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SUPPLEMENT B

TO THE

GUIDELINE ON AIR QUALITY MODELS (REVISED)

(Appendix W of 40 CFR Part 51)

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U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

NOTE

The following pages contained in Supplement B to the Guideline on Air Quality Models (Revised) (EPA Publication No. EPA-450/2-78-027R) are to be inserted in the Guideline, with Supplement A already having been incorporated. The page numbers will indicate which pages are to be added and which are to replace previous pages. As the ERT Air Quality Model (ERTAQ) and the Multiple Point Source Diffusion Model (MPSDM) are being deleted from Appendix B, pages B-19 -> B-22 and B-59 -> B-62, respectively, should be removed from any previous editions of the Guideline.

PREFACE

Industry and control agencies have long expressed a need for consistency in the application of air quality models for regulatory purposes. In the 1977 Clean Air Act, Congress mandated such consistency and encouraged the standardization of model applications. The Guideline on Air Quality Models was first published in April 1978 to satisfy these requirements by specifying models and providing guidance for their use. This guideline provides a common basis for estimating the air quality concentrations used in assessing control strategies and developing emission limits.

The continuing development of new air quality models in response to regulatory requirements and the expanded requirements for models to cover even more complex problems have emphasized the need for periodic review and update of guidance on these techniques. Four primary on-going activities provide direct input to revisions of this modeling guideline. The first is a series of annual EPA workshops conducted for the purpose of ensuring consistency and providing clarification in the application of models. The second activity, directed toward the improvement of modeling procedures, is the cooperative agreement that EPA has with the scientific community represented by the American Meteorological Society. This agreement provides scientific assessment of procedures and proposed techniques and sponsors workshops on key technical issues. The third activity is the solicitation and review of new models from the technical and user community. In the March 27, 1980 Federal Register, a procedure was outlined for the submittal to EPA of privately developed models. After extensive evaluation and scientific review, these models, as well as those made available by EPA, are considered for recognition in this guideline. The fourth activity is the extensive on-going research efforts by EPA and others in air quality and meteorological modeling.

Based primarily on these four activities, this document embodies revisions to the "Guideline on Air Quality Models." Although the text has been revised from the 1978 guide, the present content and topics are similar. As necessary, new sections and topics are included. EPA does not make changes to the guidance on a predetermined schedule, but rather on an as needed basis. EPA believes that revisions to this guideline should be timely and responsive to user needs and should involve public participation to the greatest possible extent. All future changes to the guidance will be proposed and finalized in the Federal Register. Information on the current status of modeling guidance can always be obtained from EPA's Regional Offices.

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Recommendations are made in this guide concerning air quality models, data bases, requirements for concentration estimates, the use of measured data in lieu of model estimates, and model evaluation procedures. Models are identified for some specific applications. The guidance provided here should be followed in all air quality analyses relative to State Implementation Plans and in analyses required by EPA, State and local agency air programs. The EPA may approve the use of another technique that can be demonstrated to be more appropriate than those recommended in this guide. This is discussed at greater length in Section 3.0. In all cases, the model applied to a given situation should be the one that provides the most accurate representation of atmospheric transport, dispersion, and chemical transformations in the area of interest. However, to ensure consistency, deviations from this guide should be carefully documented and fully supported.

From time to time situations arise requiring clarification of the intent of the guidance on a specific topic. Periodic workshops are held with the EPA Regional Meteorologists to ensure consistency in modeling guidance and to promote the use of more accurate air quality models and data bases. The workshops serve to provide further explanations of guideline requirements to the Regional Offices and workshop reports are issued with this clarifying information. In addition, findings from on-going research programs, new model submittals, or results from model evaluations and applications are continuously evaluated. Based on this information, changes in the guidance may be indicated.

All changes to this guidance must follow rulemaking requirements since the guideline is codified in Appendix W of part 51. EPA will promulgate proposed and final rules in the Federal Register to amend this Appendix.

Ample opportunity for public comment will be provided for each proposed change and public hearings scheduled if requested. Final rule changes will be made available through the National Technical Information Service (NTIS).

A wide range of topics on modeling and data bases are discussed in the remainder of this guideline. Chapter 2 gives an overview of models and their appropriate use. Chapter 3 provides specific guidance on the use of "preferred" air quality models and on the selection of alternative techniques. Chapters 4 through 7 provide recommendations on modeling techniques for application to simple-terrain stationary source problems, complex terrain problems, and mobile source problems. Specific modeling requirements for selected regulatory issues are also addressed. Chapter 8 discusses issues common to many modeling analyses, including acceptable model components. Chapter 9 makes recommendations for data inputs to models including source, meteorological and background air quality data. Chapter 10 covers the uncertainty in model estimates and how that information can be useful to the regulatory decision-maker. The last chapter summarizes how estimates and measurements of air quality are used in assessing source impact and in evaluating control strategies.

Appendix W to 40 CFR part 51 (the "Guideline on Air Quality Models (Revised)") itself contains three appendices: A, B, and C. Thus, when reference is made to "appendix A" in this document, it refers to the appendix A to appendix W to 40 CFR part 51. Appendices B and C are referenced in the same way.

Appendix A contains summaries of refined air quality models that are "preferred" for specific applications; both EPA models and models developed by others are included. Appendix B contains summaries of other refined models that may be considered with a case-specific justification. Appendix C contains a checklist of requirements for an air quality analysis.

3.2 Use of Alternative Models

3.2.1 Discussion

Selection of the best techniques for each individual air quality analysis is always encouraged, but the selection should be done in a consistent manner. A simple listing of models in this guide cannot alone achieve that consistency nor can it necessarily provide the best model for all possible situations. An EPA document, "Interim Procedures for Evaluating Air Quality Models",[15,16] has been prepared to assist in developing a consistent approach when justifying the use of other than the preferred modeling techniques recommended in this guide. An alternative to be considered to the performance measures contained in Chapter 3 of this document is set forth in another EPA document "Protocol for Determining the Best Performing Model".[17] The procedures in both documents provide a general framework for objective decision-making on the acceptability of an alternative model for a given regulatory application. The documents contain procedures for conducting both the technical evaluation of the model and the field test or performance evaluation.

This section discusses the use of alternate modeling techniques and defines three situations when alternative models may be used.

3.2.2 Recommendations

Determination of acceptability of a model is a Regional Office responsibility. Where the Regional Administrator finds that an alternative model is more appropriate than a preferred model, that model may be used subject to the recommendations below. This finding will normally result from a determination that (1) a preferred air quality model is not appropriate for the particular application; or (2) a more appropriate model or analytical procedure is available and is applicable.

An alternative model should be evaluated from both a theoretical and a performance perspective before it is selected for use. There are three separate conditions under which such a model will normally be approved for use: (1) if a demonstration can be made that the model produces concentration estimates equivalent to the estimates obtained using a preferred model; (2) if a statistical performance evaluation has been conducted using measured air quality data and the results of that evaluation indicate the alternative model performs better for the application than a comparable model in Appendix A; and (3) if there is no preferred model for the specific application but a refined model is needed to satisfy regulatory requirements. Any one of these three separate conditions may warrant use of an alternative model. Some known alternative models that are applicable for selected situations are contained in Appendix B. However, inclusion there does not infer any unique status relative to other alternative models that are being or will be developed in the future.

Equivalency is established by demonstrating that the maximum or highest, second highest concentrations are within 2 percent of the estimates obtained from the preferred model. The option to show equivalency is intended as a simple demonstration of acceptability for an alternative model that is so nearly identical (or contains options that can make it identical) to a preferred model that it can be treated for practical purposes as the preferred model. Two percent was selected as the basis for equivalency since it is a rough approximation of the fraction that PSD Class I increments are of the NAAQS for SO_2, i.e., the difference in concentrations that is judged to be significant. However, notwithstanding this demonstration, use of models that are not equivalent may be used when one of the two other conditions identified below are satisfied.

The procedures and techniques for determining the acceptability of a model for an individual case based on superior performance is contained in the document entitled "Interim Procedures for Evaluating Air Quality Models",[15] and should be followed, as appropriate.[a] Preparation and implementation of an evaluation protocol which is acceptable to both control agencies and regulated industry is an important element in such an evaluation.

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[a]Another EPA document, "Protocol for Determining the Best Performing Model,"[17] contains advanced statistical techniques for determining which model performs better than other competing models. In many cases, this protocol should be considered by users of the "Interim Procedures for Evaluating Air Quality Models" in preference to the material currently in Chapter 3 of that document.

When no Appendix A model is applicable to the modeling problem, an alternative refined model may be used provided that:

1. the model can be demonstrated to be applicable to the problem on a theoretical basis, and

2. the data bases which are necessary to perform the analysis are available and adequate, and

3a. performance evaluations of the model in similar circumstances have shown that the model is not biased toward underestimates, or

3b. after consultation with the EPA Regional Office, a second model is selected as a baseline or reference point for performance and the interim procedures[15]/protocol[17] are then used to demonstrate that the proposed model performs better than the reference model.

4.2 Recommendations

4.2.1 Screening Techniques

Point source screening techniques are an acceptable approach to air quality analyses. One such approach is contained in the EPA document "Screening Procedures for Estimating the Air Quality Impact of Stationary Sources".[18] A computerized version of the screening technique, SCREEN2, is available.[19,20]

All screening procedures should be adjusted to the site and problem at hand. Close attention should be paid to whether the area should be classified urban or rural in accordance with Section 8.2.8. The climatology of the area should be studied to help define the worst-case meteorological conditions. Agreement should be reached between the model user and the reviewing authority on the choice of the screening model for each analysis, and on the input data as well as the ultimate use of the results.

TABLE 4-1

Preferred Models for Selected Applications in Simple Terrain

Short Term (i.e., 1-24 hours)	Land Use	Model[1]
Single Source	Rural Urban	CRSTER RAM
Multiple Source	Rural Urban	MPTER RAM
Complicated Sources[2]	Rural/Urban	ISCST2
Buoyant Industrial Line Sources	Rural	BLP
Long Term (i.e., monthly, seasonal or annual)		
Single Source	Rural Urban	CRSTER RAM
Multiple Source	Rural Urban	MPTER CDM 2.0 or RAM[3]
Complicated Sources[2]	Rural/Urban	ISCLT2
Buoyant Industrial Line Sources	Rural	BLP

[1]Several of these models contain options which allow them to be interchanged. For Example, ISCST2 can be substituted for CRSTER and equivalent, if not identical, concentration estimates obtained. Similarly, for a point source application, MPTER with urban option can be substituted for RAM. Where a substitution is convenient to the user and equivalent estimates are assured, it may be made. The models as listed here reflect the applications for which they were originally intended.

[2]Complicated sources are those with special problems such as aerodynamic downwash, particle deposition, volume and area sources, etc.

[3]If only a few sources in an urban area are to be modeled, RAM should be used.

5.0 MODEL USE IN COMPLEX TERRAIN

5.1 Discussion

For the purpose of this guideline, complex terrain is defined as terrain exceeding the height of the stack being modeled. Complex terrain dispersion models are normally applied to stationary sources of pollutants such as SO_2 and particulates.

A major outcome from the EPA Complex Terrain Model Development project has been the publication of a refined dispersion model (CTDM) suitable for regulatory application to plume impaction assessments in complex terrain.[21] Although CTDM as originally produced was only applicable to those hours characterized as neutral or stable, a computer code for all stability conditions, CTDMPLUS,[19] together with a user's guide,[22] and on-site meteorological and terrain data processors,[23,24] is now available. Moreover, CTSCREEN,[19,25] a version of CTDMPLUS that does not require on-site meteorological data inputs, is also available as a screening technique.

The methods discussed in this section should be considered in two categories: (1) screening techniques, and (2) the refined dispersion model, CTDMPLUS, discussed below and listed in Appendix A.

Continued improvements in ability to accurately model plume dispersion in complex terrain situations can be expected, e.g., from research on lee side effects due to terrain obstacles. New approaches to improve the ability of models to realistically simulate atmospheric physics, e.g., hybrid models which incorporate an accurate wind field analysis, will ultimately provide more appropriate tools for analyses. Such hybrid modeling techniques are also acceptable for regulatory applications after the appropriate demonstration and evaluation.[15]

5.2 Recommendations

Recommendations in this Section apply primarily to those situations where the impaction of plumes on terrain at elevations equal to or greater than the plume centerline during stable atmospheric conditions are determined to be the problem. If a violation of any NAAQS or the controlling increment is indicated by using any of the preferred screening techniques, then a refined complex terrain model may be used. Phenomena such as fumigation, wind direction shear, lee-side effects, building wake- or terrain-induced downwash, deposition, chemical transformation, variable plume trajectories, and long range transport are not addressed by the recommendations in this section.

Where site-specific data are used for either screening or refined complex terrain models, a data base of at least 1 full-year of meteorological data is preferred. If more data are available, they should be used. Meteorological data used in the analysis should be reviewed for both spatial and temporal representativeness.

Placement of receptors requires very careful attention when modeling in complex terrain. Often the highest concentrations are predicted to occur under very stable conditions, when the plume is near, or impinges on, the terrain. The plume under such conditions may be quite narrow in the vertical, so that even relatively small changes in a receptor's location may substantially affect the predicted concentration. Receptors within about a kilometer of the source may be even more sensitive to location. Thus, a dense array of receptors may be required in some cases. In order to avoid excessively large computer runs due to such a large array of receptors, it is often desirable to model the area twice. The first model run would use a moderate number of receptors carefully located over the area of interest. The second model run would use a more dense array of receptors in areas showing potential for high concentrations, as indicated by the results of the first model run.

When CTSCREEN or CTDMPLUS is used, digitized contour data must be first processed by the CTDM Terrain Processor[23] to provide hill shape parameters in a format suitable for direct input to CTDMPLUS. Then the user supplies receptors either through an interactive program that is part of the model or directly, by using a text editor; using both methods to select receptors will generally be necessary to assure that the maximum concentrations are estimated by either model. In cases where a terrain feature may "appear to the plume" as smaller, multiple hills, it may be necessary to model the terrain both as a single feature **and** as multiple hills to determine design concentrations.

The user is encouraged to confer with the Regional Office if any unresolvable problems are encountered with any screening or refined analytical procedures, e.g., meteorological data, receptor siting, or terrain contour processing issues.

5.2.1 Screening Techniques

Five preferred screening techniques are currently available to aid in the evaluation of concentrations due to plume impaction during stable conditions: (1) for 24-hour impacts, the Valley Screening Technique[19] as outlined in the Valley Model User's Guide;[26] (2) CTSCREEN,[19] as outlined in the CTSCREEN User's Guide;[25] (3) COMPLEX I;[19] (4) SHORTZ/LONGZ;[19,27] and (5) Rough Terrain Dispersion Model (RTDM)[19,90] in its prescribed mode described below. As appropriate, any of these screening techniques may be used consistent with the needs, resources, and available data of the user.

