oxidants, and nitrogen dioxide--for which there are short-term (24 hours or less) health-related National Ambient Air Quality Standards (NAAQS),[2] and/or Federal Episode Criteria,[3-5] and Significant Harm Levels.[3,4,6] A sixth variable--the product of total suspended particulate and sulfur dioxide--is computed and is included in the index equation. This variable and also nitrogen dioxide are treated differently than the other pollutants because they have no short-term NAAQS. Therefore, they are reported when they exceed the Federal Episode Criteria and Significant Harm Levels. Because of the basic design of the index, any further pollutant requiring NAAQS, Federal Episode Criteria, and Significant Harm Levels can be readily added.

The index uses a "segmented linear function"* to convert each air pollutant concentration into a normalized number. The NAAQS for each pollutant corresponds to PSI=100, and the Significant Harm Level corresponds to PSI=500.

At a minimum, PSI reports the pollutant with the highest index value of all the pollutants being monitored, a dimensionless number, and a descriptor word. On days when two or more pollutants violate their

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*A segmented linear function consists of two or more straight lines, drawn between successive coordinates ("breakpoints") where each line may have a different slope.

respective NAAQS, each of the pollutants should be reported. Five descriptor words have been chosen to characterize daily air quality: "good," "moderate," "unhealthful," "very unhealthful," and "hazardous." In addition, for each descriptor word, generalized health effects and cautionary statements are provided for use when the air is characterized as "unhealthful" or worse.

For large metropolitan areas comprised of many smaller cities and suburbs where significant air quality differences may exist, the air pollution control agency may wish to report separate index values for each community. This has the advantage of showing the public how air pollution varies over the larger metropolitan area. The pollutants would be monitored at population-oriented locations where the maximum concentration for the particular pollutant is expected to occur, and the public within each community would be made aware of the worst air quality to which it is exposed.

Further guidance is given on the measurements practices and monitor siting considerations (Section 5).

PSI should not be used to rank cities. An evaluation of PSI in eight cities[7,8] illustrated the difficulties of attempting to compare air quality levels in different cities using this or any other index. PSI is designed for the daily reporting of air quality to advise the public of potentially acute, but not chronic health effects. To properly rank the air pollution problems in different cities, one should rely not just on air quality data, but should include all data on population characteristics, daily population mobility, transportation patterns, industrial composition, emission inventories, meteorological factors, and the spatial representativeness of air monitoring sites. A correct ranking should also consider the number of people actually exposed to various concentrations, as well as the frequency and duration of their exposure.

Adoption of PSI should reduce the confusion due to the existence of many indices. PSI has several advantages: (1) it is simple and can be easily understood by the public, (2) it can accommodate new pollutants,

(3) it is based on a reasonable scientific premise, (4) it relates to NAAQS, Federal Episode Criteria, and Significant Harm Levels, (5) it exhibits day-to-day variations, and (6) a qualitative trend in the index can be forecast for periods up to a day in advance, especially during episodic conditions.

2. INTRODUCTION

A major area of concern in the field of air pollution control is how to best report daily air quality to the public. A recent CEQ/EPA Report[1] indicates that of the 55 largest U. S. metropolitan air pollution control agencies, 33 use an air pollution index. In addition, five states and two Canadian Provinces operate state-wide (or Province-wide) index systems. With two minor exceptions, no two indices were found to be exactly the same. The public confusion generated by the use of so many indices is particularly evident in bordering states using different indices. Therefore, there is a need to develop a uniform index to report the daily status of air pollution.

A recent paper[9] emphasizes the need for a truly meaningful index to have a sound scientific basis. The paper suggests that such an index be based on the relationship between pollutant concentration and adverse health (welfare) effects--that is, a "damage function." Unfortunately, it is an extremely complex undertaking to relate measured air pollutant concentrations to the many diverse effects of air pollution--for example, aggravation of disease in susceptible people, increased incidence of respiratory illness in healthy persons, impairment of human motor function, reduced visibility, corrosion of materials, and soiling of buildings. Arriving at an air quality standard for a given pollutant--which is just one point in a damage function--has required vast quantities of data, medical advisory committees, detailed epidemiological studies, and other extensive research. The air quality criteria documents published for the major air pollutants[10-14] reflect the complexity of the process.

The recent paper[9] also emphasizes the importance of an index accounting for the adverse effects associated with combinations of pollutants--that is, synergism. For example, the criteria document on sulfur oxides[11] states that adverse health effects attributable to sulfur oxides are intensified in the presence of particulate matter. Understanding synergistic effects adds greatly to the problem of obtaining a truly meaningful air quality index. These problems stress the need for additional research to develop pollutant-related damage functions that take into account synergistic effects on health and welfare.

As an interim solution to these problems, this guideline recommends a uniform index to report daily air quality, along with appropriate monitoring guidance, This index will serve until a more meaningful air quality index can be created. If adopted, a uniform index should end the confusion associated with the use of many varied indices.

3. THE EPA RECOMMENDED DAILY INDICATOR--POLLUTANT STANDARDS INDEX (PSI)

The Pollutant Standards Index (PSI or ψ) is the result of a joint effort by EPA's Offices of: Research and Development, Air and Waste Management, and Planning and Management. Its evolution has included formulation of several candidate index structures,[15,16] and the index has undergone an extensive review process involving state and local air pollution control agencies, public organizations, and media representatives.

The recent CEQ/EPA compendium of air pollution indices[1] developed an "index classification system" to analyze and compare the various indices used by state, Provincial, and local agencies. Indices were categorized according to four criteria: (1) number of pollutant variables measured, (2) calculation method used to compute the index, (3) descriptor categories reported with the index, and (4) method of reporting (whether it is "combined," "maximum," or "individual").

The report found that the greatest number of the indices in use[1] incorporate five of the six National Ambient Air Quality Standard (NAAQS) pollutants (hydrocarbons are excluded because there are no direct health effects associated with the pollutant. It is controlled because it is a precursor to the formation of photochemical oxidants.); (2) use a segmented linear function*; (3) are based on the maximum of one of the pollutant variables; and (4) use three to five descriptor categories.

In the following sections, the structure of PSI is presented according to the "index classification system" categories.

3.1 Number of Pollutants

PSI includes five pollutants: carbon monoxide (CO), sulfur dioxide (SO_2), total suspended particulate matter (TSP), photochemical oxidant (O_3) and nitrogen dioxide (NO_2). Primary (that is, health related) NAAQS, and/or Federal Episode Criteria, and Significant Harm Levels exist for all five. In addition, one pollutant product $TSP \times SO_2$ is included because it has both Federal Episode Criteria and a Significant Harm Level.[3,4] As with NO_2, which has no short-term primary NAAQS, the product is reported when the Federal Episode or Significant Harm Levels are exceeded. Finally, because of the structure of the index, any pollutant identified in the future for which NAAQS, Federal Episode Criteria, and Significant Harm Levels are adopted can be added without modifying the basic form of the index.

3.2 Calculation Method

A segmented linear function is used relating actual air pollution concentrations to a normalized number. For example, PSI (ψ) equals 100 when the NAAQS for each pollutant is reached, while ψ equals 500 when the Significant Harm Level for each pollutant is reached. The normalized number should be easier for the general public to understand because it does not require one to know specific NAAQS concentrations or the many different Federal Epsiode and Significant Harm Levels.

The index breakpoints are listed in metric units (Table 1) and in parts per million (Table 2). The first breakpoint separates the descriptor

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*A segmented linear function consists of two or more straignt lines, drawn between successive coordinates ("breakpoints") where each line may have a different slope.

TABLE 1. Breakpoints for PSI (ψ) in Metric Units

Breakpoints	PSI Value (ψ)	TSP $\mu g/m^3$ 24-hr.	SO_2 $\mu g/m^3$ 24-hr.	$TSP \times SO_2$ $(\mu g/m^3)^2$	CO mg/m^3 8 hours	O_3 $\mu g/m^3$ 1-hr.	NO_2 $\mu g/m^3$ 1-hr.
50% of primary short-term NAAQS	50	75[a]	80[a]	b	5.0	80	b
Primary short-term NAAQS	100	260	365	b	10.0	160	b
Alert Level	200	375	800	65×10^3	17.0	400[c]	1130
Warning Level	300	625	1600	261×10^3	34.0	800	2260
Emergency Level	400	875	2100	393×10^3	46.0	1000	3000
Significant Harm Level	500	1000	2620	490×10^3	57.5	1200	3750

[a] Annual primary NAAQS.

[b] No index value reported at concentration levels below those specified by the Alert level criteria.

[c] For the PSI index 400 $\mu g/m^3$ appears to be a more consistent breakpoint between the descriptor words "unhealthful" and "very unhealthful" than the O_3 Alert Level of 200 $\mu g/m^3$.