The Valley Model, COMPLEX I, SHORTZ/LONGZ, and RTDM should be used only to estimate concentrations at receptors whose elevations are greater than or equal to plume height. For receptors at or below stack height, a simple terrain model should be used (see Chapter 4). Receptors between stack height and plume height present a unique problem since none of the above models were designed to handle receptors in this narrow regime, the definition of which will vary hourly as meteorological conditions vary. CTSCREEN may be used to estimate concentrations under all stability conditions at all receptors located "on terrain" above stack top, but has limited applicability in multi-source situations. As a result, the estimation of concentrations at receptors between stack height and plume height should be considered on a case-by-case basis after consultation with the EPA Regional Office; the most appropriate technique may be a function of the actual source(s) and terrain configuration unique to that application. One technique that will generally be acceptable, but is not necessarily preferred for any specific application, involves applying both a complex terrain model (except for the Valley Model) and a simple terrain model. The Valley Model should not be used for any intermediate terrain receptor. For each receptor between stack height and plume height, an hour-by-hour comparison of the concentration estimates from both models is made. The higher of the two modeled concentrations should be chosen to represent the impact at that receptor for that hour, and then used to compute the concentration for the appropriate averaging time(s). For the simple terrain models, terrain may have to be "chopped off" at stack height, since these models are frequently limited to receptors no greater than stack height.

5.2.1.1 Valley Screening Technique

The Valley Screening Technique may be used to determine 24-hour averages. This technique uses the Valley Model with the following worst-case assumptions for rural areas: (1) P-G stability "F"; (2) wind speed of 2.5 m/s; and (3) 6 hours of occurrence. For urban areas the stability should be changed to "P-G stability E."

When using the Valley Screening Technique to obtain 24-hour average concentrations the following apply: (1) multiple sources should be treated individually and the concentrations for each wind direction summed; (2) only one wind direction should be used (see User's Guide,[26] page 2-15) even if individual runs are made for each source; (3) for buoyant sources, the BID option may be used, and the option to use the 2.6 stable plume rise factor should be selected; (4) if plume impaction is likely on any elevated terrain closer to the source than the distance from the source to the final plume rise, then the transitional (or gradual) plume rise option for stable conditions should be selected.

The standard polar receptor grid found in the Valley Model User's Guide may not be sufficiently dense for all analyses if only one geographical scale factor is used. The user should choose an additional set of receptors at appropriate downwind distances whose elevations are equal to plume height minus 10 meters. Alternatively, the user may exercise the "Valley equivalent" option in COMPLEX I or SCREEN2 and note the comments above on the placement of receptors in complex terrain models.

When using the "Valley equivalent" option in COMPLEX I, set the wind profile exponents (PL) to 0.0, respectively, for all six stability classes.

5.2.1.2 CTSCREEN

CTSCREEN may be used to obtain conservative, yet realistic, worst-case estimates for receptors located on terrain above stack height. CTSCREEN accounts for the three-dimensional nature of plume and terrain interaction and requires detailed terrain data representative of the modeling domain. The model description and user's instructions are contained in the user's guide.[25] The terrain data must be digitized in the same manner as for CTDMPLUS and a terrain processor is available.[23] A discussion of the model's performance characteristics is provided in a technical paper.[91] CTSCREEN is designed to execute a fixed matrix of meteorological values for wind speed (u), standard deviation of horizontal and vertical wind speeds (σ_v, σ_w), vertical potential temperature gradient ($d\theta/dz$), friction velocity (u_*), Monin-Obukhov length (L), mixing height (z_i) as a function of terrain height, and wind directions for both neutral/stable conditions and unstable convective conditions. Table 5-1 contains the matrix of meteorological variables that is used for each CTSCREEN analysis. There are 96 combinations, including exceptions, for each wind direction for the neutral/stable case, and 108 combinations for the unstable case. The specification of wind direction, however, is handled internally, based on the source and terrain geometry. The matrix was developed from examination of the range of meteorological variables associated with maximum monitored concentrations from the data bases used to evaluate the performance of CTDMPLUS. Although CTSCREEN is designed to address a single source scenario, there are a number of options that can be selected on a case-by-case basis to address multi-source situations. However, the Regional Office should be consulted, and concurrence obtained, on the protocol for modeling multiple sources with CTSCREEN to ensure that the worst case is identified and assessed. The maximum concentration output from CTSCREEN represents a worst-case 1-hour concentration. Time-scaling factors of 0.7 for 3-hour, 0.15 for 24-hour and 0.03 for annual concentration averages are applied internally by CTSCREEN to the highest 1-hour concentration calculated by the model.

5.2.1.3 COMPLEX I

If the area is rural, COMPLEX I may be used to estimate concentrations for all averaging times. COMPLEX I is a modification of the MPTER model that incorporates the plume impaction algorithm of the Valley Model.[19] It is a multiple-source screening technique that accepts hourly meteorological data as input. The output is the same as the normal MPTER output. When using COMPLEX I the following options should be selected: (1) set terrain adjustment IOPT(1) = 1; (2) set buoyancy induced dispersion IOPT (4) = 1; (3) set IOPT (25) = 1; (4) set the terrain adjustment values to 0.5, 0.5, 0.5 0.5, 0.0, 0.0, (respectively for six stability classes); and (5) set Z MIN = 10.

When using the "Valley equivalent" option (only) in COMPLEX I, set the wind profile exponents (PL) to 0.0, respectively, for all six stability classes. For all other regulatory uses of COMPLEX I, set the wind profile exponents to the values used in the simple terrain models, i.e., 0.07, 0.07, 0.10, 0.15, 0.35, and 0.55, respectively, for rural modeling.

Gradual plume rise should be used to estimate concentrations at nearby elevated receptors, if plume impaction is likely on any elevated terrain closer to the source than the distance from the source to the final plume rise (see Section 8.2.5).

5.2.1.4 SHORTZ/LONGZ

If the source is located in an urbanized (Section 8.2.8) complex terrain valley, then the suggested screening technique is SHORTZ for short-term averages or LONGZ for long-term averages. SHORTZ and LONGZ may be used as screening techniques in these complex terrain applications without demonstration and evaluation. Application of these models in other than urbanized valley situations will require the same evaluation and demonstration procedures as are required for all Appendix B models.

Both SHORTZ and LONGZ have a number of options. When using these models as screening techniques for urbanized valley applications, the options listed in Table 5-2 should be selected.

5.2.1.5 RTDM (Screening Mode)

RTDM with the options specified in Table 5-3 may be used as a screening technique in rural complex terrain situations without demonstration and evaluation.

The RTDM screening technique can provide a more refined concentration estimate if on-site wind speed and direction characteristic of plume dilution and transport are used as input to the model. In complex terrain, these winds can seldom be estimated accurately from the standard surface (10m level) measurements. Therefore, in order to increase confidence in model estimates, EPA recommends that wind data input to RTDM should be based on fixed measurements at stack top height. For stacks greater than 100m, the measurement height may be limited to 100m in height relative to stack base. However, for very tall stacks, see guidance in Section 9.3.3.2. This recommendation is broadened to include wind data representative of plume transport height where such data are derived from measurements taken with remote sensing devices such as SODAR. The data from both fixed and remote measurements should meet quality assurance and recovery rate requirements. The user should also be aware that RTDM in the screening mode accepts the input of measured wind speeds at only one height. The default values for the wind speed profile exponents shown in Table 5-3 are used in the model to

determine the wind speed at other heights. RTDM uses wind speed at stack top to calculate the plume rise and the critical dividing streamline height, and the wind speed at plume transport level to calculate dilution. RTDM treats wind direction as constant with height.

RTDM makes use of the "critical dividing streamline" concept and thus treats plume interactions with terrain quite differently from other models such as SHORTZ and COMPLEX I. The plume height relative to the critical dividing streamline determines whether the plume impacts the terrain, or is lifted up and over the terrain. The receptor spacing to identify maximum impact concentrations is quite critical depending on the location of the plume in the vertical. Analysis of the expected plume height relative to the height of the critical dividing streamline should be performed for differing meteorological conditions in order to help develop an appropriate array of receptors. Then it is advisable to model the area twice according to the suggestions in Section 5.2.

5.2.1.6 Restrictions

For screening analyses using the Valley Screening Technique, COMPLEX I or RTDM, a sector greater than 22½° should not be allowed. Full ground reflection should always be used in the Valley Screening Technique and COMPLEX I.

5.2.2 Refined Analytical Techniques

When the results of the screening analysis demonstrate a possible violation of NAAQS or the controlling PSD increments, a more refined analysis may need to be conducted.

The Complex Terrain Dispersion Model PLus Algorithms for Unstable Situations (CTDMPLUS) is a refined air quality model that is preferred for use in all stability conditions for complex terrain applications. CTDMPLUS is a sequential model that requires five input files: (1) general program specifications; (2) a terrain data file; (3) a receptor file; (4) a surface meteorological data file; and (5) a user created meteorological profile data file. Two optional input files consist of hourly emissions parameters and a file containing upper air data from rawinsonde data files, e.g., a National Climatic Data Center TD-6201 file, unless there are no hours categorized as unstable in the record. The model description and user instructions are contained in Volume 1 of the User's Guide.[22] Separate publications[23,24] describe the terrain preprocessor system and the meteorological preprocessor program. In *Part I* of a technical article[92] is a discussion of the model and its preprocessors; the model's performance characteristics are discussed in *Part II* of the same article.[93] The size of the CTDMPLUS executable file on a personal computer is approximately 360K bytes. The model produces hourly average concentrations of stable pollutants, i.e., chemical transformation or decay of species and settling/deposition are not simulated. To obtain concentration averages corresponding to the NAAQS, e.g., 3- or 24-hour, or annual averages, the user must execute a postprocessor program such as CHAVG.[19] CTDMPLUS is applicable to all receptors on terrain elevations above stack top. However, the model contains no algorithms for simulating building downwash or the mixing or recirculation found in cavity zones in the lee of a hill. The path taken by a plume through an array of hills cannot be simulated. CTDMPLUS does not explicitly simulate calm meteorological periods, and for those situations the user should follow the guidance in Section 9.3.4. The user should follow the recommendations in the User's Guide under General Program Specifications for: (1) selecting mixed layer heights, (2) setting minimum scalar wind speed to 1 m/s, and (3) scaling wind direction with height. Close coordination with the Regional Office is essential to insure a consistent, technically sound application of this model.

The performance of CTDMPLUS is greatly improved by the use of meteorological data from several levels up to plume height. However, due to the vast range of source-plume-hill geometries possible in complex terrain, detailed requirements for meteorological monitoring in support of refined analyses using CTDMPLUS should be determined on a case-by-case basis. The following general guidance should be considered in the development of a meteorological monitoring protocol for regulatory applications of CTDMPLUS and reviewed in detail by the Regional Office before initiating any monitoring. As appropriate, the On-Site Meteorological Program Guidance document[66] should be consulted for specific guidance on siting requirements for meteorological towers, selection and exposure of sensors, etc. As more experience is gained with the model in a variety of circumstances, more specific guidance may be developed.

Site specific meteorological data are critical to dispersion modeling in complex terrain and, consequently, the meteorological requirements are more demanding than for simple terrain. Generally, three different meteorological files (referred to as surface, profile, and rawin files) are needed to run CTDMPLUS in a regulatory mode.

The surface file is created by the meteorological preprocessor (METPRO)[24] based on on-site measurements or estimates of solar and/or net radiation, cloud cover and ceiling, and the mixed layer height. These data are used in METPRO to calculate the various surface layer scaling parameters (roughness length, friction velocity, and Monin-Obukhov length) which are needed to run the model. All of the user inputs required for the surface file are based either on surface observations or on measurements at or below 10m.

The profile data file is prepared by the user with on-site measurements (from at least three levels) of wind speed, wind direction, turbulence, and potential temperature. These measurements should be obtained up to the representative plume height(s) of interest (i.e., the plume height(s) under those conditions important to the determination of the design concentration). The representative plume height(s) of interest should be determined using an appropriate complex terrain screening procedure (e.g., CTSCREEN) and should be documented in the monitoring/modeling protocol. The necessary meteorological measurements should be obtained from an appropriately sited meteorological tower augmented by SODAR if the representative plume height(s) of interest exceed 100m. The meteorological tower need not exceed the lesser of the representative plume height of interest (the highest plume height if there is more than one plume height of interest) or 100m.

Locating towers on nearby terrain to obtain stack height or plume height measurements for use in profiles by CTDMPLUS should be avoided unless it can clearly be demonstrated that such measurements would be representative of conditions affecting the plume.

The rawin file is created by a second meteorological preprocessor (READ62)[24] based on NWS (National Weather Service) upper air data. The rawin file is used in CTDMPLUS to calculate vertical potential temperature gradients for use in estimating plume penetration in unstable conditions. The representativeness of the off-site NWS upper air data should be evaluated on a case-by-case basis.

In the absence of an appropriate refined model, screening results may need to be used to determine air quality impact and/or emission limits.

TABLE 5-1a

NEUTRAL/STABLE METEOROLOGICAL MATRIX FOR CTSCREEN

Variable	Specific Values				
U (m/s)	1.0	2.0	3.0	4.0	5.0
σ_v (m/s)	0.3	0.75			
σ_w (m/s)	0.08	0.15	0.30	0.75	
$\Delta\theta/\Delta z$ (K/m)	0.01	0.02	0.035		
WD	(Wind direction optimized internally for each meteorological combination)				

Exceptions:

(1) If U ≤ 2 m/s and σ_v ≤ 0.3 m/s, then include σ_w = 0.04 m/s.

(2) If σ_w = 0.75 m/s and U ≥ 3.0 m/s, then $\Delta\theta/\Delta z$ is limited to ≤ 0.01 K/m.

(3) If U ≥ 4 m/s, then σ_w ≥ 0.15 m/s.

(4) $\sigma_w \le \sigma_v$

TABLE 5-1b

UNSTABLE/CONVECTIVE METEOROLOGICAL MATRIX FOR CTSCREEN

Variable	Specific Values				
U (m/s)	1.0	2.0	3.0	4.0	5.0
u_* (m/s)	0.1	0.3	0.5		
L (m)	-10	-50	-90		
$\Delta\theta/\Delta z$ (K/m)	0.030 (potential temperature gradient above z_i)				
z_i (m)	0.5h (where h = terrain height)	1.0h	1.5h		

TABLE 5-2

Preferred Options for the SHORTZ/LONGZ Computer Codes When Used in a Screening Mode

Option		Selection
I Switch 9		If using NWS data, set = 0 If using site-specific data, check with the Regional Office
I Switch 17		Set = 1 (urban option)
GAMMA 1		Use default values (0.6 entrainment coefficient)
GAMMA 2		Always default to "stable"
XRY		Set = 0 (50m rectilinear expansion distance)
NS, VS, FRQ (SHORTZ) NUS, VS, FRQ (LONGZ)	(particle size, etc.)	Do not use (applicable only in flat terrain)
ALPHA		Select 0.9
SIGEPU SIGAPU	(dispersion parameters)	Use Cramer curves (default); if site-specific turbulence data are available, see Regional Office for advice.
P (wind profile)		Select default values given in Table 2-2 of User's Instructions; if site-specific data are available, see Regional Office for advice.

TABLE 5-3

Preferred Options for the RTDM Computer Code When Used in a Screening Mode

Parameter	Variable	Value	Remarks
PR001-003	SCALE		Scale factors assuming horizontal distance is in kilometers, vertical distance is in feet, and wind speed is in meters per second
PR004	ZWIND1	Wind measurement height	See Section 5.2.1.4
	ZWIND2	Not used	Height of second anemometer
	IDILUT	1	Dilution wind speed scaled to plume height
	ZA	0 (default)	Anemometer-terrain height above stack base
PR005	EXPON	0.09, 0.11, 0.12, 0.14, 0.2, 0.3 (default)	Wind profile exponents
PR006	ICOEF	3 (default)	Briggs Rural/ASME (1979) dispersion parameters
PR009	IPPP	0 (default)	Partial plume penetration; not used
PR010	IBUOY	1 (default)	Buoyancy-enhanced dispersion is used
	ALPHA	3.162 (default)	Buoyancy-enhanced dispersion coefficient
PR011	IDMX	1 (default)	Unlimited mixing height for stable conditions
PR012	ITRANS	1 (default)	Transitional plume rise is used
PR013	TERCOR	6*0.5 (default)	Plume patch correction factors
PR014	RVPTG	0.02, 0.035 (default)	Vertical potential temperature gradient values for stabilities E and F
PR015	ITIPD	1	Stack-tip downwash is used
PR020	ISHEAR	0 (default)	Wind shear; not used
PR022	IREFL	1 (default)	Partial surface reflection is used
PR023	IHORIZ	2 (default)	Sector averaging
	SECTOR	6*22.5 (default)	Using 22.5° sectors
PR016 to 019; 021; and 024	IY, IZ, IRVPTG, IHVPTG;IEPS; IEMIS	0	Hourly values of turbulence, vertical potential temperature gradient, wind speed profile exponents, and stack emissions are not used

6.0 MODELS FOR OZONE, CARBON MONOXIDE AND NITROGEN DIOXIDE

6.1 Discussion

Models discussed in this section are applicable to pollutants often associated with mobile sources, e.g., ozone (O_3), carbon monoxide (CO) and nitrogen dioxide (NO_2). Where stationary sources of CO and NO_2 are of concern, the reader is referred to Sections 4 and 5.

A control agency with jurisdiction over areas with significant ozone problems and which has sufficient resources and data to use a photochemical dispersion model is encouraged to do so. Experience with and evaluations of the Urban Airshed Model show it to be an acceptable, refined approach, and better data bases are becoming available that support the more sophisticated analytical procedures. However, empirical models (e.g., EKMA) fill the gap between more sophisticated photochemical dispersion models and proportional (rollback) modeling techniques and may be the only applicable procedure if the available data bases are insufficient for refined dispersion modeling.

Models for assessing the impact of carbon monoxide emissions are needed for a number of different purposes, e.g., to evaluate the effects of point sources, congested intersections and highways, as well as the cumulative effect on ambient CO concentrations of all sources of CO in an urban area.[94,95]

Nitrogen oxides are reactive and also an important contribution to the photochemical ozone problem. They are usually of most concern in areas of high ozone concentrations. Unless suitable photochemical dispersion models are used, assumptions regarding the conversion of NO to NO_2 are

6.2 Recommendations

6.2.1 Models for Ozone

The Urban Airshed Model (UAM)[19,28] is recommended for photochemical or reactive pollutant modeling applications involving entire urban areas. To ensure proper execution of this numerical model, users must satisfy the extensive input data requirements for the model as listed in Appendix A and the users guide. Users are also referred to the "Guideline for Regulatory Application of the Urban Airshed Model"[29] for additional data requirements and procedures for operating this model.

The empirical model, City-specific EKMA,[19,30-33] has limited applicability for urban ozone analyses. Model users should consult the appropriate Regional Office on a case-by-case basis concerning acceptability of this modeling technique.

Appendix B contains some additional models that may be applied on a case-by-case basis for photochemical or reactive pollutant modeling. Other photochemical models, including multi-layered trajectory models, that are available may be used if shown to be appropriate. Most photochemical dispersion models require emission data on individual hydrocarbon species and may require three dimensional meteorological information on an hourly basis. Reasonably sophisticated computer facilities are also often required. Because the input data are not universally available and studies to collect such data are very resource intensive, there are only limited evaluations of those models.

For those cases which involve estimating the impact on ozone concentrations due to stationary sources of VOC and NO_x, whether for permitting or other regulatory cases, the model user should consult the appropriate Regional Office on the acceptability of the modeling technique.

Proportional (rollback/forward) modeling is not an acceptable procedure for evaluating ozone control strategies.

6.2.2 Models for Carbon Monoxide

For analyzing CO impacts at roadway intersections, users should follow the procedures in the "Guideline for Modeling Carbon Monoxide from Roadway Intersections".[34] The recommended model for such analyses is CAL3QHC.[35] This model combines CALINE3 (already in Appendix A) with a traffic model to calculate delays and queues that occur at signalized intersections. In areas where the use of either TEXIN2 or CALINE4 has previously been established, its use may continue. The capability exists for these intersection models to be used in either a screening or refined mode. The screening approach is described in reference 34; a refined approach may be considered on a case-by-case basis. The latest version of the MOBILE (mobile source emission factor) model should be used for emissions input to intersection models.

For analyses of highways characterized by uninterrupted traffic flows, CALINE3 is recommended, with emissions input from the latest version of the MOBILE model.

The recommended model for urban areawide CO analyses is RAM or Urban Airshed Model (UAM); see Appendix A. Information on SIP development and requirements for using these models can be found in references 34, 96, 97 and 98.

Where point sources of CO are of concern, they should be treated using the screening and refined techniques described in Section 4 or 5 of the Guideline.

6.2.3 Models for Nitrogen Dioxide (Annual Average)

A three-tiered screening approach is recommended to obtain annual average estimates of NO_2 from point sources for New Source Review analysis, including PSD, and for SIP planning purposes:

a. Initial screen: Use an appropriate Gaussian model from Appendix A to estimate the maximum annual average concentration and assume a total conversion of NO to NO_2. If the concentration exceeds the NAAQS and/or PSD increments for NO_2, proceed to the 2nd level screen.

b. 2nd level screen: Apply the Ozone Limiting Method[36] to the annual NO_x estimate obtained in (a) above using a representative average annual ozone concentration. If the result is still greater than the NAAQS, and/or PSD increments, the more refined Ozone Limiting Method in the 3rd level screen should be applied.

c. 3rd level screen: Apply the Ozone Limiting Method separately for each hour of the year or multi-year period. Use representative hourly NO_2 background and ozone levels in the calculations.

In urban areas, a proportional model may be used as a preliminary assessment to evaluate control strategies to meet the NAAQS for multiple minor sources, i.e., minor point, area and mobile sources of NO_x; concentrations resulting from major point sources should be estimated separately as discussed above, then added to the impact of the minor sources. An acceptable screening technique for urban complexes is to assume that all NO_x is emitted in the form of NO_2 and to use a model from Appendix A for nonreactive pollutants to estimate NO_2 concentrations. A more accurate estimate can be obtained by (1) calculating the annual average concentrations of NO_x with an urban model, and (2) converting these estimates to NO_2 concentrations based on a spatially averaged NO_2/NO_x annual ratio determined from an existing air quality monitoring network.

To demonstrate compliance with NO_2 PSD increments in urban areas, emissions from major and minor sources should be included in the modeling analysis. Point and area source emissions should be modeled as discussed above. If mobile source emissions do not contribute to localized areas of high ambient NO_2 concentrations, they should be modeled as area sources. When modeled as area sources, mobile source emissions should be assumed uniform over the entire highway link and allocated to each area source grid square based on the portion of highway link within each grid square. If localized areas of high concentrations are likely, then mobile sources should be modeled as line sources with the preferred model ISCLT2.

In situations where there are sufficient hydrocarbons available to significantly enhance the rate of NO to NO_2 conversion, the assumptions implicit in the Ozone Limiting Procedure may not be appropriate. More refined techniques should be considered on a case-by-case basis and agreement with the reviewing authority should be obtained. Such techniques should consider individual quantities of NO and NO_2 emissions, atmospheric transport and dispersion, and atmospheric transformation of NO to NO_2. Where it is available site-specific data on the conversion of NO to NO_2 may be used. Photochemical dispersion models, if used for other pollutants in the area, may also be applied to the NO_x problem.

transport distances are limited in detail. This limitation is a result of the expense to perform the field studies required to verify and improve mesoscale and long range transport models. Particularly important and sparse are meteorological data adequate for generating three dimensional wind fields. Application of models to complicated terrain compounds the difficulty. EPA has completed limited evaluation of several long range transport (LRT) models against two sets of field data. The evaluation results are discussed in the document, "Evaluation of Short-Term Long-Range Transport Models."[99,100] For the time being, long range and mesoscale transport models must be evaluated for regulatory use on a case-by-case basis.

There are several regulatory programs for which air pathway analysis procedures and modeling techniques have been developed. For continuous emission releases, ISC2 forms the basis of many analytical techniques. EPA is continuing to evaluate the performance of a number of proprietary and public domain models for intermittent and non-stack emission releases. Until EPA completes its evaluation, it is premature to recommend specific models for air pathway analyses of intermittent and non-stack releases in this guideline.

Regional scale models are used by EPA to develop and evaluate national policy and assist State and local control agencies. Two such models are the Regional Oxidant Model (ROM)[101,102,103] and the Regional Acid Deposition Model (RADM).[104] Due to the level of resources required to apply these models, it is not envisioned that regional scale models will be used directly in most model applications.

7.2.2 Particulate Matter

The new particulate matter NAAQS, promulgated on July 1, 1987 (52 FR 24634), includes only particles with an aerodynamic diameter less than or equal to a nominal 10 micrometers (PM-10). EPA has also proposed regulations for PSD increments measured as PM-10 in a notice published on October 5, 1989 (54 FR 41218).

Screening techniques like those identified in Section 4 are also applicable to PM-10 and to large particles. It is recommended that subjectively determined values for "half-life" or pollutant decay not be used as a surrogate for particle removal. Conservative assumptions which do not allow removal or transformation are suggested for screening. Proportional models (rollback/forward) may not be applied for screening analysis, unless such techniques are used in conjunction with receptor modeling.

Refined models such as those in Section 4 are recommended for PM-10 and large particles. However, where possible, particle size, gas-to-particle formation, and their effect on ambient concentrations may be considered. For urban-wide refined analyses CDM 2.0 or RAM should be used. CRSTER and MPTER are recommended for point sources of small particles. For source-specific analyses of complicated sources, the ISC2 model is preferred. No model recommended for general use at this time accounts for secondary particulate formation or other transformations in a manner suitable for SIP control strategy demonstrations. Where possible, the use of receptor models[38,39,105,106,107] in conjunction with dispersion models is encouraged to more precisely characterize the emissions inventory and to validate source specific impacts calculated by the dispersion model. A SIP development guideline,[108] model reconciliation guidance,[106] and an example model application[109] are available to assist in PM-10 analyses and control strategy development.

Under certain conditions, recommended dispersion models are not available or applicable. In such circumstances, the modeling approach should be approved by the appropriate Regional Office on a case-by-case basis. For example, where there is no recommended air quality model and area sources are a predominant component of PM-10, an attainment demonstration may be based on rollback of the apportionment derived from two reconciled receptor models, if the strategy provides a conservative demonstration of attainment. At this time, analyses involving model calculations for distances beyond 50km and under stagnation conditions should also be justified on a case-by-case basis (see Sections 7.2.6 and 8.2.10).

As an aid to assessing the impact on ambient air quality of particulate matter generated from prescribed burning activities, reference 110 is available.

7.2.4 Visibility

The visibility regulations as promulgated in December 1980 require consideration of the effect of new sources on the visibility values of Federal Class I areas. The state of scientific knowledge concerning identifying, monitoring, modeling, and controlling visibility impairment is contained in an EPA report "Protecting Visibility: An EPA Report to Congress".[42] In 1985, EPA promulgated Federal Implementation Plans (FIPs) for states without approved visibility provisions in their SIPs. A monitoring plan was established as part of the FIPs.[b]

Guidance and a screening model, VISCREEN, is contained in the EPA document "Workbook for Plume Visual Impact Screening and Analysis (Revised)."[43] VISCREEN can be used to calculate the potential impact of a plume of specified emissions for specific transport and dispersion conditions. If a more comprehensive analysis is required, any refined model should be selected in consultation with the EPA Regional Office and the appropriate Federal Land Manager who is responsible for determining whether there is an adverse effect by a plume on a Class I area.

PLUVUE II, listed in Appendix B, may be applied on a case-by-case basis when refined plume visibility evaluations are needed. Plume visibility models have been evaluated against several data sets.[44,45]

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[b] 40 CFR 51.300-307

7.2.5 Good Engineering Practice Stack Height

The use of stack height credit in excess of Good Engineering Practice (GEP) stack height or credit resulting from any other dispersion technique is prohibited in the development of emission limitations by 40 CFR 51.118 and 40 CFR 51.164. The definitions of GEP stack height and dispersion technique are contained in 40 CFR 51.100. Methods and procedures for making the appropriate stack height calculations, determining stack height credits and an example of applying those techniques are found in references 46, 47, 48, and 49.

If stacks for new or existing major sources are found to be less than the height defined by EPA's refined formula for determining GEP height,[c] then air quality impacts associated with cavity or wake effects due to the nearby building structures should be determined. Detailed downwash screening procedures[18] for both the cavity and wake regions should be followed. If more refined concentration estimates are required, the Industrial Source Complex (ISC2) model contains algorithms for building wake calculations and should be used. Fluid modeling can provide a great deal of additional information for evaluating and describing the cavity and wake effects.

[c]The EPA refined formula height is defined as H + 1.5L (see Reference 46).