TABLE 2. Breakpoints for PSI (ψ) in Parts Per Million

Breakpoints	PSI Value (ψ)	SO_2 24-hr.	$TSP \times SO_2$ ($\mu g/m^3 \times$ ppm)	CO 8 hours	O_3 1-hr.	NO_2 1-hr.
50% of primary NAAQS	50	.03[a]	b	4.5	0.04	b
Primary NAAQS	100	.14	b	9.0	0.08	b
Alert Level	200	.30	22.727	15.0	0.20[c]	0.60
Warning Level	300	.60	91.259	30.0	0.40	1.20
Emergency Level	400	.80	137.413	40.0	0.50	1.60
Significant Harm Level	500	1.00	171.329	50.0	0.60	2.00

[a] Annual primary NAAQS.

[b] No index value reported at concentration levels below those specified by the Alert Level criteria.

[c] For the PSI index 0.2 ppm appears to be a more consistent breakpoint between the descriptor words "unhealthful" and "very unhealthful" than the O_3 Alert Level of 0.1 ppm.

categories "good" and "moderate." For CO and O_3, the first breakpoint was chosen at 50 percent of the primary NAAQSs. In the case of TSP and SO_2, concentrations equal to their respective primary annual NAAQS were chosen because the frequent occurrence of values greater than these concentrations could lead to violations of their respective annual NAAQS. In an area where a violation of either the annual primary TSP or SO_2 standard occurs, approximately 50 percent or more of the days will thus be classified as "moderate" or worse. This approach minimizes the potential for public confusion which might arise from a preponderance of days reported as "good," followed by the report that the annual health-related standard has been violated.

The breakpoints between the primary NAAQS and Significant Harm Levels are somewhat arbitrarily set at the Federal Episode Alert, Warning, and Emergency Levels, except for oxidants. In the case of oxidant, 400 $\mu g/m^3$ was used as the PSI breakpoint for the descriptor words "unhealthful" and "very unhealthful" because it appears to be more consistent with the descriptor words than the suggested administrative Alert level of 200 $\mu g/m^3$.*

Figures 1 through 5 show the segmented linear function for each of the NAAQS pollutants, and Figure 6 showsthe function for the product of TSP and SO_2. If NAAQS for new pollutants are adopted in the future, they can be accommodated by drawing a new segmented linear function.

3.3 Descriptor Categories

PSI is primarily a health related index as shown by the descriptor words: "good," "moderate," "unhealthful," "very unhealthful," and "hazardous," (Table 3). The breakpoints used to separate these descriptor words are somewhat arbitrary. On the basis of health effects data above, it is not possible to establish a sharp demarcation between any two descriptor words. However, when the five pollutantswere examined in the context of severity of health effects, their NAAQS and EPA suggested administrative Alert, Warning, and Emergency levels tended to provide convenient breakpoints, except for the oxidant Alert level, which was replaced with 400 $\mu g/m^3$, as discussed earlier.

*Several air pollution control agencies are using 400 $\mu g/m^3$ instead of 200 $\mu g/m^3$ as their Alert level with concurrence by the Environmental Protection Agency.

TABLE 3. COMPARISON OF PSI VALUES WITH POLLUTANT CONCENTRATIONS, DESCRIPTOR WORDS GENERALIZED HEALTH EFFECTS, AND CAUTIONARY STATEMENTS

INDEX VALUE	AIR QUALITY LEVEL	POLLUTANT LEVELS TSP (24-hour), μg/m³	SO₂ (24-hour), μg/m³	CO (8-hour), mg/m³	O₃ (1-hour), μg/m³	NO₂ (1-hour), μg/m³	HEALTH EFFECT DESCRIPTOR	GENERAL HEALTH EFFECTS	CAUTIONARY STATEMENTS
500	SIGNIFICANT HARM	1000	2620	57 5	1200	3750			
							HAZARDOUS	Premature death of ill and elderly Healthy people will experience adverse symptoms that affect their normal activity	All persons should remain indoors, keeping windows and doors closed All persons should minimize physical exertion and avoid traffic
400	EMERGENCY	875	2100	46 0	1000	3000			
								Premature onset of certain diseases in addition to significant aggravation of symptoms and decreased exercise tolerance in healthy persons	Elderly and persons with existing diseases should stay indoors and avoid physical exertion General population should avoid outdoor activity
300	WARNING	625	1600	34.0	800	2260			
							VERY UNHEALTHFUL	Significant aggravation of symptoms and decreased exercise tolerance in persons with heart or lung disease, with widespread symptoms in the healthy population	Elderly and persons with existing heart or lung disease should stay indoors and reduce physical activity
200	ALERT	375	800	17 0	400[c]	1130			
							UNHEALTHFUL	Mild aggravation of symptoms in susceptible persons, with irritation symptoms in the healthy population	Persons with existing heart or respiratory ailments should reduce physical exertion and outdoor activity
100	NAAQS	260	365	10 0	160	a			
							MODERATE		
50	50% OF NAAQS	75[b]	80[b]	5 0	80	a			
							GOOD		
0		0	0	0	0	a			

[a]No index values reported at concentration levels below those specified by "Alert Level" criteria.

[b]Annual primary NAAQS

[c]400 μg/m³ was used instead of the O_3 Alert Level of 200 μg/m³ (see text)

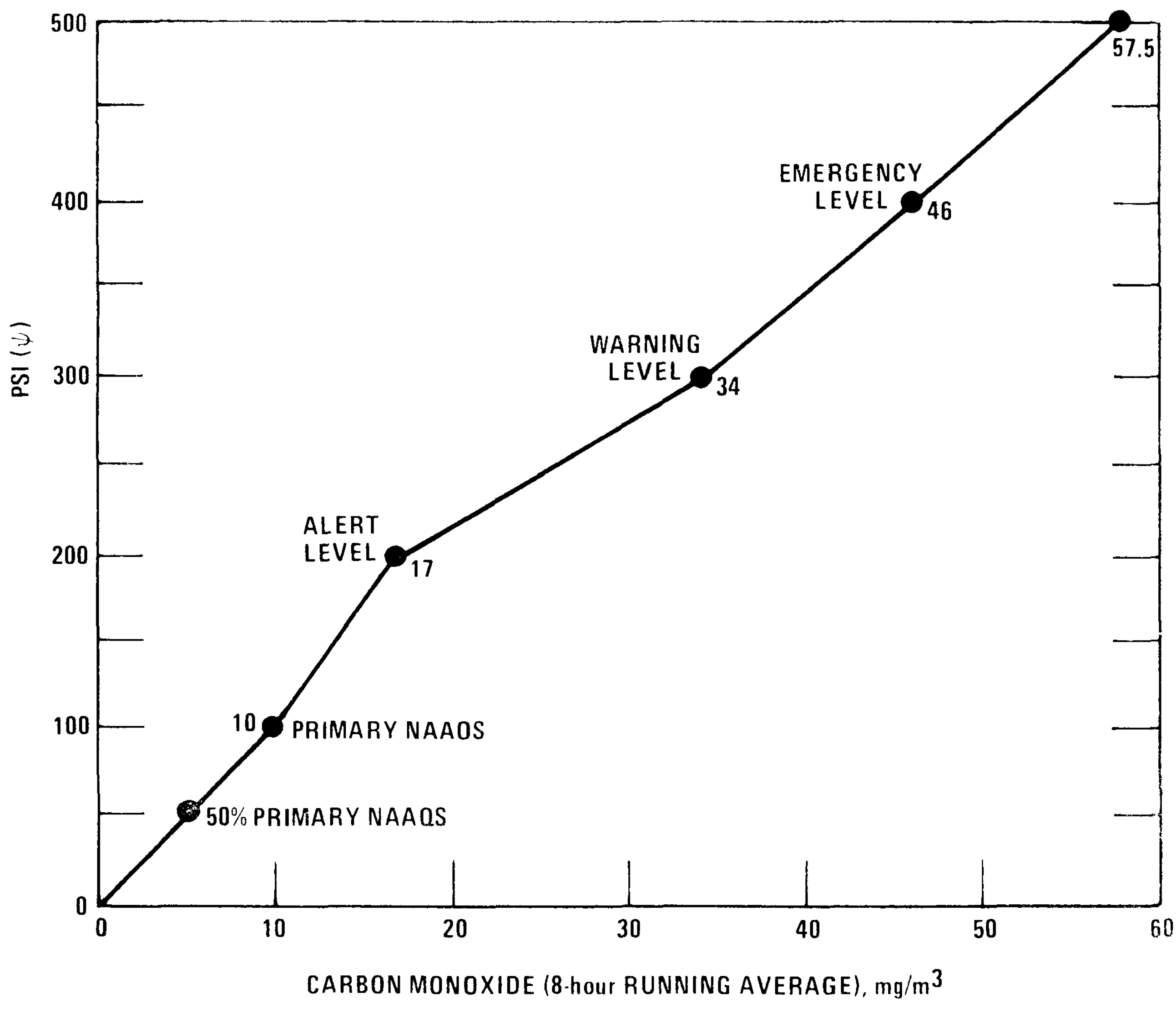


Figure 1. PSI function for carbon monoxide

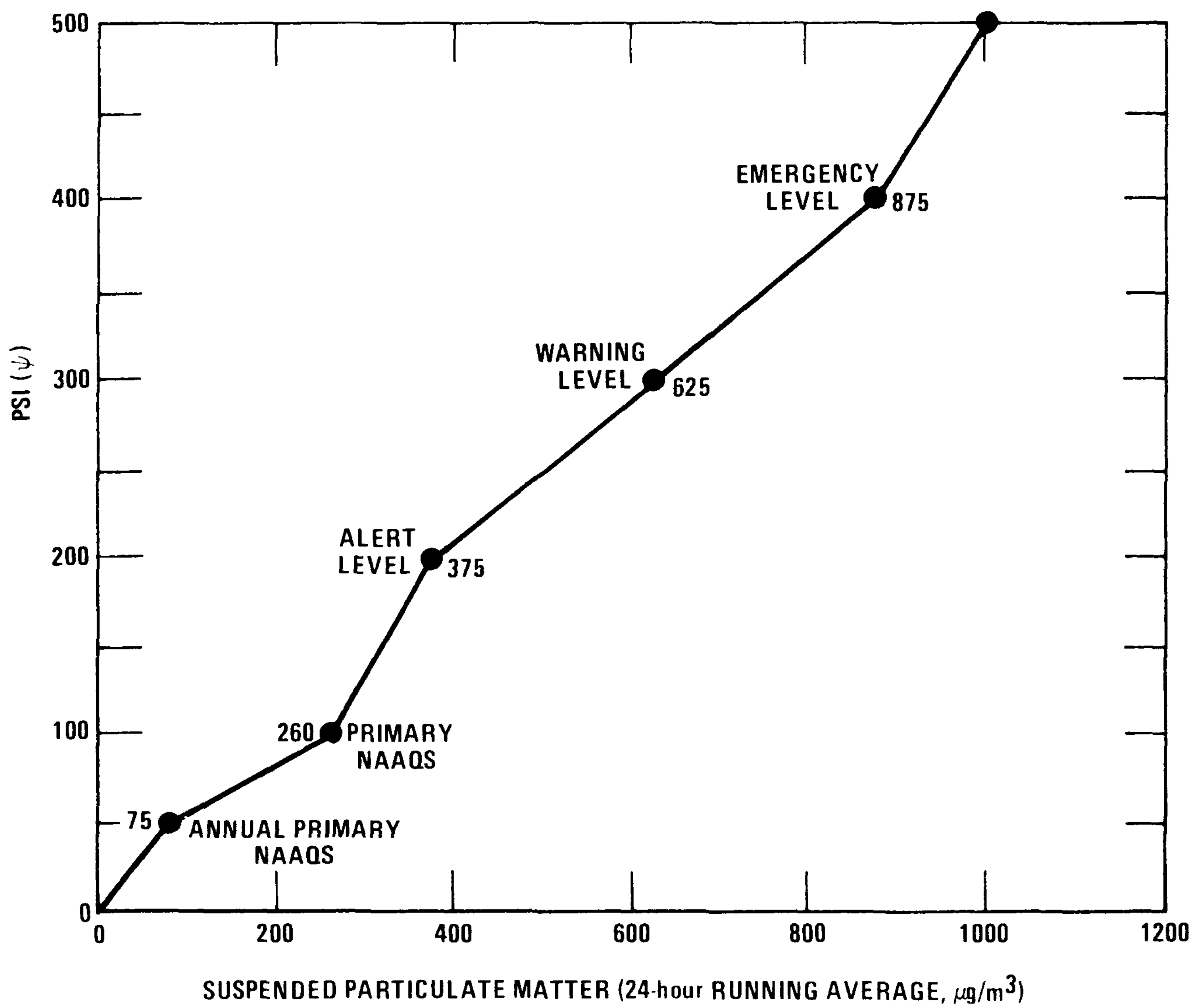


Figure 2. PSI function for suspended particulate matter

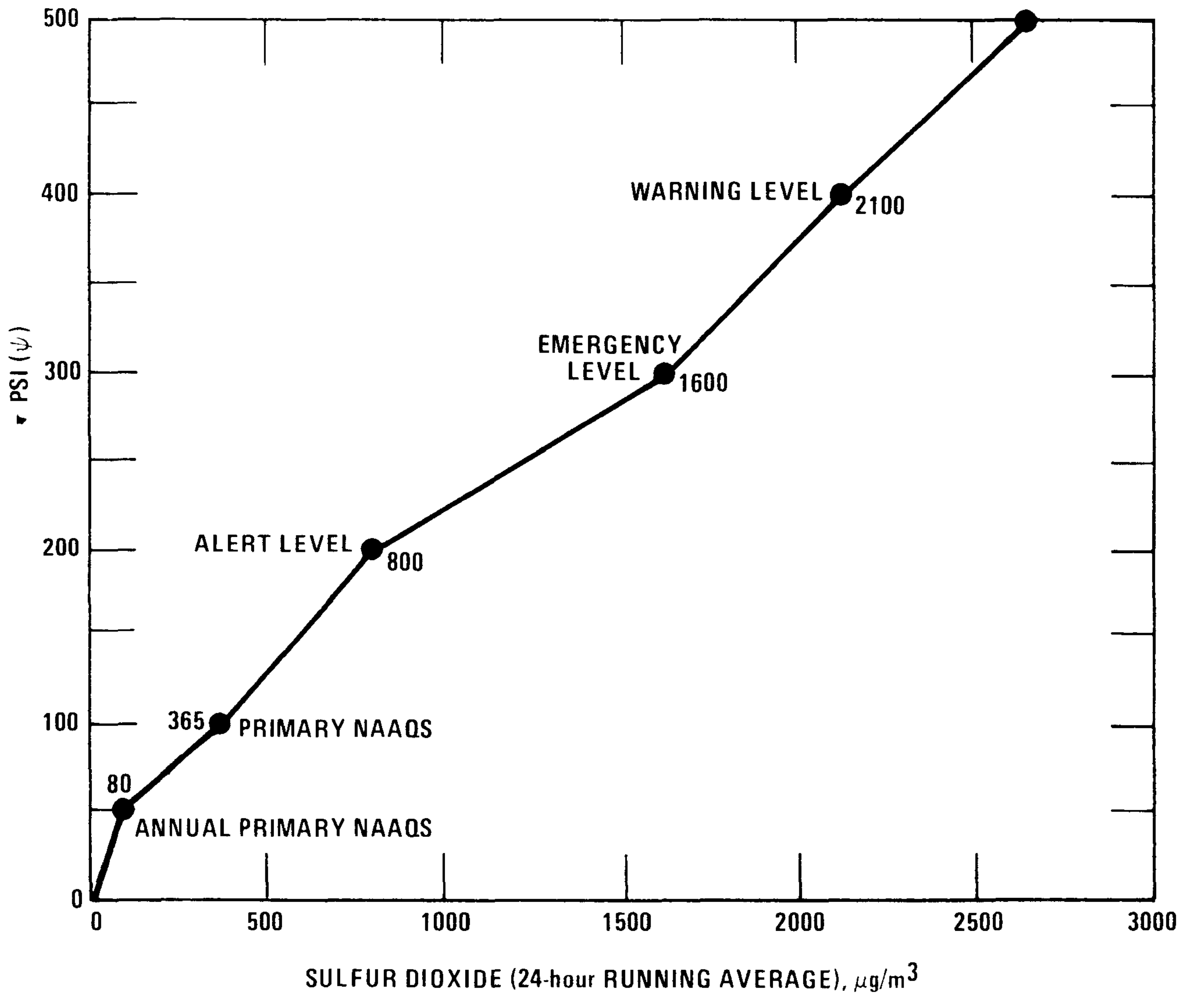


Figure 3. PSI function for sulfur dioxide