7.2.6 Long Range Transport (LRT) (i.e., beyond 50km)

Section 165(e) of the Clean Air Act requires that suspected significant impacts on PSD Class I areas be determined. However, 50km is the useful distance to which most Gaussian models are considered accurate for setting emission limits. Since in many cases PSD analyses may show that Class I areas may be threatened at distances greater than 50km from new sources, some procedure is needed to (1) determine if a significant impact will occur, and (2) identify the model to be used in setting an emission limit if the Class I increments are threatened (models for this purpose should be approved for use on a case-by-case basis as required in Section 3.2). This procedure and the models selected for use should be determined in consultation with the EPA Regional Office and the appropriate Federal Land Manager (FLM). While the ultimate decision on whether a Class I area is adversely affected is the responsibility of the permitting authority, the FLM has an affirmative responsibility to protect air quality related values that may be affected.

If LRT is determined to be important, then estimates utilizing an appropriate refined model for receptors at distances greater than 50 km should be obtained. MESOPUFF II, listed in Appendix B, may be applied on a case-by-case basis when LRT estimates are needed. Additional information on applying this model is contained in the EPA document "A Modeling Protocol For Applying MESOPUFF II to Long Range Transport Problems".[111]

7.2.7 Modeling Guidance for Other Governmental Programs

When using the models recommended or discussed in this guideline in support of programmatic requirements not specifically covered by EPA regulations, the model user should consult the appropriate Federal or State agency to ensure the proper application and use of that model. For modeling associated with PSD permit applications that involve a Class I area, the appropriate Federal Land Manager should be consulted on all modeling questions.

The Offshore and Coastal Dispersion (OCD) model[112] was developed by the Minerals Management Service and is recommended for estimating air quality impact from offshore sources on onshore flat terrain areas. The OCD model is not recommended for use in air quality impact assessments for onshore sources. Sources located on or just inland of a shoreline where fumigation is expected should be treated in accordance with Section 8.2.9.

The Emissions and Dispersion Modeling System (EDMS)[113] was developed by the Federal Aviation Administration and the United States Air Force and is recommended for air quality assessment of primary pollutant impacts at airports or air bases. Regulatory application of EDMS is intended for estimating the cumulative effect of changes in aircraft operations, point source, and mobile source emissions on pollutant concentrations. It is not intended for PSD, SIP, or other regulatory air quality analyses of point or mobile sources at or peripheral to airport property that are independent of changes in aircraft operations. If changes in other than aircraft operations are associated with analyses, a model recommended in Chapter 4, 5, or 6 should be used.

7.2.8 Air Pathway Analyses (Air Toxics and Hazardous Waste)

Modeling is becoming an increasingly important tool for regulatory control agencies to assess the air quality impact of releases of toxics and hazardous waste materials. Appropriate screening techniques[114,115] for calculating ambient concentrations due to various well-defined neutrally buoyant toxic/hazardous pollutant releases are available.

Several regulatory programs within EPA have developed modeling techniques and guidance for conducting air pathway analyses as noted in references 116-129. ISC2 forms the basis of the modeling procedures for air pathway analyses of many of these regulatory programs and, where identified, is appropriate for obtaining refined ambient concentration estimates of neutrally buoyant continuous air toxic releases from traditional sources. Appendix A to this Guideline contains additional models appropriate for obtaining refined estimates of continuous air toxic releases from traditional sources. Appendix B contains models that may be used on a case-by-case basis for obtaining refined estimates of denser-than-air intermittent gaseous releases, e.g., DEGADIS;[130] guidance for the use of such models is also available.[131]

Many air toxics models require input of chemical properties and/or chemical engineering variables in order to appropriately characterize the source emissions prior to dispersion in the atmosphere; reference 132 is one source of helpful data. In addition, EPA has numerous programs to determine emission factors and other estimates of air toxic emissions. The Regional Office should be consulted for guidance on appropriate emission estimating procedures and any uncertainties that may be associated with them.

8.2 Recommendations

8.2.1 Design Concentrations

8.2.1.1 Design Concentrations for Criteria Pollutants with Deterministic Standards

An air quality analysis for SO_2, CO, Pb, and NO_2 is required to determine if the source will (1) cause a violation of the NAAQS, or (2) cause or contribute to air quality deterioration greater than the specified allowable PSD increment. For the former, background concentration (see Section 9.2) should be added to the estimated impact of the source to determine the design concentration. For the latter, the design concentration includes impact from all increment consuming sources.

If the air quality analyses are conducted using the period of meteorological input data recommended in Section 9.3.1.2 (e.g., 5 years of NWS data or 1 year of site-specific data), then the design concentration based on the highest, second-highest short term concentration or long term average, whichever is controlling, should be used to determine emission limitations to assess compliance with the NAAQS and to determine PSD increments.

When sufficient and representative data exist for less than a 5-year period from a nearby NWS site, or when on-site data have been collected for less than a full continuous year, or when it has been determined that the on-site data may not be temporally representative, then the highest concentration estimate should be considered the design value. This is because the length of the data record may be too short to assure that the conditions producing worst-case estimates have been adequately sampled. The highest value is then a surrogate for the concentration that is not to be exceeded more than once per year (the wording of the deterministic standards). Also, the highest concentration should be used whenever selected worst-case conditions are input to a screening technique. This specifically applies to the use of techniques such as outlined in "Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised".[18] Specific guidance for CO may be found in the "Guideline for Modeling Carbon Monoxide from Roadway Intersections".[34]

If the controlling concentration is an annual average value and multiple years of data (on-site or NWS) are used, then the design value is the highest of the annual averages calculated for the individual years. If the controlling concentration is a quarterly average and multiple years are used, then the highest individual quarterly average should be considered the design value.

As long a period of record as possible should be used in making estimates to determine design values and PSD increments. If more than 1 year of site-specific data is available, it should be used.

8.2.1.2 Design Concentrations for Criteria Pollutants with Expected Exceedance Standards

Specific instructions for the determination of design concentrations for criteria pollutants with expected exceedance standards, ozone and PM-10, are contained in special guidance documents for the preparation of SIPs for those pollutants.[86,108] For all SIP revisions the user should check with the Regional Office to obtain the most recent guidance documents and policy memoranda concerning the pollutant in question.

8.2.5 Plume Rise

The plume rise methods of Briggs[56,57] are incorporated in the preferred models and are recommended for use in all modeling applications. No provisions in these models are made for fumigation or multistack plume rise enhancement or the handling of such special plumes as flares; these problems should be considered on a case-by-case basis.

Since there is insufficient information to identify and quantify dispersion during the transitional plume rise period, gradual plume rise is not generally recommended for use. There are two exceptions where the use of gradual plume rise is appropriate: (1) in complex terrain screening procedures to determine close-in impacts; (2) when calculating the effects of building wakes. The building wake algorithm in the ISC2 model incorporates and automatically (i.e., internally) exercises the gradual plume rise calculations. If the building wake is calculated to affect the plume for any hour, gradual plume rise is also used in downwind dispersion calculations to the distance of final plume rise, after which final plume rise is used.

Stack tip downwash generally occurs with poorly constructed stacks and when the ratio of the stack exit velocity to wind speed is small. An algorithm developed by Briggs (Hanna, et al.)[57] is the recommended technique for this situation and is found in the point source preferred models.

Where aerodynamic downwash occurs due to the adverse influence of nearby structures, the algorithms included in the ISC2 model[58] should be used.

8.2.9 Fumigation

Fumigation occurs when a plume (or multiple plumes) is emitted into a stable layer of air and that layer is subsequently mixed to the ground either through convective transfer of heat from the surface or because of advection to less stable surroundings. Fumigation may cause excessively high concentrations but is usually rather short-lived at a given receptor. There are no recommended refined techniques to model this phenomenon. There are, however, screening procedures (see "Screening Procedures for Estimating the Air Quality Impact of Stationary Sources"[18]) that may be used to approximate the concentrations. Considerable care should be exercised in using the results obtained from the screening techniques.

Fumigation is also an important phenomenon on and near the shoreline of bodies of water. This can affect both individual plumes and area-wide emissions. When fumigation conditions are expected to occur from a source or sources with tall stacks located on or just inland of a shoreline, this should be addressed in the air quality modeling analysis. The Shoreline Dispersion Model (SDM) listed in Appendix B may be applied on a case-by-case basis when air quality estimates under shoreline fumigation conditions are needed.[133] Information on the results of EPA's evaluation of this model together with other coastal fumigation models may be found in reference 134. Selection of the appropriate model for applications where shoreline fumigation is of concern should be determined in consultation with the Regional Office.

8.2.10 Stagnation

Stagnation conditions are characterized by calm or very low wind speeds, and variable wind directions. These stagnant meteorological conditions may persist for several hours to several days. During stagnation conditions, the dispersion of air pollutants, especially those from low-level emissions sources, tends to be minimized, potentially leading to relatively high ground-level concentrations.

When stagnation periods such as these are found to occur, they should be addressed in the air quality modeling analysis. WYNDvalley, listed in Appendix B, may be applied on a case-by-case basis for stagnation periods of 24 hours or longer in valley-type situations. Caution should be exercised when applying the model to elevated point sources. Users should consult with the appropriate Regional Office prior to regulatory application of WYNDvalley.

9.1.2 Recommendations

For point source applications the load or operating condition that causes maximum ground-level concentrations should be established. As a minimum, the source should be modeled using the design capacity (100 percent load). If a source operates at greater than design capacity for periods that could result in violations of the standards or PSD increments, this load[d] should be modeled. Where the source operates at substantially less than design capacity, and the changes in the stack parameters associated with the operating conditions could lead to higher ground level concentrations, loads such as 50 percent and 75 percent of capacity should also be modeled. A range of operating conditions should be considered in screening analyses; the load causing the highest concentration, in addition to the design load, should be included in refined modeling. The following example for a power plant is typical of the kind of data on source characteristics and operating conditions that may be needed. Generally, input data requirements for air quality models necessitate the use of metric units; where English units are common for engineering usage, a conversion to metric is required.

a. Plant layout. The connection scheme between boilers and stacks, and the distance and direction between stacks, building parameters (length, width, height, location and orientation relative to stacks) for plant structures which house boilers, control equipment, and surrounding buildings within a distance of approximately five stack heights.

b. Stack parameters. For all stacks, the stack height and inside diameter (meters), and the temperature (K) and volume flow rate (actual cubic meters per second) or exit gas velocity (meters per second) for operation at 100 percent, 75 percent and 50 percent load.

c. Boiler size. For all boilers, the associated megawatts, 10^6 BTU/hr, and pounds of steam per hour, and the design and/or actual fuel consumption rate for 100 percent load for coal (tons/hour), oil (barrels/hour), and natural gas (thousand cubic feet/hour).

d. Boiler parameters. For all boilers, the percent excess air used, the boiler type (e.g., wet bottom, cyclone, etc.), and the type of firing (e.g., pulverized coal, front firing, etc.).

e. Operating conditions. For all boilers, the type, amount and pollutant contents of fuel, the total hours of boiler operation and the boiler capacity factor during the year, and the percent load for peak conditions.

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[d]Malfunctions which may result in excess emissions are not considered to be a normal operating condition. They generally should not be considered in determining allowable emissions. However, if the excess emissions are the result of poor maintenance, careless operation, or other preventable conditions, it may be necessary to consider them in determining source impact.

f. Pollution control equipment parameters. For each boiler served and each pollutant affected, the type of emission control equipment, the year of its installation, its design efficiency and mass emission rate, the data of the last test and the tested efficiency, the number of hours of operation during the latest year, and the best engineering estimate of its projected efficiency if used in conjunction with coal combustion; data for any anticipated modifications or additions.

g. Data for new boilers or stacks. For all new boilers and stacks under construction and for all planned modifications to existing boilers or stacks, the scheduled date of completion, and the data or best estimates available for items (a) through (f) above following completion of construction or modification.

In stationary point source applications for compliance with short term ambient standards, SIP control strategies should be tested using the emission input shown on Table 9-1. When using a refined model, sources should be modeled sequentially with these loads for every hour of the year. To evaluate SIPs for compliance with quarterly and annual standards, emission input data shown in Table 9-1 should again be used. Emissions from area sources should generally be based on annual average conditions. The source input information in each model user's guide should be carefully consulted and the checklist in Appendix C should also be consulted for other possible emission data that could be helpful. PSD NAAQS compliance demonstrations should follow the emission input data shown in Table 9-2. For purposes of emissions trading, new source review and demonstrations, refer to current EPA policy and guidance to establish input data.

Line source modeling of streets and highways requires data on the width of the roadway and the median strip, the types and amounts of pollutant emissions, the number of lanes, the emissions from each lane and the height of emissions. The location of the ends of the straight roadway segments should be specified by appropriate grid coordinates. Detailed information and data requirements for modeling mobile sources of pollution are provided in the user's manuals for each of the models applicable to mobile sources.

The impact of growth on emissions should be considered in all modeling analyses covering existing sources. Increases in emissions due to planned expansion or planned fuel switches should be identified. Increases in emissions at individual sources that may be associated with a general industrial/commercial/residential expansion in multi-source urban areas should also be treated. For new sources the impact of growth on emissions should generally be considered for the period prior to the start-up date for the source. Such changes in emissions should treat increased area source emissions, changes in existing point source emissions which were not subject to preconstruction review, and emissions due to sources with permits to construct that have not yet started operation.

TABLE 9-1 MODEL EMISSION INPUT DATA FOR POINT SOURCES[1]

Averaging Time	Emission Limit (#/MMBtu)[2] X	Operating Level (MMBtu/hr)[2] X	Operating Factor (e.g., hr/yr, hr/day)
Stationary Point Source(s) Subject to SIP Emission Limit(s) Evaluation for Compliance with Ambient Standards (Including Areawide Demonstrations)			
Annual & quarterly:	Maximum allowable emission limit or federally enforceable permit limit.	Actual or design capacity (whichever is greater), or federally enforceable permit condition.	Actual operating factor averaged over most recent 2 years.[3]
Short term:	Maximum allowable emission limit or federally enforceable permit limit.	Actual or design capacity (whichever is greater), or federally enforceable permit condition.[4]	Continuous operation, i.e., all hours of each time period under consideration (for all hours of the meteorological data base).[5]
Nearby Background Source(s) Same input requirements as for stationary point source(s) above.			
Other Background Source(s) If modeled (see Section 9.2.3), input data requirements are defined below.			
Annual & quarterly:	Maximum allowable emission limit or federally enforceable permit limit.	Annual level when actually operating, averaged over the most recent 2 years.[3]	Actual operating factor averaged over the most recent 2 years.[3]
Short term:	Maximum allowable emission limit or federally enforceable permit limit.	Annual level when actually operating, averaged over the most recent 2 years.[3]	Continuous operation, i.e., all hours of each time period under consideration (for all hours of the meteorological data base).[5]

[1] The model input data requirements shown on this table apply to stationary source control strategies for STATE IMPLEMENTATION PLANS. For purposes of emissions trading, new source review, or prevention of significant deterioration, other model input criteria may apply. Refer to the policy and guidance for these programs to establish the input data.