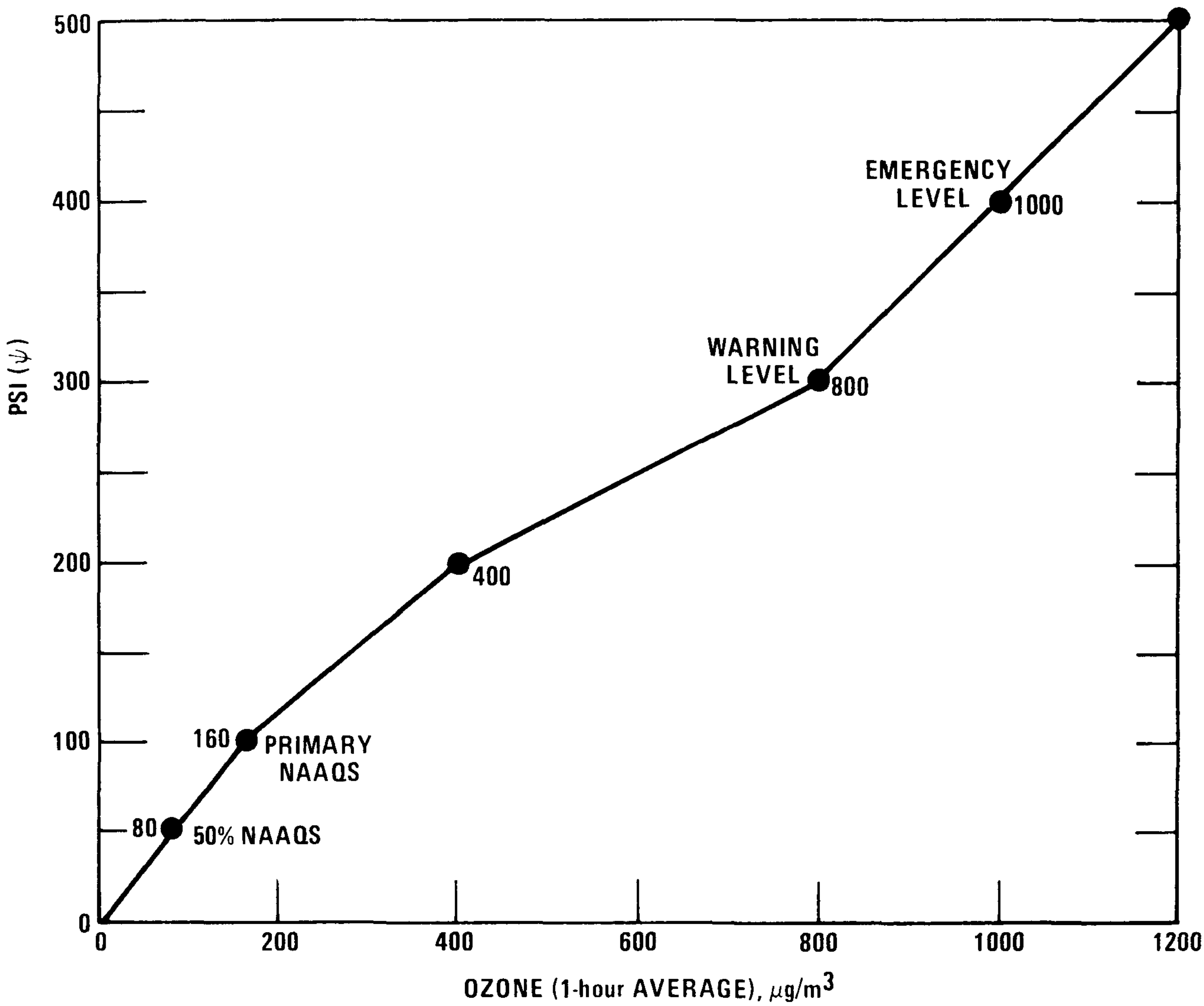


Figure 4. PSI function for photochemical ozone

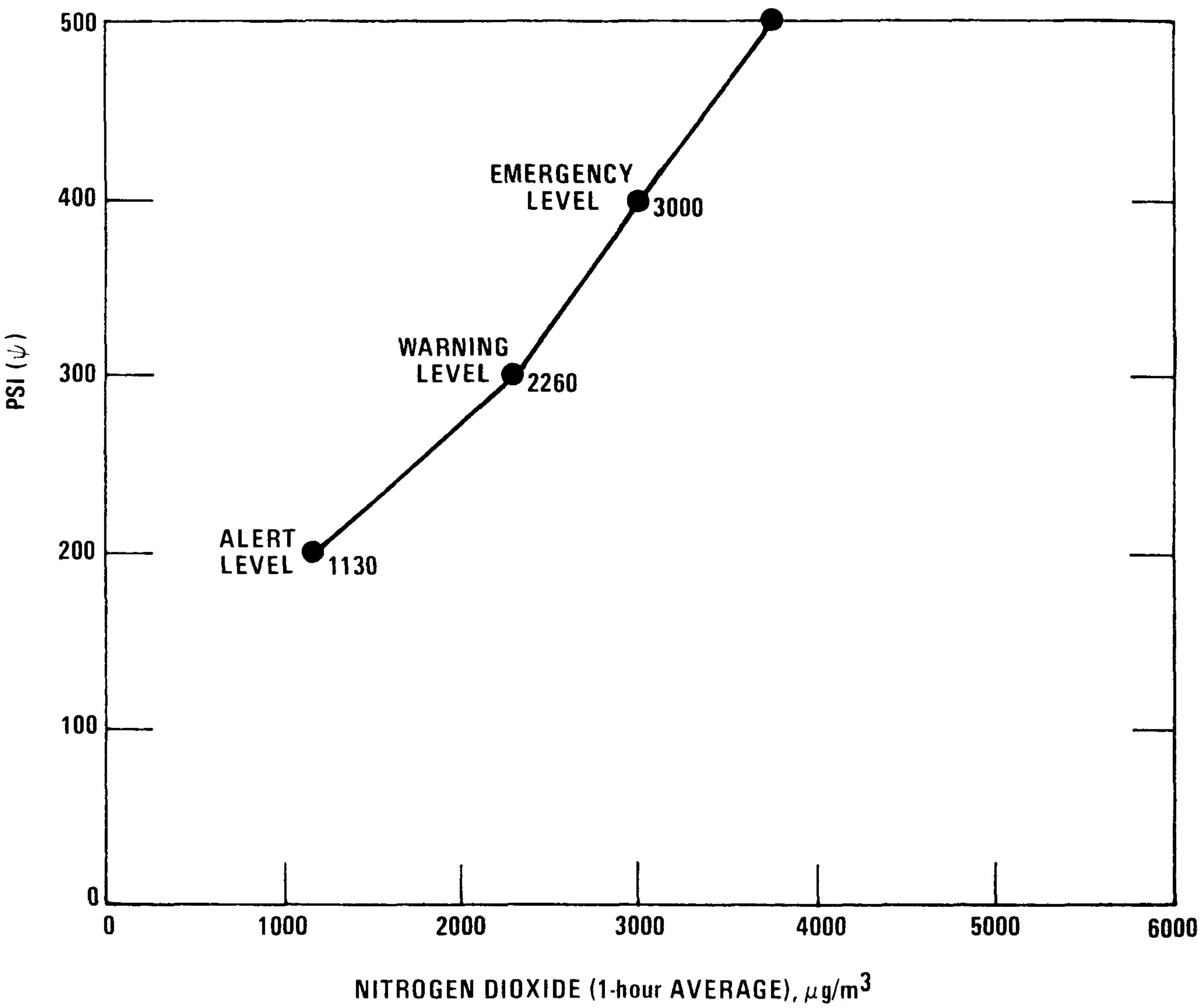


Figure 5. PSI function for nitrogen dioxide.

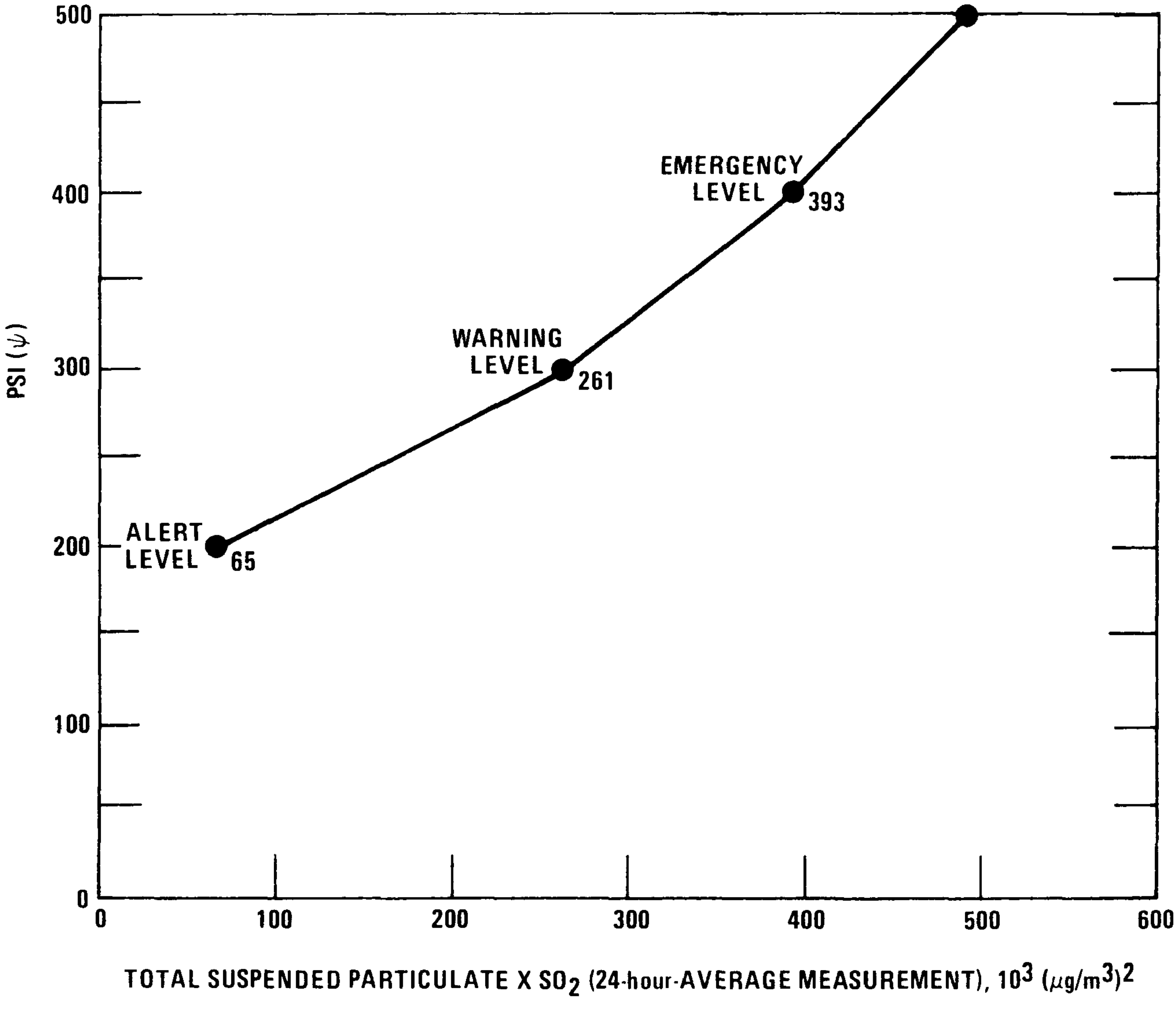


Figure 6. PSI function for product of total suspended particulate and sulfur dioxide

Air pollution levels between the short-term primary NAAQS and the Alert level for TSP, SO_2, and CO and 400 $\mu g/m^3$ for O_3 are deemed "unhealthful," because mild aggravation of respiratory symptoms in susceptible persons and irritation symptoms in the healthy population occur at some point above the short-term primary NAAQS and at and below the Alert levels for TSP, SO_2, and CO and 400 $\mu g/m^3$ for O_3.[10-13] NO_2 is not reported until concentrations exceed the Alert level because no short-term NAAQS has been established.[14] Air pollution concentrations above the Alert level but below the Warning level are classified as "very unhealthful," while concentrations above the Warning level are "hazardous."

These classifications are related to generalized health effects and appropriate cautionary statements (Table 3).[17] A single set of generalized health effects and cautionary statements is indicated for the descriptor words "unhealthful" and "very unhealthful." The "hazardous" category has two sets of generalized health effects and cautionary statements. The first set is reported when the index exceeds 300 and the second when the index exceeds 400 indicating the increasing severity of the air pollution levels.

In the case of TSP and SO_2, short-term secondary air quality standards also exist below their primary NAAQS. Secondary standards are designed to protect against the adverse effects of pollution on the public welfare (animals vegetation, materials, visibility, etc.). According to PSI, if their short-term secondary NAAQSs are violated, the concentrations would be classified as "moderate" or worse. While this descriptor word is valid from a health view-point, the air quality is unsatisfactory from the standpoint of welfare effects. Because PSI is a health-related index, the user may wish to report on the possible welfare effects when either the short-term TSP or SO_2 NAAQS is violated.

4. REPORTING PROCEDURES

PSI has been designed to be as flexible as possible in allowing air pollution control agencies to decide for themselves the information to include in their reports to the various media. This section examines the recommended method of reporting the index, the reporting of the Federal Episode Criteria, and the concept of flexible media reporting.

4.1 Reporting the Index

Since each pollutant is examined separately by comparing its measured concentration with the NAAQS, the Episode Levels, and the Significant Harm Level, each pollutant can be reported separately. At the minimum, the pollutant with the highest index value should be reported to advise the public of the worst air pollution to which it is exposed. On days when two or more pollutants violate their respective NAAQS--that is, have PSI values greater than 100--then each of the pollutants should be reported. The index values of the other pollutants may also be reported for completeness. When the air pollution level is reported as "unhealthful," "very unhealthful," or "hazardous," cautionary statements should also be used. In addition, the generalized health effects can be used.

Users of PSI may wish to report on the health effects of each pollutant individually, thereby providing more detailed language on each pollutant than is available in Table 3. In preparing such information for the public, the user is encouraged to seek appropriate medical advice and to consult the literature.[10-14]

4.2 Reporting the Federal Episode Criteria

When the Federal Episode Levels for each pollutant are exceeded, the user should report the administrative actions associated with the Alert, Warning, or Emergency Levels. The issuance of administrative actions depends, of course, upon the forecast of meteorological conditions affecting future pollution levels.

Issuance of administrative actions also apply to the product of TSP and SO_2, which has both Federal Episode Criteria and Significant Harm Levels.[2,3] Although available health effects information has not been codified to tie the descriptor words to the product of TSP and SO_2, the product is included for purposes of administrative completeness.

4.3. Forecasting the Index

The forecasting of a quantitative index for periods up to a day in advance would be difficult without extensive meteorological data and specialized expertise that some air pollution control agencies may not possess. However, qualitative index forecasting is practicable using the National Weather

Service's Air Pollution Weather Forecast Program.[18,19] With this weather information, along with available emissions and air quality trend data, agencies can develop techniques or procedures to forecast the relative change in the index by using the following word descriptors: No significant change, decrease, or increase. The principal responsibility for obtaining the necessary emission and air quality information lies with the air pollution control agency using the index. The air pollution control agency would integrate the meteorological information and apply the predictive methods to generate the forecast. The information needs for forecasting relative index changes is discussed further in Appendix A.

4.4 Flexible Media Reporting

The index has been designed to be as flexible as possible in reporting the status of air quality to the public. Either short or long reports can be used. For television, the report could read, "Today the air pollution index is 50, the air quality is good." However, when the air pollution becomes unhealthful, then several possible reports could be considered for television, the news media, or telephone recordings. For example, when oxidant pollution reaches a concentration of 280 $\mu g/m^3$ (0.14 ppm), the report could take several different forms.

(1) Today, the air pollution index is 150. The air is "unhealthful." The pollutant O_3 is responsible.

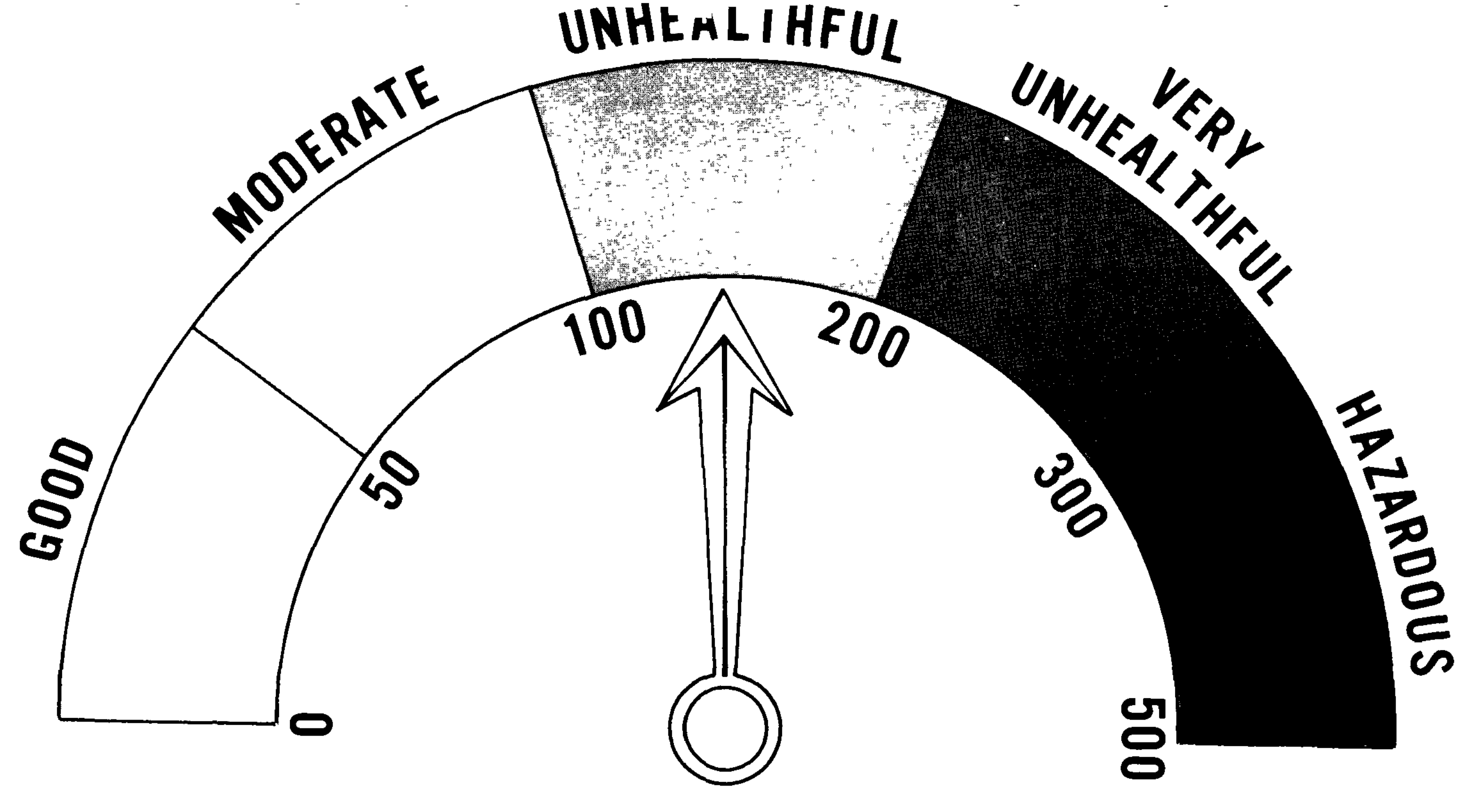
(2) An air pollution alert has (or has not) been called based on the forecast for the remainder of the day (and/or) tomorrow.