[2] Terminology applicable to fuel burning sources; analogous terminology (e.g., #/throughput) may be used for other types of sources.

[3] Unless it is determined that this period is not representative.

[4] Operating levels such as 50 percent and 75 percent of capacity should also be modeled to determine the load causing the highest concentration.

[5] If operation does not occur for all hours of the time period of consideration (e.g., 3 or 24 hours) and the source operation is constrained by a federally enforceable permit condition, an appropriate adjustment to the modeled emission rate may be made (e.g., if operation is only 8:00 a.m. to 4:00 p.m. each day, only these hours will be modeled with emissions from the source. Modeled emissions should not be averaged across non-operating time periods.)

TABLE 9-2 POINT SOURCE MODEL INPUT DATA (EMISSIONS) FOR PSD NAAQS COMPLIANCE DEMONSTRATIONS

Averaging Time	Emission Limit (#/MMBtu)[1]	X	Operating Level (MMBtu/hr)[1]	X	Operating Factor (e.g., hr/yr, hr/day)
			Proposed Major New or Modified Source		
Annual & quarterly:	Maximum allowable emission limit or federally enforceable permit limit.		Design capacity or federally enforceable permit condition.		Continuous operation (i.e., 8760 hours).[2]
Short term: (≤ 24 hours)	Maximum allowable emission limit or federally enforceable permit limit.		Design capacity or federally enforceable permit condition.[3]		Continuous operation (i.e., all hours of each time period under consideration) (for all hours of the meteorological data base).[2]
			Nearby Background Source(s)[4]		
Annual & quarterly:	Maximum allowable emission limit or federally enforceable permit limit.		Actual or design capacity (whichever is greater), or federally enforceable permit condition.		Actual operating factor averaged over the most recent 2 years.[6,7]
Short term: (≤ 24 hours)	Maximum allowable emission limit or federally enforceable permit limit.		Actual or design capacity (whichever is greater), or federally enforceable permit condition.[3]		Continuous operation (i.e., all hours of each time period under consideration) (for all hours of the meteorological data base).[2]
			Other Background Source(s)[6]		
Annual & quarterly:	Maximum allowable emission limit or federally enforceable permit limit.		Annual level when actually operating, averaged over the most recent 2 years.[5]		Actual operating factor averaged over the most recent 2 years.[6,7]
Short term (≤ 24 hours)	Maximum allowable emission limit or federally enforceable permit limit.		Annual level when actually operating, averaged over the most recent 2 years.[5]		Continuous operation (i.e., all hours of each time period under consideration) (for all hours of the meteorological data base).[2]

[1] Terminology applicable to fuel burning sources; analogous terminology (e.g., #/throughput) may be used for other types of sources.

[2] If operation does not occur for all hours of the time period of consideration (e.g., 3 or 24 hours) and the source operation is constrained by a federally enforceable permit condition, an appropriate adjustment to the modeled emission rate may be made (e.g., if operation is only 8:00 a.m. to 4:00 p.m. each day, only these hours will be modeled with emissions from the source. Modeled emissions should not be averaged across non-operating time periods.

[3] Operating levels such as 50 percent and 75 percent of capacity should also be modeled to determine the load causing the highest concentration.

[4] Includes existing facility to which modification is proposed if the emissions from the existing facility will not be affected by the modification. Otherwise use the same parameters as for major modification.

[5] Unless it is determined that this period is not representative.

[6] Generally, the ambient impacts from non-nearby background sources can be represented by air quality data unless adequate data do not exist.

[7] For those permitted sources not yet in operation or that have not established an appropriate factor, continuous operation (i.e., 8760 hours) should be used.

9.2.2 Recommendations (Isolated Single Source)

Two options are available to determine the background concentration near isolated sources.

Option One: Use air quality data collected in the vicinity of the source to determine the background concentration for the averaging times of concern.[e] Determine the mean background concentration at each monitor by excluding values when the source in question is impacting the monitor. The mean annual background is the average of the annual concentrations so determined at each monitor. For shorter averaging periods, the meteorological conditions accompanying the concentrations of concern should be identified. Concentrations for meteorological conditions of concern, at monitors not impacted by the source in question, should be averaged for each separate averaging time to determine the average background value. Monitoring sites inside a 90° sector downwind of the source may be used to determine the area of impact. One hour concentrations may be added and averaged to determine longer averaging periods.

Option Two: If there are no monitors located in the vicinity of the source, a "regional site" may be used to determine background. A "regional site" is one that is located away from the area of interest but is impacted by similar natural and distant man-made sources.

9.2.3 Recommendations (Multi-Source Areas)

In multi-source areas two components of background should be determined.

Nearby Sources: All sources expected to cause a significant concentration gradient in the vicinity of the source or sources under consideration for emission limit(s) should be explicitly modeled. For evaluation for compliance with the short term and annual ambient standards, the nearby sources should be modeled using the emission input data shown in Table 9-1 or 9-2. The number of such sources is expected to be small except in unusual situations. The nearby source inventory should be determined in consultation with the reviewing authority. It is envisioned that the nearby sources and the sources under consideration will be evaluated together using an appropriate Appendix A model.

The impact of the nearby sources should be examined at locations where interactions between the plume of the point source under consideration and those of nearby sources (plus natural background) can occur. Significant locations include: (1) the area of maximum impact of the point source; (2) the area of maximum impact of nearby sources; and (3) the area where all sources combine to cause maximum impact. These locations may be identified through trial and error analyses.

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[e]For purposes of PSD, the location of monitors as well as data quality assurance procedures must satisfy requirements listed in the PSD Monitoring Guidelines.[63]

Other Sources: That portion of the background attributable to all other sources (e.g., natural sources, minor sources and distant major sources) should be determined by the procedures found in Section 9.2.2 or by application of a model using Table 9-1 or 9-2.

9.3.3.2 Recommendations

Site-specific Data Collection

The document "On-Site Meteorological Program Guidance for Regulatory Modeling Applications"[66] provides recommendations on the collection and use of on-site meteorological data. Recommendations on characteristics, siting, and exposure of meteorological instruments and on data recording, processing, completeness requirements, reporting, and archiving are also included. This publication should be used as a supplement to the limited guidance on these subjects now found in the "Ambient Monitoring Guidelines for Prevention of Significant Deterioration"[63] and the "Quality Assurance Handbook for Air Pollution Measurement Systems"[67] contains such information for meteorological measurements. As a minimum, site-specific measurements of ambient air temperature, transport wind speed and direction, and the parameters to determine Pasquill-Gifford stability categories should be available in meteorological data sets to be used in modeling. Care should be taken to ensure that monitors are located to represent the area of concern and that they are not influenced by very localized effects. Site-specific data for model applications should cover as long a period of measurement as is possible to ensure adequate representation of "worst-case" meteorology. The Regional Office will determine the appropriateness of the measurement locations.

All site-specific data should be reduced to hourly averages. Table 9-3 lists the wind related parameters and the averaging time requirements.

Temperature Measurements

Temperature measurements should be made at standard shelter height (2m) in accordance with the guidance in reference 66.

Wind Measurements

Wind speed and direction should be measured at or near plume height for use in estimating transport and dilution. To approximate this, if a source has a stack below 100m, select the stack top height as the transport wind measurement height. For sources with stacks extending above 100m, a 100m tower is suggested unless the stack top is significantly above 100 meters (200m or more). In cases with stacks 200m or above, the Regional Office should determine the appropriate measurement height on a case-by-case basis. Remote sensing may be a feasible alternative. The dilution wind speed used in determining plume rise and also used in the Gaussian dispersion equation is, by convention, defined as the wind speed at stack top.

Multiple level (typically three or more) measurements of wind temperature and turbulence (wind fluctuation statistics) are required for refined modeling applications in complex terrain. Such measurements should be obtained up to the representative plume height(s) of interest (i.e., the plume height(s) under those conditions important to the determination of the design concentration). The representative plume height(s) of interest should be determined using an appropriate complex terrain screening

procedure (e.g., CTSCREEN) and should be documented in the monitoring/modeling protocol. The necessary meteorological measurements should be obtained from an appropriately sited meteorological tower augmented by SODAR if the representative plume height(s) of interest exceed 100m. The meteorological tower need not exceed the lesser of the representative plume height of interest (the highest plume height if there is more than one plume height of interest) or 100m.

For routine tower and surface measurements, the wind speed should be measured using an anemometer, and the wind direction measured using a horizontal vane. Specifications for wind measuring instruments and systems are contained in the "On-Site Meteorological Program Guidance for Regulatory Modeling Applications".[66]

Stability Categories

The Pasquill-Gifford (P-G) stability categories, as originally defined, couple near-surface measurements of wind speed with subjectively determined insolation assessments based on hourly cloud cover and ceiling observations. The wind speed measurements are made at or near 10m. The insolation rate is typically assessed using observations of cloud cover and ceiling based on criteria outlined by Turner.[50] In the absence of site specific observations of cloud cover and ceiling, alternative procedures using wind fluctuation statistics (i.e., the σ_A and σ_E methods)[66] and Turner's method with off-site cloud cover and ceiling and on-site 10m wind speed are recommended.

The two methods of stability classification which use wind fluctuation statistics, the σ_A and σ_E methods, are described in detail in EPA's "On-Site Meteorological Program Guidance for Regulatory Modeling Applications"[66] (note applicable tables in Chapter 6). In the case of the σ_A method it should be noted that wind meander may occasionally bias the determination of σ_A and thus lead to an erroneous determination of the P-G stability category. To minimize wind direction meander contributions, σ_A may be determined for each of four 15-minute periods in an hour. However, 360 samples are needed during each 15-minute period. If the σ_A method is being used for stability determinations in these situations, take the square root of one-quarter of the sum of the square of the four 15 minute σ_A's, as illustrated in the footnote to Table 9-3. While this approach is an acceptable alternative for determining stability, as qualified above, σ_A's calculated in this manner are not likely to be suitable for input to models under development that are designed to accept on-site hourly σ's based on 60-minute periods. For additional information on stability classification using wind fluctuation statistics, see references 68-72.

In summary, when on-site data are being used, P-G stability categories should be estimated based on:

(1) Turner's method[55] using site-specific data which include cloud cover, ceiling height and surface (~10m) wind speeds;

(2) σ_E from site-specific measurements in accordance with guidance;[66]

(3) σ_A from site-specific measurements in accordance with guidance;[66]

(4) Turner's method[55] using site-specific wind speed with cloud cover and ceiling height from a nearby NWS site.

Meteorological Data Processors

The following meteorological preprocessors are recommended by EPA: RAMMET, PCRAMMET, STAR, PCSTAR, MPRM,[135] and METPRO.[24] RAMMET is the recommended meteorological preprocessor for use in applications employing hourly NWS data. The RAMMET format is the standard data input format used in sequential Gaussian models recommended by EPA. PCRAMMET is the PC equivalent of the mainframe version (RAMMET). STAR is the recommended preprocessor for use in applications employing joint frequency distributions (wind direction and wind speed by stability class) based on NWS data. PCSTAR is the PC equivalent of the mainframe version (STAR). MPRM is the recommended preprocessor for use in applications employing on-site meteorological data. MPRM is a general purpose meteorological data preprocessor which supports regulatory models requiring RAMMET formatted data and STAR formatted data. In addition to on-site data, MPRM provides equivalent processing of NWS data. METPRO is the required meteorological data preprocessor for use with CTDMPLUS. All of the above mentioned data preprocessors are available for downloading from the SCRAM BBS.[19]

TABLE 9-3

Averaging Times for Site-Specific Wind and Turbulence Measurements

Parameter	Averaging Time
Surface wind speed (for use in stability determinations)	1-hr
Transport direction	1-hr
Dilution wind speed	1-hr
Turbulence measurements (σ_E and σ_A) for use in stability determinations	1-hr[1]

[1] To minimize meander effects in σ_A when wind conditions are light and/or variable, determine the hourly average σ value from four sequential 15-minute σ's according to the following formula:

$$\sigma_{1\text{-}hr} = \sqrt{\frac{\sigma_{15}^2 + \sigma_{15}^2 + \sigma_{15}^2 + \sigma_{15}^2}{4}}$$

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10.1.4 Evaluation of Models

A number of actions are being taken to ensure that the best model is used correctly for each regulatory application and that a model is not arbitrarily imposed. First, this guideline clearly recommends the most appropriate model be used in each case. Preferred models, based on a number of factors, are identified for many uses. General guidance on using alternatives to the preferred models is also provided. Second, all the models in eight categories (i.e., rural, urban, industrial complex, reactive pollutants, mobile source, complex terrain, visibility and long range transport) that are candidates for inclusion in this guideline are being subjected to a systematic performance evaluation and a peer scientific review.[85] The same data bases are being used to evaluate all models within each of eight categories. Statistical performance measures, including measures of difference (or residuals) such as bias, variance of difference and gross variability of the difference, and measures of correlation such as time, space, and time and space combined as recommended by the AMS Woods Hole Workshop,[11] are being followed. The results of the scientific review are being incorporated in this guideline and will be the basis for future revision.[12,13] Third, more specific information has been provided for justifying the site specific use of alternative models in the documents "Interim Procedures for Evaluating Air Quality Models",[15] and the "Protocol for Determining the Best Performing Model".[17] Together these documents provide methods that allow a judgment to be made as to what models are most appropriate for a specific application. For the present, performance and the theoretical evaluation of models are being used as an indirect means to quantify one element of uncertainty in air pollution regulatory decisions.

11.0 REGULATORY APPLICATION OF MODELS

11.1 Discussion

Procedures with respect to the review and analysis of air quality modeling and data analyses in support of SIP revisions, PSD permitting or other regulatory requirements need a certain amount of standardization to ensure consistency in the depth and comprehensiveness of both the review and the analysis itself. This section recommends procedures that permit some degree of standardization while at the same time allowing the flexibility needed to assure the technically best analysis for each regulatory application.

Dispersion model estimates, especially with the support of measured air quality data, are the preferred basis for air quality demonstrations. Nevertheless, there are instances where the performance of recommended dispersion modeling techniques, by comparison with observed air quality data, may be shown to be less than acceptable. Also, there may be no recommended modeling procedure suitable for the situation. In these instances, emission limitations may be established solely on the basis of observed air quality data as would be applied to a modeling analysis. The same care should be given to the analyses of the air quality data as would be applied to a modeling analysis.