(3) Repeat the above and add the following cautionary statements: "Persons with existing heart or respiratory ailments should reduce physical exertion and outdoor activity."

(4) The report could include everything said in (1), (2), and (3) and then add that "unhealthful" air can cause "mild aggravation of symptoms in susceptible persons, with irritation symptoms in the healthy population."

(5) Finally, the report could conclude with the forecast of tomorrow's air pollution level, such as "no change in the air pollution level is expected."

Table 3 should be referred to in preparing the air pollution status report to the public. Figures 7 and 8 illustrate the above ozone example



PSI = 150

POLLUTANT: Oxidants

TODAY'S HEALTH IMPLICATIONS: Respiratory ailment and heart disease patients should reduce exertion and outdoor activity.

FORECAST: No change.

Figure 7. Example of possible PSI report for television (colors: Good - blue, Moderate - green, Unhealthful - yellow, Very Unhealthful - orange, Hazardous - red)

Figure 8. Example of possible PSI report for newspaper (black-and-white)

by showing possible reports for the television and newspaper, respectively. Both figures provide essential information, indicating the PSI value, the critical pollutant, the health implications for the public, and the next day's forecast. Each of the descriptor categories has been given equal weight. The information is displayed so that it can be presented as rapidly as possible in an easy-to-understand format.

5. MONITORING REQUIREMENTS

5.1 Need for Monitoring Uniformity

In order for PSI to be readily accepted, the data used in calculating the index must be comparable from site to site within a region. Since these data are to be obtained at existing air monitoring sites, certain easily implementable practices can eliminate considerable variability in the data. Among these are using: (1) uniformity of site types--that is, residential, commercial, etc.; (2) Federal Reference Methods or their equivalent; (3) standardizing sampling height and probe exposure; and (4) good housekeeping and quality control procedures to provide high quality data.

5.2 Network Considerations

Air pollution control agencies need not undertake additional monitoring requirements in the implementation of PSI, but can simply select sites from their existing network. The sites selected, however, should generally meet two basic criteria: (1) sites should be representative of population exposure--that is, not unduly influenced by a single emission point or background-oriented, and (2) sites should be located in areas of maximum concentration for the pollutant of interest, but should not be unduly influenced by any single source. Areas suitable for monitoring, by pollutant are

- TSP - populated areas substantially downwind of large sources or in the midst of numerous area sources.
- SO_2 - populated areas substantially downwind of large sources or in the midst of numerous area sources.

- CO - densely populated, high-traffic volume areas, including areas in the center city.
- O_3 - populated areas substantially downwind of areas of maximum hydrocarbon emissions density, such as the central business district. The site should be 100 meters or more removed from major traffic arteries or parking lots.
- NO_2 - populated areas downwind of areas of high traffic density.

If a pollutant(s) is (are) measured at several locations within a metropolitan area, it would be desirable (if possible) to base the index on the site showing the highest reading on a given day. This would mean that different sites would be used on different days.

For large metropolitan areas comprised of many smaller cities and suburbs where significant air quality differences may exist, the air pollution control agency may wish to report separate index values for each community. This has the additional advantages of showing the public how air pollution varies over the larger metropolitan area. Furthermore, for example, the photochemical pollutants tend to be higher in the suburban fringe.

5.3 Measurement Practices and Reporting Frequencies

5.3.1. Use of Federal Reference Methods

Since PSI is based on the NAAQS, the Federal Reference Methods (FRM) or equivalent should be used where possible. Such methods are consistent with the averaging time of the primary standards. Further, continuous methods should be used, where possible, to facilitate the reporting of the index numbers two or three times per day.

5.3.2 Carbon Monoxide, Nitrogen Dioxide, and Ozone

The FRM for CO is based on the nondispersive infrared measurement principle. The proposed method for NO_2 and the existing method for O_3 employ the chemiluminescence measurement principle and give continuous data. A FRM or equivalent method for CO, NO_2, and O_3 must also meet performance specifications set forth in the Federal Register.[20]

5.3.3 Sulfur Dioxide

The FRM for SO_2 is the pararosaniline 24-hour bubbler method. The solution may be analyzed automatically or manually at the central laboratory. Serious logistics problems can arise if an index number must be calculated from multiple sites two or three times per day. Fortunately, there are procedures for designating continuous SO_2 analyzers as equivalent to the FRM,[20] and from these 24-hour running averages are easily obtained. Therefore, the use of the continuous SO_2 analyzer is recommended to collect the data used in the index. If one is not available, then a pararosaniline 24-hour bubbler method can be used if several precautions are taken. To prevent deterioration in the sample, the sample should be collected at ambient temperature or no warmer than 15°C if ambient temperatures are below freezing. The sample should then be analyzed as soon as possible, with no later than a six-hour delay from end of sampling to analysis.

5.3.4 Total Suspended Particulate

The FRM for TSP uses a high-volume sampler and specifies a midnight-to-midnight 24-hour sample followed by a 24-hour equilibration at a relative humidity less than 50 percent. This leads to a two-day delay in the reported value. For index reporting, the simplest modification to the FRM is to make the sampling time more convenient--that is, 8 a.m.-to-8 a.m. or noon-to-noon, etc. The sample could be weighed immediately to provide a TSP value for the index. Later a true value could be calculated after the recommended equilibration time of 24 hours. A study in EPA Region IV has shown that the true TSP values are usually within 10 percent of the values measured immediately after collection.[21] The true value would be recorded as the correct one, reported to the National Aerometric Data Bank, and used to calculate annual averages and maxima.

5.3.4.1 Staggered high-volume sampler measurements

During episode conditions, the air pollution control agency may find it necessary to inform the public of existing conditions two or three times per day. Therefore, several high-volume samplers could run for 24 hour periods staggered every 4 to 6 hours throughout the episode. The sample could be weighed immediately, and that weight used in deciding what action should be taken concerning the possible emergency. Then the filter would be equilibrated for 24 hours and reweighed.

5.3.4.2 Alternative measurements

The paper tape sampler and the integrating nephelometer can be used to indicate the need for overlapping high-volume sampler measurements. The paper tape sampler has been used in most previous indices and has both Federal Episode Criteria and a Significant Harm Level. The Coefficient of Haze (COH) value from the paper tape sampler, however, is poorly correlated with TSP levels. In addition, the paper tape sampler has not been determined to be an "equivalent method" to the FRM. Therefore, its use should be limited to index reporting and must not be used to determine compliance with the NAAQS for particulate matter.

A newer instrument relatively untested in routine field applications is the integrating nephelometer. It measures the scattering of light from small particles and correlates well with visibility and TSP measurements. Both the paper tape sampler and the nephelometer can produce a running 24-hour value which can be used as a qualitative indicator of TSP loadings in the atmosphere.

5.3.5 Frequency of Reporting and Appropriate Averaging Times

The frequency of reporting is left up to the agency, within these suggested ranges. It may be desirable to report the index once a day but probably not more than three times per day. Because the high-volume sampler has a 24-hour averaging period, agencies might consider operating two or more high-volume samplers at the same station but with off-set time periods, ending between 8 a.m. and 6 p.m. to provide reporting information during the most desirable period.

If the agency desires, the paper tape sampler or integrating nephelometer could be used in conjunction with the high-volume sampler to provide estimates of the most recent ambient particulate loading. Thus used, the paper tape sampler provides some guidance on whether or not to undertake more intensive measurements during high air pollution levels.

Appropriate averaging times for which the index should be tabulated and reported for each pollutant are:

- TSP - TSP values taken with the high-volume sampler are discrete 24-hour values. Monitoring and data collection should be on a schedule consistent with the agency's need to report the air quality index. Other overlapping times may be employed by those agencies wishing to report more than one index value per day.
- SO_2 - The suggested reporting value is the most current 24-hour running average since the last reporting period.
- CO - Although there are two standards for CO (8 hours and 1 hour), the 8-hour standard is usually considered the limiting one and will be the one violated in the vast majority of cases. The most current 8-hour running average since the last reporting should be used. In addition, the agency could also report the index value associated with the highest 8-hour average during the reporting period.
- O_3 - The suggested reporting value for O_3 is the highest hourly value since the last reporting period. The reporting periods are usually 24 hours or shorter.
- NO_2 - Although the standard for NO_2 is an annual one, there are hourly values associated with episode criteria; therefore, using the highest hourly value since the last reporting period is recommended.

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APPENDIX A

INFORMATION NEEDS FOR FORECASTING PSI

INTRODUCTION

The information needed to qualitatively forecast the Pollutant Standards Index (PSI) is of two types: (1) pollutant-related and (2) meteorological. The pollutant-related information may include data on source locations, physical source characteristics and emissions, atmospheric-physio-chemical transformation processes, and actual air quality measurements and trends. Meteorological information that may be included are data on synoptic weather features, on meteorological parameters indicative of the dispersive capability of the lower atmosphere, and of the photochemical potential. It might also include information on the effect of local terrain complexities upon meteorological parameters. Together, pollutant-related and meteorological information form the input to locally tailored predictive techniques such as mathematical models, statistically derived methods, or other techniques that may be applied along with subjective judgment to some degree.

The necessary pollutant-related information is to be obtained by the air pollution control (APC) agency having local responsibility for issuing the Index. The National Weather Service (NWS) is the primary agency supplying the needs of APC agencies for meteorological information. NWS services include issuance of advisories on air pollution potential and air stagnations. However, some APC agencies and/or their consultants may also collect and interpret meteorological information to supplement that available from the NWS.

GENERAL DATA NEEDS

The types and amounts of pollutant-related information needed will vary depending on the particular pollutant(s) of concern and the source to monitoring site configurations in the particular geographical area. For example, in the Los Angeles Basin, photochemical oxidant is the primary pollutant of concern and since precursor sources (mainly mobile) are widespread, the potential for maximum impact exists over a rather large area. In contrast, in Pittsburgh and Birmingham where suspended particulate matter from industrial ferrous emissions will most likely cause elevated pollutant levels, the maximum impact will probably be more localized; thus, pollutant-related information may not have to be as extensive. It is also important to know the diurnal, weekly, and seasonal characteristics of emissions. For instance, carbon monoxide concentrations are closely associated both spatially and temporally with automobile emissions. Typical diurnal patterns reflect morning and evening peaks in vehicular traffic. High concentrations may shift weekly in response to changes in workday versus weekend automotive travel patterns. Seasonal patterns may shift in some areas with vacation travel.

Generally, an up-to-date emissions inventory should be available for communities where PSI is to be utilized in order to adequately assess the source to monitoring site impact relationships. For point sources (usually > 100 tons/year of a pollutant) information should include the source location, pollutants emitted, emission rates, and stack parameters. Area source data, including lesser point emissions, are not normally as specific. Available area emissions, in tons per year, are usually quantified by city or county. Vehicular emissions may be estimated by combining local traffic pattern information with documented vehicle-fleet emissions rates. These emissions data are available from the EPA National Emissions Data System (NEDS), state planning agencies, and private sources. It may be necessary to supplement these data with emissions information affecting the various temporal cycles; for instance, information on the normal operating schedules of large point sources and on traffic volume cycles in congested areas.

Trends in the concentrations of pollutants can also be useful in predicting the PSI. Trend information might include the day-to-day variation in peak hourly values or 24-hour averages. Trends data should always be evaluated relative to changes taking place or anticipated in emissions or meteorology. Persistence of a trend would especially aid in arriving at the PSI forecast if no definitive changes in emissions or meteorological features are indicated. Interpretations of trends information, on a day-to-day basis, require care and experience because of the fluctuations that for varied reasons tend to occur about a mean trend.

The types of meteorological information that could be used for forecasting the PSI have been rather well defined through past experience with forecasting methods developed in support of air pollution control activities.

This support has largely dealt with forecasting indices and episodic conditions. The meteorological features and parameters that are most often utilized in forecasting air quality indices at the present time are:

- Character and Movement of Air Masses and Fronts
- Areas of Air Mass Subsidence
- Incidence, Intensity, and Height of Inversions
- Mixing Layer Height
- Prevailing Wind Direction
- Mean Wind Speed (Surface and Mixing Layer)
- Ventilation (Mixing Layer Mean Wind Speed x Mixing Height
- Precipitation
- Temperature
- Total Sky Cover

Of course, the emphasis placed on particular features and parameters listed above will vary with location and pollutant(s) of concern.

NWS INFORMATION AND SUPPORT SERVICES

The NWS operates a comprehensive Air Pollution Weather Forecast Program. The program is administered from NWS National and Regional Headquarters with operational program elements at the National Meteorological Center (NMC) and local Weather Service Forecast Offices (WSFO's). Details of the program are contained in the NWS Operations Manual[1] and Technical Procedures Bulletins.[2] This program generates a variety of national, regional, and local air pollution weather forecast products which are issued to the public, to control agencies, or to both, as appropriate.

The NMC is responsible for providing the large-scale meteorological guidance used by field offices in the preparation of advisories and other products which are particularized and tailored to specific geographic areas to user requirements.

The air pollution weather products of NMC are comprised of the following elements:

a. <u>Forecast Air Stagnation Charts</u>. Issued every morning on facsimile, these four panel computer based charts depict expected areas of atmospheric stagnation (Figure 1).

b. <u>Air Stagnation Narrative</u>. This plain language teletype message describing the Air Stagnation Charts, is issued every morning.

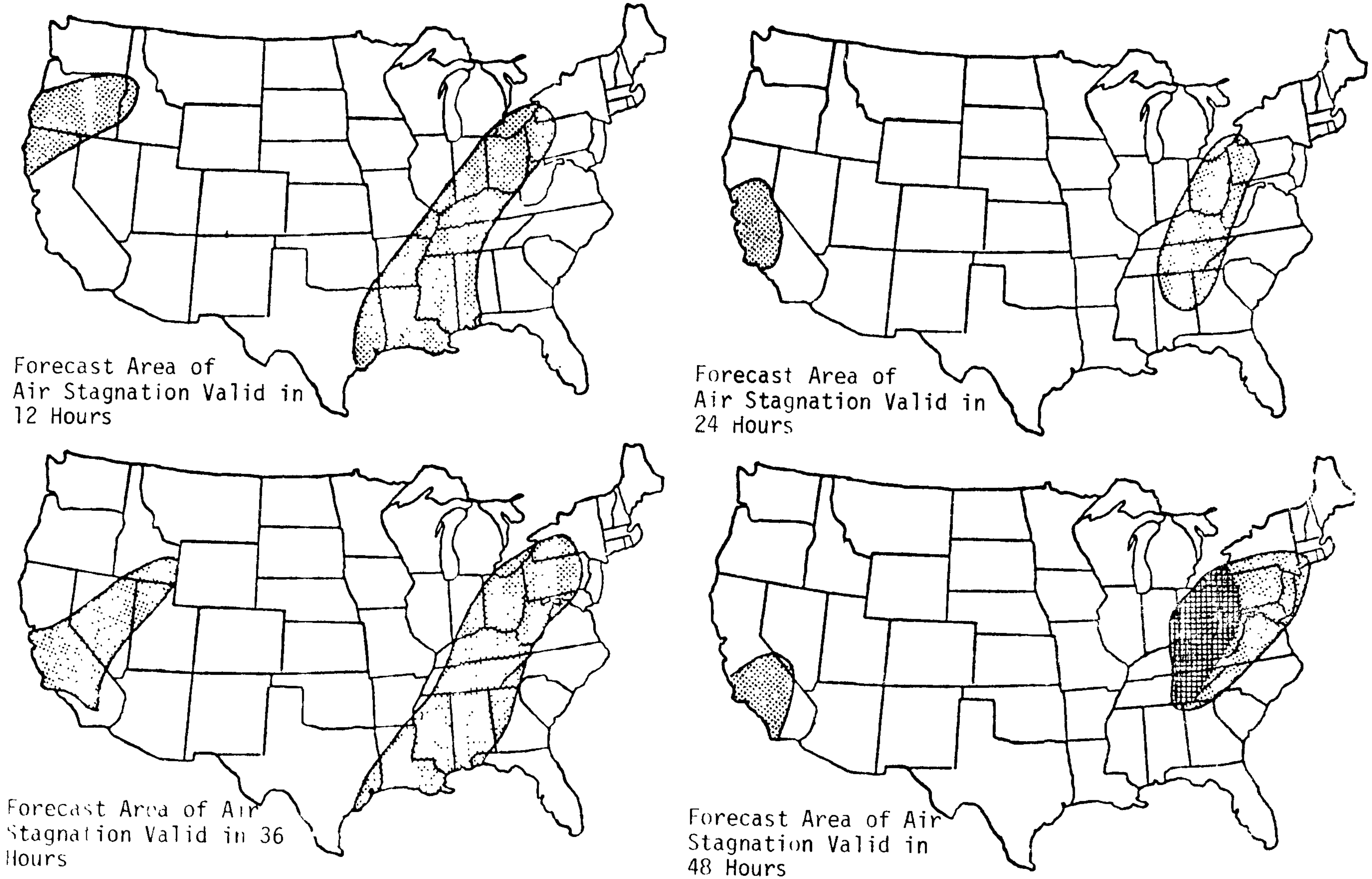

Figure 1. Sample of Stagnation Chart sent on facsimile, depicting significant areas of large-scale stagnation. Shaded area indicates area of large-scale stagnation, hatched area indicates area that is under large-scale stagnation on all four panels.

c. Air Stagnation Data. This computer derived teletype message currently consists of today's mixing height and transport wind speeds for selected NWS stations.