The current NAAQS for SO_2 and CO are both stated in terms of a concentration not to be exceeded more than once a year. There is only an annual standard for NO_2 and a quarterly standard for Pb. The PM-10 and ozone standards permit the exceedance of a concentration on an average of not more than once a year; the convention is to average over a 3-year period.[5,86,103] This

11.2 Recommendations

11.2.1 Analysis Requirements

Every effort should be made by the Regional Office to meet with all parties involved in either a SIP revision or a PSD permit application prior to the start of any work on such a project. During this meeting, a protocol should be established between the preparing and reviewing parties to define the procedures to be followed, the data to be collected, the model to be used, and the analysis of the source and concentration data. An example of requirements for such an effort is contained in the Air Quality Analysis Checklist included here as Appendix C. This checklist suggests the level of detail required to assess the air quality resulting from the proposed action. Special cases may require additional data collection or analysis and this should be determined and agreed upon at this preapplication meeting. The protocol should be written and agreed upon by the parties concerned, although a formal legal document is not intended. Changes in such a protocol are often required as the data collection and analysis progresses. However, the protocol establishes a common understanding of the requirements.

An air quality analysis should begin with a screening model to determine the potential of the proposed source or control strategy to violate the PSD increment or NAAQS. It is recommended that the screening techniques found in "Screening Procedures for Estimating the Air Quality Impact of Stationary Sources"[18] be used for point source analyses. Screening procedures for area source analysis are discussed in "Applying Atmospheric Simulation Models to Air Quality Maintenance Areas".[87] For mobile source impact assessments the "Guideline for Modeling Carbon Monoxide from Roadway Intersections"[34] is available.

If the concentration estimates from screening techniques indicate that the PSD increment or NAAQS may be approached or exceeded, then a more refined modeling analysis is appropriate and the model user should select a model according to recommendations in Sections 4-8. In some instances, no refined technique may be specified in this guide for the situation. The model user is then encouraged to submit a model developed specifically for the case at hand. If that is not possible, a screening technique may supply the needed results.

Regional Offices should require permit applicants to incorporate the pollutant contributions of all sources into their analysis. Where necessary this may include emissions associated with growth in the area of impact of the new or modified source's impact. PSD air quality assessments should consider the amount of the allowable air quality increment that has already been granted to any other sources. Therefore, the most recent source applicant should model the existing or permitted sources in addition to the one currently under consideration. This would permit the use of newly acquired data or improved modeling techniques if

11.2.3 Emission Limits

11.2.3.1 Design Concentrations

Emission limits should be based on concentration estimates for the averaging time that results in the most stringent control requirements. The concentration used in specifying emission limits is called the design value or design concentration and is a sum of the concentration contributed by the source and the background concentration.

To determine the averaging time for the design value, the most restrictive National Ambient Air Quality Standard (NAAQS) should be identified by calculating, for each averaging time, the ratio of the applicable NAAQS (S) minus background (B) to the predicted concentration (P) (i.e., (S-B)/P). The averaging time with the lowest ratio identifies the most restrictive standard. If the annual average is the most restrictive, the highest estimated annual average concentration from one or a number of years of data is the design value. When short term standards are most restrictive, it may be necessary to consider a broader range of concentrations than the highest value. For example, for pollutants such as SO_2, the highest, second-highest concentration is the design value. For pollutants with statistically based NAAQS, the design value is found by determining the more restrictive of: (1) the short-term concentration that is not expected to be exceeded more than once per year over the period specified in the standard, or (2) the long-term concentration that is not expected to exceed the long-term NAAQS. Determination of design values for PM-10 is presented in more detail in the "PM-10 SIP Development Guideline".[103]

When the highest, second-highest concentration is used in assessing potential violations of a short term NAAQS, criteria that are identified in "Guideline for Interpretation of Air Quality Standards"[88] should be followed. This guideline specifies that a violation of a short term standard occurs at a site when the standard is exceeded a second time. Thus, emission limits that protect standards for averaging times of 24 hours or less are appropriately based on the highest, second-highest estimated concentration plus a background concentration which can reasonably be assumed to occur with the concentration.

11.2.3.2 NAAQS Analyses for New or Modified Sources

For new or modified sources predicted to have a significant ambient impact[63] and to be located in areas designated attainment or unclassifiable for the SO_2, Pb, NO_2, or CO NAAQS, the demonstration as to whether the source will cause or contribute to an air quality violation should be based on: (1) the highest estimated annual average concentration determined from annual averages of individual years; or (2) the highest, second-highest estimated concentration for averaging times of 24-hours or less; and (3) the significance of the spatial and temporal contribution to any modeled violation. For Pb, the highest estimated concentration based on an individual calendar quarter averaging period should be used. Background concentrations should be added to the estimated impact of the source. The most restrictive standard should be used in all cases to assess the threat of an air quality violation. For new or modified sources predicted to have a significant ambient impact[63] in areas designated attainment or unclassifiable for the

PM-10 NAAQS, the demonstration of whether or not the source will cause or contribute to an air quality violation should be based on sufficient data to show whether: (1) the projected 24-hour average concentrations will exceed the 24-hour NAAQS more than once per year, on average; (2) the expected (i.e., average) annual mean concentration will exceed the annual NAAQS; and (3) the source contributes significantly, in a temporal and spatial sense, to any modeled violation.

11.2.3.3 PSD Air Quality Increments and Impacts

The allowable PSD increments for criteria pollutants are established by regulation and cited in 40 CFR 51.166. These maximum allowable increases in pollutant concentrations may be exceeded once per year at each site, except for the annual increment that may not be exceeded. The highest, second-highest increase in estimated concentrations for the short term averages as determined by a model should be less than or equal to the permitted increment. The modeled annual averages should not exceed the increment.

Screening techniques defined in Sections 4 and 5 can sometimes be used to estimate short term incremental concentrations for the first new source that triggers the baseline in a given area. However, when multiple increment-consuming sources are involved in the calculation, the use of a refined model with at least 1 year of on-site or 5 years of off-site NWS data is normally required. In such cases, sequential modeling must demonstrate that the allowable increments are not exceeded temporally and spatially, i.e., for all receptors for each time period throughout the year(s) (time period means the appropriate PSD averaging time, e.g., 3-hour, 24-hour, etc.).

The PSD regulations require an estimation of the SO_2, particulate matter, and NO_2 impact on any Class I area. Normally, Gaussian models should not be applied at distances greater than can be accommodated by the steady state assumptions inherent in such models. The maximum distance for refined Gaussian model application for regulatory purposes is generally considered to be 50km. Beyond the 50km range, screening techniques may be used to determine if more refined modeling is needed. If refined models are needed, long range transport models should be considered in accordance with Section 7.2.6. As previously noted in Sections 3 and 7, the need to involve the Federal Land Manager in decisions on potential air quality impacts, particularly in relation to PSD Class I areas, cannot be overemphasized.

11.2.3.4 Emissions Trading Policy (Bubbles)

EPA's final Emissions Trading Policy, commonly referred to as the "bubble policy," was published in the Federal Register in 1986.[89] Principles contained in the policy should be used to evaluate ambient impacts of emission trading activities.

Emission increases and decreases within the bubble should result in ambient air quality equivalence. Two levels of analysis are defined for establishing this equivalence. In a Level I analysis the source configuration and setting must meet certain limitations (defined in the policy) that ensure ambient equivalence; no modeling is required. In a Level II analysis a modeling demonstration of ambient equivalence is required but only the sources involved in the emissions trade are modeled. The resulting ambient estimates of net increases/decreases are compared to a set of significance levels to determine if the bubble can be approved. A Level II analysis requires the use of a refined model and the most recent readily available full year of representative meteorological data. Sequential modeling must demonstrate that the significance levels are met temporally and spatially, i.e., for all receptors for each time period throughout the year (time period means the appropriate NAAQS averaging time, e.g., 3-hour, 24-hour, etc.).

For those bubbles that cannot meet the Level I or Level II requirements, the Emissions Trading Policy allows for a Level III analysis. A Level III analysis, from a modeling standpoint, is generally equivalent to the requirements for a standard SIP revision where all sources (and background) are considered and the estimates are compared to the NAAQS as in Section 11.2.3.2.

The Emissions Trading Policy allows States to adopt generic regulations for processing bubbles. The modeling procedures recommended in this guideline apply to such generic regulations. However, an added requirement is that the modeling procedures contained in any generic regulation must be replicable such that there is no doubt as to how each individual bubble will be modeled. In general this means that the models, the data bases and the procedures for applying the model must be defined in the regulation. The consequences of the replicability requirement are that bubbles for sources located in complex terrain and certain industrial sources where judgments must be made on source characterization cannot be handled generically.

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Hales, J. M., 1976. Tall Stacks and the Atmospheric Environment. EPA Publication No. EPA-450/3-76-007. U.S. Environmental Protection Agency, Research Triangle Park, NC.

[h]The documents listed here are major sources of supplemental information on the theory and application of mathematical air quality models.

APPENDIX A TO APPENDIX W OF PART 51

Table of Contents

A.0 INTRODUCTION AND AVAILABILITY

This appendix summarizes key features of refined air quality models preferred for specific regulatory applications. For each model, information is provided on availability, approximate cost in 1990, regulatory use, data input, output format and options, simulation of atmospheric physics, and accuracy. These models may be used without a formal demonstration of applicability provided they satisfy the recommendations for regulatory use; not all options in the models are necessarily recommended for regulatory use.

Many of these models have been subjected to a performance evaluation using comparisons with observed air quality data. A summary of such comparisons for models contained in this appendix is included in "A Survey of Statistical Measures of Model Performance and Accuracy for Several Air Quality Models," EPA-450/4-83-001. Where possible, several of the models contained herein have been subjected to evaluation exercises, including (1) statistical performance tests recommended by the American Meteorological Society and (2) peer scientific reviews. The models in this appendix have been selected on the basis of the results of the model evaluations, experience with previous use, familiarity of the model to various air quality programs, and the costs and resource requirements for use.

The Availability statement for models in this Appendix that refers to the User's Network for Applied Modeling of Air Pollution (UNAMAP) should be ignored since UNAMAP is no longer operational. However, all models and user's documentation in this appendix are available from:

Computer Products
National Technical Information Service (NTIS)
U.S. Department of Commerce
Springfield, VA 22161
Phone: (703) 487-4650

In addition, model codes and selected, abridged user's guides are available from the Support Center for Regulatory Air Models Bulletin Board System[19] (SCRAM BBS), telephone (919) 541-5742. The SCRAM BBS is an electronic bulletin board system designed to be user friendly and accessible from anywhere in the country. Model users with personal computers are encouraged to use the SCRAM BBS to download current model codes and text files.

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A.5 INDUSTRIAL SOURCE COMPLEX MODEL (ISC2)

Reference: Environmental Protection Agency, 1992. User's Guide for the Industrial Source Complex (ISC2) Dispersion Models, Volumes 1, 2, and 3. EPA Publication Nos. EPA-450/4-92-008a-c. Environmental Protection Agency, Research Triangle Park, NC. (NTIS Nos. PB 92-232461, PB 92-232453, and PB 92-232479, respectively)

Availability: The model code is available on the Support Center for Regulatory Air Models Bulletin Board System and also from the National Technical Information Service (see page A-1).

Abstract: The ISC2 model is a steady-state Gaussian plume model which can be used to assess pollutant concentrations from a wide variety of sources associated with an industrial source complex. This model can account for the following: settling and dry deposition of particles; downwash; area, line and volume sources; plume rise as a function of downwind distance; separation of point sources; and limited terrain adjustment. It operates in both long-term and short-term modes.

a. Recommendations for Regulatory Use

ISC2 is appropriate for the following applications:

- industrial source complexes;
- rural or urban areas;
- flat or rolling terrain;
- transport distances less than 50 kilometers;
- 1-hour to annual averaging times; and
- continuous toxic air emissions.

The following options should be selected for regulatory applications:

For short term or long term modeling, set the regulatory "default option"; i.e., use the keyword *DFAULT*, which automatically selects stack tip downwash, final plume rise, buoyancy induced dispersion (BID), the vertical potential temperature gradient, a treatment for calms, the appropriate wind profile exponents, the appropriate value for pollutant half-life, and a revised building wake effects algorithm; set the "rural option" (use the keyword *RURAL*) or "urban option" (use the keyword *URBAN*); and set the "concentration option" (use the keyword *CONC*).

b. Input Requirements

Source data: location, emission rate, physical stack height, stack gas exit velocity, stack inside diameter, and stack gas temperature. Optional inputs include source elevation, building dimensions, particle size distribution with corresponding settling velocities, and surface reflection coefficients.

Meteorological data: ISCST2 requires hourly surface weather data from the preprocessor program RAMMET, which provides hourly stability class,wind direction, wind speed, temperature, and mixing height. For ISCLT2, input includes stability wind rose (STAR deck), average afternoon mixing height, average morning mixing height, and average air temperature.

Receptor data: coordinates and optional ground elevation for each receptor.

c. Output

Printed output options include:

- program control parameters, source data, and receptor data;
- tables of hourly meteorological data for each specified day;
- "N"-day average concentration or total deposition calculated at each receptor for any desired source combinations;
- concentration or deposition values calculated for any desired source combinations at all receptors for any specified day or time period within the day;
- tables of highest and second highest concentration or deposition values calculated at each receptor for each specified time period during a(n) "N"-day period for any desired source combinations, and tables of the maximum 50 concentration or deposition values calculated for any desired source combinations for each specified time period.

d. Type of Model

ISC2 is a Gaussian plume model.

e. Pollutant Types

ISC2 may be used to model primary pollutants and continuous releases of toxic and hazardous waste pollutants. Settling and deposition are treated.

f. Source-Receptor Relationships

ISC2 applies user-specified locations for point, line, area and volume sources, and user-specified receptor locations or receptor rings.

User input topographic evaluation for each receptor is used. Elevations above stack top are reduced to the stack top elevation, i.e., "terrain chopping".

User input height above ground level may be used when necessary to simulate impact at elevated or "flag pole" receptors, e.g., on buildings.

Actual separation between each source-receptor pair is used.

g. Plume Behavior

ISC2 uses Briggs (1969, 1971, 1975) plume rise equations for final rise.

Stack tip downwash equation from Briggs (1974) is used.

Revised building wake effects algorithm is used. For stacks higher than building height plus one-half the lesser of the building height or building width, the building wake algorithm of Huber and Snyder (1976) is used. For lower stacks, the building wake algorithm of Schulman and Scire (Schulman and Hanna, 1986) is used, but stack tip downwash and BID are not used.

For rolling terrain (terrain not above stack height), plume centerline is horizontal at height of final rise above source.

Fumigation is not treated.

h. Horizontal Winds

Constant, uniform (steady-state) wind is assumed for each hour.

Straight line plume transport is assumed to all downwind distances.

Separate wind speed profile exponents (EPA, 1980) for both rural and urban cases are used.