The WSFO's have responsibility for local forecast products within designated geographic boundaries, including the issuance of the following three basic air pollution products:

a. Air Stagnation Advisories (ASA). Issued to the public and control agencies when locally established critical values of transport wind, mixing height, and ventilation are forecast to be reached and conditions are expected to persist for at least 36 hours, causing probable significant decrease in air quality.

b. Special Dispersion Statements. A special product issued only to control agencies when a potential air pollution situation is determined by an NWS forecaster to exist but no ASA will be issued because such an issuance would not be in the public interest.

c. Dispersion Outlooks. A routine product issued by all WSFO's where it has been determined that the APC needs routine meteorological information to facilitate day-to-day operations and adequate manpower is available at the WSFO. The format, content, and issuance times of this product is determined by the WSFO and APC. The Dispersion Outlook is issued only to the APC.

Occasionally, air pollution episodes of public concern may occur during non-stagnant situations. These involve predesignated episode levels that require control actions to improve the air quality condition. In these situations, the WSFO provides the appropriate government agencies with the meteorological support necessary for pollution control or abatement procedures.

In conjunction with these services, the NWS provides supplemental, low-level upper air soundings at designated stations upon request from agencies and/or WSFO's. This program which provides for greater spatial and temporal detail on dispersion conditions, especially during episodes or potential episodes, is available for several cities. These locations are listed below, together with the sounding scheduled:

Location	Program
Birmingham, Ala.	1 per day routine week day, week-end and second daily observation on call
Charleston, W. Va.	1 per day routine week day, week-end and second daily observation on call
Chicago, Ill.	1 per day routine week day, week-end and second daily observation on call
El Monte, Ca.	2 per day routine week days except occasionally omit afternoon soundings on well ventilated days
Houston, Tex.	1 per day routine week day, weekends and second daily sounding on call
Los Angeles, Ca.	2 per day, 7 days a week
Philadelphia, Penn.	all observations on call

Additionally, special low-level soundings are available on an on-call basis at the regular upper air observation facilities near Denver, Co., New York, N.Y., Oakland, Ca., Pittsburgh, Pa., and Washington, D.C. An aircraft sounding is available at Sacramento, Ca. Through a Cooperative effort, state APC agencies take soundings as needed in Seattle, Boston, Portland, Ore., and San Jose, Ga. These are taken at special facilities that were established by the NWS.

The NWS has, up until recently, not been too closely involved nationwide in predicting conditions conducive to buildup of photochemical pollutants. Because of recent interest and increasing demand for such information, the NWS is in the process of evaluating possible techniques with the objective of modifying or adding to current air pollution weather forecast products and services.

DEVELOPMENT OF PREDICTION METHODOLOGY

The available services and information briefly described above form the basis for developing a local community procedure for making local qualitative forecasts of the PSI. These forecasts can be reasonably made for periods up to a day in advance in terms of No Significant Change, Increase, or Decrease. It is advisable for agencies planning to use the index along with a forecast procedure to have personnel on their staffs familiar with meteorological data and how these data may be applied in development of index prediction methodology.

Considering the wealth of information available from the NWS, it seems logical that the issuance of an index forecast should be scheduled at intervals complementary to operations at the NWS. This would allow the APC agency to have the advantage of the most current NMC weather products and WSFO air pollution forecast services. In addition, it would encourage further cooperation and support of the local NWS facility. However, while it can be expected that NWS meteorologists will be able to closely coordinate with a local agency in arriving at index change predictions during potential or actual episodic conditions, they will most likely not be able to give such attention to routine day-to-day forecasting of the index. Also, NWS personnel would not be expected to have detailed knowledge of pollutant-related factors.

Where an APC agency may have developed the expertise necessary to make quantitative predictions of the PSI for the following day, they should be encouraged to make these predictions. However, it should be cautioned that making quantitative predictions of air quality or air quality indices should not be attempted without a reasonable expectation of success based on well-tested techniques. Otherwise, a less than satisfactory forecast record could result, which would tend to have an adverse effect on public acceptance of the PSI.

Mathematical air quality simulation models have to date not been used to any appreciable extent in index prediction. Because of their relative complexity, cost of modifying for local use, and time and expense that may be involved in making day-to-day predictions, their use for predicting the index qualitatively will initially be limited. However, where APC agencies may progress to the point of making quantitative forecasts, the use of models may become necessary. A listing and brief description of possible air quality models that could be applied are contained in OAQPS Guideline No. 1.2-031.[3]

CURRENT USE OF METEOROLOGICAL INFORMATION IN INDEX PREDICTION

Approximately half of the 25 local agencies currently issuing air pollution indices make forecasts of their index a day in advance. Of these, only one third have meteorologists on their staffs, while the remainder rely upon NWS meteorologists for interpretation of meteorological data. Three of the local agencies were selected to serve as examples of how varying degrees of meteorological information can be incorporated into air quality index forecasting.

One of the more sophisticated forecast techniques, the Air Pollution Dispersal Index, was developed six years ago by the State of Colorado Department of Health in Denver.[4] A forecast is issued each morning for four time periods, a.m. today, p.m. today, a.m. tomorrow, and p.m. tomorrow. The technique developed by department meteorologists is based upon concepts of mixing heights and wind speed discussed by Holzworth in AP-101,[5] and employs a nomogram of wind speed vs. mixing heights, with isolines of constant ventilation factor values serving to demarcate four dispersion categories. These categories are:

Ventilation Factor (m^2/sec) (Wind Speed x Mixing Height)	Associated Dispersion
< 2000	Bad
> 2000 to 4000	Fair
> 4000 to 6000	Good
> 6000	Excellent

The mixing heights used for the "today" forecast are determined from a plot of the Denver morning upper air sounding, the morning minimum surface temperature at Stapleton Airport plus 3° to 4°C, and the forecast afternoon maximum temperature. The "tomorrow" mixing heights are determined from the forecast 24-hour minimum and 36-hour maximum temperature, and a forecast of the sounding using locally-tailored analytical techniques. All transport wind speeds are derived from either observed or forecast NWS data. Critical factors in Denver are the typical low-level morning inversions which serve to deteriorate air quality and the occurrence or forecast of rain or snow which automatically leads to a forecast of improving air quality.

The City of Philadelphia Department of Public Health[4] uses general meteorological conditions and a NWS Air Stagnation Index to predict the Philadelphia Air Quality Index. The local agency receives meteorological information twice daily from the Philadelphia NWS office. Parameters of most concern are wind speed, gustiness and the likelihood of a frontal passage with its associated turbulent mixing. Wind direction is not a vital concern since emission sources in the city are relatively well distributed in all directions. Specifically, the Air Stagnation Index is formulated from the algebraic sum of several weighted meteorological parameters as shown in Table 1. To determine the index value, the weights associated with each observed parameter are summed. When at least one of the meteorological values is

TABLE 1. Air Stagnation Check Sheet[1]

Meteorological parameters	Value categories	Weights
morning wind speed (knots)	> 10	STOP
	≤ 10 > 8	-1
	≤ 8 > 6	+1
	≤ 6	+2
afternoon and evening wind speed (knots)	> 11	STOP
	≤ 11 > 9	-1
	≤ 9 > 6	+1
	≤ 6	+2
morning mixing height (meters)	> 1500	STOP
	≤ 1500 > 750	-1
	≤ 750 > 500	0
afternoon ventilation factor (meter^2/sec)	> 8000	STOP
	≤ 8000 > 6000	-2
	≤ 6000 > 4000	0
	≤ 4000	+1

[1]Philadelphia Forecast Office
National Weather Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

associated with a "STOP," excellent dispersion is forecast. Otherwise, dispersion is forecast according to the following scheme:

Sum of weights	Forecast dispersion
-1, -2, -3	good
0	marginally good
+1	marginally poor
+2, +3	poor

However, due to the nature of the Philadelphia Air Quality Index, a dramatic change in dispersion is required to effect a change in the index values.

The Department of Public Health in Dallas[4] uses meteorological data in a very qualitative manner. The general weather situation is examined daily with primary importance directed toward stagnating high pressure systems, cold frontal passages, and prevailing wind direction. NMC trajectory analysis data, surface weather patterns, and prognostic charts are used in a non-rigorous manner. For example, geographical plots of smoke and haze reports are occasionally used to determine the area extent and approach of pollutants due to large scale circulation patterns.

Improving conditions are forecast with the occurrence of precipitation, a frontal passage, and increasing wind speed. Deteriorating air quality is predicted when trajectories persist from local or more distant sources or sources areas.

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16. ABSTRACT
The U.S. EPA's Pollutant Standard Index (PSI) is the result of a joint effort on the part of EPA's Offices of Air and Waste Management, Research and Development, and Planning and Management. The guideline suggests the use of an air quality index for those local and state air pollution control agencies wishing to report an air quality index on a daily basis. The PSI places maximum emphasis on protecting the public health; that is, it advises the public of any possible adverse health effects due to pollution. The index incorporates five major pollutants: carbon monoxide, oxidants, particulates, sulfur dioxide, and nitrogen dioxide. "Good" air quality falls in the 0 to 50 range, "moderate" air quality from 50 to 100, "unhealthful" from 100 to 200, "very unhealthful" from 200 to 300, and "hazardous" above 300.

17. KEY WORDS AND DOCUMENT ANALYSIS

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Pollutant Standards Index Air Quality Index Air Pollution Index		

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