An optional treatment for calm winds is included for short term modeling.

i. Vertical Wind Speed

Vertical wind speed is assumed equal to zero.

j. Horizontal Dispersion

Rural dispersion coefficients from Turner (1969) are used, with no adjustments for surface roughness or averaging time.

Urban dispersion coefficients from Briggs (Gifford, 1976) are used.

Buoyancy induced dispersion (Pasquill, 1976) is included.

Six stability classes are used.

k. Vertical Dispersion

Rural dispersion coefficients from Turner (1969) are used, with no adjustments for surface roughness.

Urban dispersion coefficients from Briggs (Gifford, 1976) are used.

Buoyancy induced dispersion (Pasquill, 1976) is included.

Six stability classes are used.

Mixing height is accounted for with multiple reflections until the vertical plume standard deviation equals 1.6 times the mixing height; uniform vertical mixing is assumed beyond that point.

Perfect reflection is assumed at the ground.

l. Chemical Transformation

Chemical transformations are treated using exponential decay. Time constant is input by the user.

m. Physical Removal

Settling and dry deposition of particulates are treated.

n. Evaluation Studies

Bowers, J. F., and A. J. Anderson, 1981. An Evaluation Study for the Industrial Source Complex (ISC) Dispersion Model, EPA Publication No. EPA-450/4-81-002. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Bowers, J. F., A. J. Anderson, and W. R. Hargraves, 1982. Tests of the Industrial Source Complex (ISC) Dispersion Model at the Armco Middletown, Ohio Steel Mill, EPA Publication No. EPA-450/4-82-006. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Scire, J. S., and L. L. Schulman, 1981. Evaluation of the BLP and ISC Models with SF_6 Tracer Data and SO_2 Measurements at Aluminum Reduction Plants. Air Pollution Control Association Specialty Conference on Dispersion Modeling for Complex Sources, St. Louis, MO.

A.8 URBAN AIRSHED MODEL (UAM)

References: Environmental Protection Agency, 1990. User's Guide for the Urban Airshed Model, Volume I-VIII. EPA Publication Nos. EPA-450/4-90-007a-c, d(R), e-g, and EPA-454/B-93-004, respectively. U.S. Environmental Protection Agency, Research Triangle Park, NC (NTIS Nos. PB 91-131227, PB 91-131235, PB 91-131243, PB 93-122380, PB 91-131268, PB 92-145382, and PB 92-224849, respectively, for Vols. I-VII).

Availability: The model code is available on the Support Center for Regulatory Air Models Bulletin Board System and also from the National Technical Information Service (see page A-1).

Abstract: UAM is an urban scale, three dimensional, grid type numerical simulation model. The model incorporates a condensed photochemical kinetics mechanism for urban atmospheres. The UAM is designed for computing ozone (O_3) concentrations under short-term, episodic conditions lasting one or two days resulting from emissions of oxides of nitrogen (NO_x), volatile organic compounds (VOC), and carbon monoxide (CO). The model treats urban VOC emissions as their carbon-bond surrogates.

a. Recommendations for Regulatory Use

UAM is appropriate for the following applications: urban areas having significant ozone attainment problems and one hour averaging times.

UAM has many options but no specific recommendations can be made at this time on all options. The reviewing agency should be consulted on selection of options to be used in regulatory applications.

b. Input Requirements

Source data: gridded, hourly emissions of PAR, OLE, ETH, XYL, TOL, ALD2, FORM, ISOR, ETOTH, MEOH, CO, NO, and NO_2 for low-level sources. For major elevated point sources, hourly emissions, stack height, stack diameter, exit velocity, and exit temperature.

Meteorological data: hourly, gridded, divergence free, u and v wind components for each vertical level; hourly gridded mixing heights and surface temperatures; hourly exposure class; hourly vertical potential temperature gradient above and below the mixing height; hourly surface atmospheric pressure; hourly water mixing ratio; and gridded surface roughness lengths.

Air quality data: concentration of all carbon bond 4 species at the beginning of the simulation for each grid cell; and hourly concentrations of each pollutant at each level along the inflow boundaries and top boundary of the modeling region.

Other data requirements are: hourly mixed layer average, NO_2 photolysis rates; and ozone surface uptake resistance along with associated gridded vegetation (scaling) factors.

c. Output

Printed output includes:

- gridded instantaneous concentration fields at user-specified time intervals for user-specified pollutants and grid levels;
- gridded time-average concentration fields for user-specified time intervals, pollutants, and grid levels.

d. Type of Model

UAM is a three dimensional, numerical, photochemical grid model.

e. Pollutant Types

UAM may be used to model ozone (O_3) formation from oxides of nitrogen (NO_x) and volatile organic compound (VOC) emissions.

f. Source-Receptor Relationship

Low-level area and point source emissions are specified within each surface grid cell. Emissions from major point sources are placed within cells aloft in accordance with calculated effective plume heights.

Hourly average concentrations of each pollutant are calculated for all grid cells at each vertical level.

g. Plume Behavior

Plume rise is calculated for major point sources using relationships recommended by Briggs (1971).

h. Horizontal Winds

See Input Requirements.

i. Vertical Wind Speed

Calculated at each vertical grid cell interface from the mass continuity relationship using the input gridded horizontal wind field.

j. Horizontal Dispersion

Horizontal eddy diffusivity is set to a user specified constant value (nominally 50 m^2/s).

k. Vertical Dispersion

Vertical eddy diffusivities for unstable and neutral conditions calculated using relationships of Lamb et al. (1977); for stable conditions, the relationship of Businger and Arya (1974) is employed. Stability class, friction velocity, and Monin-Obukhov length determined using procedure of Liu et al. (1976).

l. Chemical Transformation

UAM employs a simplified version of the Carbon-Bond IV Mechanism (CBM-IV) developed by Gery et al. (1988) employing various steady state approximations.

m. Physical Removal

Dry deposition of ozone and other pollutant species are calculated. Vegetation (scaling) factors are applied to the reference surface uptake resistance of each species depending on land use type.

n. Evaluation Studies

Builtjes, P. J. H., K. D. van der Hurt, and S. D. Reynolds, 1982. Evaluation of the Performance of a Photochemical Dispersion Model in Practical Applications, 13th International Technical Meeting on Air Pollution Modeling and Its Application, Ile des Embiez, France.

Cole, H. S., D. E. Layland, G. K. Moss, and C. F. Newberry, 1983. The St. Louis Ozone Modeling Project. EPA Publication No. EPA-450/4-83-019. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Dennis, R. L., M. W. Downton, and R. S. Keil, 1983. Evaluation of Performance Measures for an Urban Photochemical Model. EPA Publication No. EPA-450/4-83-021. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Haney, J. L. and T. N. Braverman, 1985. Evaluation and Application of the Urban Airshed Model in the Philadelphia Air Quality Control Region. EPA Publication No. EPA-450/4-85-003. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Layland, D. E. and H. S. Cole, 1983. A Review of Recent Applications of the SAI Urban Airshed Model. EPA Publication No. EPA-450/4-84-004. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Layland, D. E., S. D. Reynolds, H. Hogo and W. R. Oliver, 1983. Demonstration of Photochemical Grid Model Usage for Ozone Control Assessment. 76th Annual Meeting of the Air Pollution Control Association, Atlanta, GA.

Morris, R. E. et al., 1990. Urban Airshed Model Study of Five Cities. EPA Publication No. EPA-450/4-90-006a-g. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Reynolds, S. D., H. Hogo, W. R. Oliver, L. E. Reid, 1982. Application of the SAI Airshed Model to the Tulsa Metropolitan Area, SAI No. 82004. Systems Applications, Inc., San Rafael, CA.

Schere, K. L. and J. H. Shreffler, 1982. Final Evaluation of Urban-Scale Photochemical Air Quality Simulation Models. EPA Publication No. EPA-600/3-82-094. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Seigneur C., T. W. Tesche, C. E. Reid, P. M. Roth, W. R. Oliver, and J. C. Cassmassi, 1981. The Sensitivity of Complex Photochemical Model Estimates to Detail In Input Information, Appendix A - A Compilation of Simulation Results. EPA Publication No. EPA-450/4-81-031b. U.S. Environmental Protection Agency, Research Triangle Park, NC.

South Coast Air Quality Management District, 1989. Air Quality Management Plan--Appendix V-R (Urban Airshed Model Performance Evaluation). El Monte, CA.

Stern, R. and B. Scherer, 1982. Simulation of a Photochemical Smog Episode in the Rhine-Ruhr Area with a Three Dimensional Grid Model. 13th International Technical Meeting on Air Pollution Modeling and Its Application, Ile des Embiez, France.

Tesche, T. W., C. Seigneur, L. E. Reid, P. M. Roth, W. R. Oliver, and J. C. Cassmassi, 1981. The Sensitivity of Complex Photochemical Model Estimates to Detail in Input Information. EPA Publication No. EPA-450/4-81-031a. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Tesche, T. W., W. R. Oliver, H. Hogo, P. Saxeena and J. L. Haney, 1983. Volume IV--Assessment of NO_x Emission Control Requirements in the South Coast Air Basin--Appendix A. Performance Evaluation of the Systems Applications Airshed Model for the 26-27 June 1974 O_3 Episode in the South Coast Air Basin, SYSAPP 83/037. Systems Applications, Inc., San Rafael, CA.

Tesche, T. W., W. R. Oliver, H. Hogo, P. Saxeena and J. L. Haney, 1983. Volume IV--Assessment of NO_x Emission Control Requirements in the South Coast Air Basin--Appendix B. Performance Evaluation of the Systems Applications Airshed Model for the 7-8 November 1978 NO_2 Episode in the South Coast Air Basin, SYSAPP 83/038. Systems Applications, Inc., San Rafael, CA.

Tesche, T. W, 1988. Accuracy of Ozone Air Quality Models. *Journal of Environmental Engineering*, 114(4): 739-752.

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A.9 OFFSHORE AND COASTAL DISPERSION MODEL (OCD)

Reference: DiCristofaro, D. C. and S. R. Hanna, 1989. OCD: The Offshore and Coastal Dispersion Model, Version 4. Volume I: User's Guide, and Volume II: Appendices. Sigma Research Corporation, Westford, MA. (NTIS Nos. PB 93-144384 and PB 93-144392)

Availability: This model code is available on the Support Center for Regulatory Air Models Bulletin Board System and also from the National Technical Information Service (see page A-1).

Technical Contact:
Minerals Management Service
Attn: Mr. Dirk Herkoff
Parkway Atrium Building,
381 Elden Street, Herndon, VA 22070-4817
Phone: (703) 787-1735

Abstract: OCD is a straight-line Gaussian model developed to determine the impact of offshore emissions from point, area or line sources on the air quality of coastal regions. OCD incorporates overwater plume transport and dispersion as well as changes that occur as the plume crosses the shoreline. Hourly meteorological data are needed from both offshore and onshore locations. These include water surface temperature, overwater air temperature, mixing height, and relative humidity.

Some of the key features include platform building downwash, partial plume penetration into elevated inversions, direct use of turbulence intensities for plume dispersion, interaction with the overland internal boundary layer, and continuous shoreline fumigation.

a. Recommendations for Regulatory Use

OCD has been recommended for use by the Minerals Management Service for emissions located on the Outer Continental Shelf (50 FR 12248; 28 March 1985). OCD is applicable for overwater sources where onshore receptors are below the lowest source height. Where onshore receptors are above the lowest source height, offshore plume transport and dispersion may be modeled on a case-by-case basis in consultation with the EPA Regional Office.

b. Input Requirements

Source data: point, area or line source location, pollutant emission rate, building height, stack height, stack gas temperature, stack inside diameter, stack gas exit velocity, stack angle from vertical, elevation of stack base above water surface and gridded specification of the land/water surfaces. As an option, emission rate, stack gas exit velocity and temperature can be varied hourly.

Meteorological data (over water): wind direction, wind speed, mixing height, relative humidity, air temperature, water surface temperature, vertical wind direction shear (optional), vertical temperature gradient (optional), turbulence intensities (optional).

Meteorological data (over land): wind direction, wind speed, temperature, stability class, mixing height.

Receptor data: location, height above local ground-level, ground-level elevation above the water surface.

c. Output

All input options, specification of sources, receptors and land/water map including locations of sources and receptors.

Summary tables of five highest concentrations at each receptor for each averaging period, and average concentration for entire run period at each receptor.

Optional case study printout with hourly plume and receptor characteristics. Optional table of annual impact assessment from non-permanent activities.

Concentration files written to disk or tape can be used by ANALYSIS postprocessor to produce the highest concentrations for each receptor, the cumulative frequency distributions for each receptor, the tabulation of all concentrations exceeding a given threshold, and the manipulation of hourly concentration files.

d. Type of Model

OCD is a Gaussian plume model constructed on the framework of the MPTER model.

e. Pollutant Types

OCD may be used to model primary pollutants. Settling and deposition are not treated.

f. Source-Receptor Relationship

Up to 250 point sources, 5 area sources, or 1 line source and 180 receptors may be used.

Receptors and sources are allowed at any location.

The coastal configuration is determined by a grid of up to 3600 rectangles. Each element of the grid is designated as either land or water to identify the coastline.

g. Plume Behavior

As in MPTER, the basic plume rise algorithms are based on Briggs' recommendations.

Momentum rise includes consideration of the stack angle from the vertical.

The effect of drilling platforms, ships, or any overwater obstructions near the source are used to decrease plume rise using a revised platform downwash algorithm based on laboratory experiments.

Partial plume penetration of elevated inversions is included using the suggestions of Briggs (1975) and Weil and Brower (1984).

Continuous shoreline fumigation is parameterized using the Turner method where complete vertical mixing through the thermal internal boundary layer (TIBL) occurs as soon as the plume intercepts the TIBL.

h. Horizontal Winds

Constant, uniform wind is assumed for each hour.

Overwater wind speed can be estimated from overland wind speed using relationship of Hsu (1981).

Wind speed profiles are estimated using similarity theory (Businger 1973). Surface layer fluxes for these formulas are calculated from bulk aerodynamic methods.

i. Vertical Wind Speed

Vertical wind speed is assumed equal to zero.

j. Horizontal Dispersion

Lateral turbulence intensity is recommended as a direct estimate of horizontal dispersion. If lateral turbulence intensity is not available, it is estimated from boundary layer theory. For wind speeds less than 8 m/s, lateral turbulence intensity is assumed inversely proportional to wind speed.

Horizontal dispersion may be enhanced because of obstructions near the source. A virtual source technique is used to simulate the initial plume dilution due to downwash.

Formulas recommended by Pasquill (1976) are used to calculate buoyant plume enhancement and wind direction shear enhancement.

At the water/land interface, the change to overland dispersion rates is modeled using a virtual source. The overland dispersion rates can be calculated from either lateral turbulence intensity or Pasquill-Gifford curves. The change is implemented where the plume intercepts the rising internal boundary layer.

k. Vertical Dispersion

Observed vertical turbulence intensity is not recommended as a direct estimate of vertical dispersion. Turbulence intensity should be estimated from boundary layer theory as default in the model. For very stable conditions, vertical dispersion is also a function of lapse rate.

Vertical dispersion may be enhanced because of obstructions near the source. A virtual source technique is used to simulate the initial plume dilution due to downwash.

Formulas recommended by Pasquill (1976) are used to calculate buoyant plume enhancement.

At the water/land interface, the change to overland dispersion rates is modeled using a virtual source. The overland dispersion rates can be calculated from either vertical turbulence intensity or the Pasquill-Gifford coefficients. The change is implemented where the plume intercepts the rising internal boundary layer.

l. Chemical Transformation

Chemical transformations are treated using exponential decay. Different rates can be specified by month and by day or night.

m. Physical Removal

Physical removal is also treated using exponential decay.

n. Evaluation Studies

DiCristofaro, D. C. and S. R. Hanna, 1989. OCD: The Offshore and Coastal Dispersion Model. Volume I: User's Guide. Sigma Research Corporation, Westford, MA.

Hanna, S. R. and D. C. DiCristofaro, 1988. Development and Evaluation of the OCD/API Model. Final Report, API Pub. 4461, American Petroleum Institute, Washington, D.C.

Hanna, S. R., L. L. Schulman, R. J. Paine and J. E. Pleim, 1984. The Offshore and Coastal Dispersion (OCD) Model User's Guide, Revised. OCS Study, MMS 84-0069. Environmental Research & Technology, Inc., Concord, MA. (NTIS No. PB 86-159803)

Hanna, S. R., L. L. Schulman, R. J. Paine, J. E. Pleim and M. Baer, 1985. Development and Evaluation of the Offshore and Coastal Dispersion (OCD) Model. *Journal of the Air Pollution Control Association*, 35: 1039-1047.

A.10 EMISSIONS AND DISPERSION MODELING SYSTEM (EDMS)

Reference:

Segal, H. M., 1991. "EDMS - Microcomputer Pollution Model for Civilian Airports and Air Force Bases: User's Guide." FAA Report No. FAA-EE-91-3; USAF Report No. ESL-TR-91-31, Federal Aviation Administration, 800 Independence Avenue, S.W., Washington, D.C. 20591. (NTIS No. ADA 240528)

Segal, H. M., and Hamilton, P. L., 1988. "A Microcomputer Pollution Model for Civilian Airports and Air Force Bases - Model Description." FAA Report No. FAA-EE-88-4; USAF Report No.ESL-TR-88-53, Federal Aviation Administration, 800 Independence Avenue, S.W., Washington, D.C. 20591. (NTIS No. ADA 199003)

Segal, H. M., 1988. "A Microcomputer Pollution Model for Civilian Airports and Air Force Bases - Model Application and Background." FAA Report No. FAA-EE-88-5; USAF Report No. ESL-TR-88-55, Federal Aviation Administration, 800 Independence Avenue, S.W., Washington, D.C. 20591. (NTIS No. ADA 199794)

Availability: EDMS is available for $40 from the address listed below:

Federal Aviation Administration
Attn: Mr. Howard Segal, AEE-120
800 Independence Avenue, S.W.
Washington, D.C. 20591
Phone: (202) 267-3494

Abstract:

EDMS is a combined emissions/dispersion model for assessing pollution at civilian airports and military air bases. This model, which was jointly developed by the Federal Aviation Administration (FAA) and the United States Air Force (USAF), produces an emission inventory of all airport sources and calculates concentrations produced by these sources at specified receptors. The system stores emission factors for fixed sources such as fuel storage tanks and incinerators and also for mobile sources such as automobiles or aircraft. EDMS incorporates an emissions model to calculate an emission inventory for each airport source and a dispersion model, the Graphical Input Microcomputer Model (GIMM), (Segal, 1983) to calculate pollutant concentrations produced by these sources at specified receptors. The GIMM, which processes point, area, and line sources, also incorporates a special meteorological preprocessor for processing up to one year of National Climatic Data Center (NCDC) hourly data. The model operates in both a screening and refined mode, accepting up to 170 sources and 10 receptors.

a. Recommendations for Regulatory Use

EDMS is appropriate for the following applications:

- cumulative effect of changes in aircraft operations, point source and mobile source emissions at airports or air bases;

- simple terrain;

- transport distances less than 50 kilometers; and

- 1-hour to annual averaging times.

b. Input Requirements

All data are entered through a "runtime" version of the Condor data base which is an integral part of EDMS. Typical entry items are source and receptor coordinates, percent cold starts, vehicles per hour, etc. Some point sources, such as heating plants, require stack height, stack diameter, and effluent temperature inputs.

Wind speed, wind direction, hourly temperature, and Pasquill-Gifford stability category (P-G) are the meteorological inputs. They can be entered manually through the EDMS data entry screens or automatically through the processing of previously loaded NCDC hourly data.

c. Output

Printed outputs consist of:

- a monthly and yearly emission inventory report for each source entered; and

- a concentration summing report for up to 8760 hours (one year) of data.

d. Type of Model

For its emissions inventory calculations, EDMS uses algorithms consistent with the EPA Compilation of Air Pollutant Emission Factors, AP-42. For its dispersion calculations, EDMS uses the GIMM model which is described in reports FAA-EE-88-4 and FAA-EE-88-5, referenced above. GIMM uses a Gaussian plume algorithm.

e. Pollutant Types

EDMS inventories and calculates the dispersion of carbon monoxide, nitrogen oxides, sulphur oxides, hydrocarbons, and suspended particles.

f. Source-Receptor Relationship

Up to 170 sources and 10 receptors can be treated simultaneously. Area sources are treated as a series of lines that are positioned perpendicular to the wind.

Line sources (roadways, runways) are modeled as a series of points. Terrain elevation differences between sources and receptors are neglected.

Receptors are assumed to be at ground level.

g. Plume Behavior

Plume rise is calculated for all point sources (heating plants, incinerators, etc.) using Briggs plume rise equations (Catalano, 1986; Briggs, 1969; Briggs, 1971; Briggs, 1972).

Building and stack tip downwash effects are not treated.

Roadway dispersion employs a modification to the Gaussian plume algorithms as suggested by Rao and Keenan (1980) to account for close-in vehicle-induced turbulence.

h. Horizontal Winds

Steady state winds are assumed for each hour. Winds are assumed to be constant with altitude.

Winds are entered manually by the user or automatically by reading previously loaded NCC annual data files.

i. Vertical Wind Speed

Vertical wind speed is assumed to be zero.

j. Horizontal Dispersion

Four stability classes are used (P-G classes B through E).

Horizontal dispersion coefficients are computed using a table lookup and linear interpolation scheme. Coefficients are based on Pasquill (1976) as adapted by Petersen (1980).

A modified coefficient table is used to account for traffic-enhanced turbulence near roadways. Coefficients are based upon data included in Rao and Keenan (1980).

k. Vertical Dispersion

Four stability classes are used (P-G classes B through E).

Vertical dispersion coefficients are computed using a table lookup and linear interpolation scheme. Coefficients are based on Pasquill (1976) as adapted by Petersen (1980).

A modified coefficient table is used to account for traffic-enhanced turbulence near roadways. Coefficients are based upon data from Rao and Keenan (1980).

l. <u>Chemical Transformation</u>

Chemical transformations are not accounted for.

m. <u>Physical Removal</u>

Deposition is not treated.

n. <u>Evaluation Studies</u>

Segal, H. M. and P. L. Hamilton, 1988. A Microcomputer Pollution Model for Civilian Airports and Air Force Bases - Model Description. FAA Report No. FAA-EE-88-4; USAF Report No. ESL-TR-88-53, Federal Aviation Administration, 800 Independence Avenue, S.W., Washington, D.C. 20591.

Segal, H. M., 1988. A Microcomputer Pollution Model for Civilian Airports and Air Force Bases - Model Application and Background. FAA Report No. FAA-EE-88-5; USAF Report No. ESL-TR-88-55, Federal Aviation Administration, 800 Independence Avenue, S.W., Washington, D.C. 20591.

A.11 Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations (CTDMPLUS)

Reference: Perry, S. G., D. J. Burns, L. H. Adams, R. J. Paine, M. G. Dennis, M. T. Mills, D. G. Strimaitis, R. J. Yamartino and E. M. Insley, 1989. User's Guide to the Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations (CTDMPLUS). Volume 1: Model Descriptions and User Instructions. EPA Publication No. EPA-600/8-89-041. Environmental Protection Agency, Research Triangle Park, NC. (NTIS No. PB 89-181424)

Paine, R. J., D. G. Strimaitis, M. G. Dennis, R. J. Yamartino, M. T. Mills and E. M. Insley, 1987. User's Guide to the Complex Terrain Dispersion Model, Volume 1. EPA Publication No. EPA-600/8-87-058a. U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS No. PB 88-162169)

Availability: This model code is available on the Support Center for Regulatory Air Models Bulletin Board System and also from the National Technical Information Service (See page A-1).

Abstract: CTDMPLUS is a refined point source Gaussian air quality model for use in all stability conditions for complex terrain applications. It contains, in its entirety, the technology of CTDM for stable and neutral conditions. However, CTDMPLUS can also simulate daytime, unstable conditions, and has a number of additional capabilities for improved user friendliness. Its use of meteorological data and terrain information is different from other EPA models; considerable detail for both types of input data is required and is supplied by preprocessors specifically designed for CTDMPLUS. CTDMPLUS requires the parameterization of individual hill shapes using the terrain preprocessor and the association of each model receptor with a particular hill.

a. Recommendation for Regulatory Use

CTDMPLUS is appropriate for the following applications:

- elevated point sources;
- terrain elevations above stack top;
- rural or urban areas;
- transport distances less than 50 kilometers; and
- one hour to annual averaging times when used with a post-processor program such as CHAVG.

b. Input Requirements

Source data: For each source, user supplies source location, height, stack diameter, stack exit velocity, stack exit temperature, and emission rate; if variable emissions are appropriate, the user supplies hourly values for emission rate, stack exit velocity, and stack exit temperature.

Meteorological data: the user must supply hourly averaged values of wind, temperature and turbulence data for creation of the basic meteorological data file ("PROFILE"). Meteorological preprocessors then create a SURFACE data file (hourly values of mixed layer heights, surface friction velocity, Monin-Obukhov length and surface roughness length) and a RAWINsonde data file (upper air measurements of pressure, temperature, wind direction, and wind speed).

Receptor data: receptor names (up to 400) and coordinates, and hill number (each receptor must have a hill number assigned).

Terrain data: user inputs digitized contour information to the terrain preprocessor which creates the TERRAIN data file (for up to 25 hills).

c. Output

When CTDMPLUS is run, it produces a concentration file, in either binary or text format (user's choice), and a list file containing a verification of model inputs, i.e.,

- input meteorological data from "SURFACE" and "PROFILE"
- stack data for each source
- terrain information
- receptor information
- source-receptor location (line printer map).

In addition, if the case-study option is selected, the listing includes:

- meteorological variables at plume height
- geometrical relationships between the source and the hill
- plume characteristics at each receptor, i.e.,
  - -> distance in along-flow and cross flow direction
  - -> effective plume-receptor height difference
  - -> effective σ_y & σ_z values, both flat terrain and hill induced (the difference shows the effect of the hill)
  - -> concentration components due to WRAP, LIFT and FLAT.

If the user selects the TOPN option, a summary table of the top 4 concentrations at each receptor is given. If the ISOR option is selected, a source contribution table for every hour will be printed.

A separate disk file of predicted (1-hour only) concentrations ("CONC") is written if the user chooses this option. Three forms of output are possible:

1) a binary file of concentrations, one value for each receptor in the hourly sequence as run;

2) a text file of concentrations, one value for each receptor in the hourly sequence as run; or

3) a text file as described above, but with a listing of receptor information (names, positions, hill number) at the beginning of the file.

   Hourly information provided to these files besides the concentrations themselves includes the year, month, day, and hour information as well as the receptor number with the highest concentration.

d. Type of Model

CTDMPLUS is a refined steady-state, point source plume model for use in all stability conditions for complex terrain applications.

e. Pollutant Types

CTDMPLUS may be used to model non-reactive, primary pollutants.

f. Source-Receptor Relationship

Up to 40 point sources, 400 receptors and 25 hills may be used. Receptors and sources are allowed at any location. Hill slopes are assumed not to exceed 15^0, so that the linearized equation of motion for Bouissinesq flow are applicable. Receptors upwind of the impingement point, or those associated with any of the hills in the modeling domain, require separate treatment.

g. Plume Behavior

As in CTDM, the basic plume rise algorithms are based on Briggs' (1975) recommendations.

A central feature of CTDMPLUS for neutral/stable conditions is its use of a critical dividing-streamline height (H_c) to separate the flow in the vicinity of a hill into two separate layers. The plume component in the upper layer has sufficient kinetic energy to pass over the top of the hill while streamlines in the lower portion are constrained to flow in a horizontal plane around the hill. Two separate components of CTDMPLUS compute ground-level concentrations resulting from plume material in each of these flows.

The model calculates on an hourly (or appropriate steady averaging period) basis how the plume trajectory (and, in stable/neutral conditions, the shape) is deformed by each hill. Hourly profiles of wind and temperature measurements are used by CTDMPLUS to compute plume rise, plume penetration (a formulation is included to handle penetration into elevated stable layers, based on Briggs (1984)), convective scaling parameters, the value of H_c, and the Froude number above H_c.

h. Horizontal Winds

CTDMPLUS does not simulate calm meteorological conditions. Both scalar and vector wind speed observations can be read by the model. If vector wind speed is unavailable, it is calculated from the scalar wind speed. The assignment of wind speed (either vector or scalar) at plume height is done by either:

- interpolating between observations above and below the plume height, or

- extrapolating (within the surface layer) from the nearest measurement height to the plume height.

i. Vertical Wind Speed

Vertical flow is treated for the plume component above the critical dividing streamline height (H_c); see "Plume Behavior".

j. Horizontal Dispersion

Horizontal dispersion for stable/neutral conditions is related to the turbulence velocity scale for lateral fluctuations, σ_v, for which a minimum value of 0.2 m/s is used. Convective scaling formulations are used to estimate horizontal dispersion for unstable conditions.

k. Vertical Dispersion

Direct estimates of vertical dispersion for stable/neutral conditions are based on observed vertical turbulence intensity, e.g., σ_w (standard deviation of the vertical velocity fluctuation). In simulating unstable (convective) conditions, CTDMPLUS relies on a skewed, bi-Gaussian probability density function (PDF) description of the vertical velocities to estimate the vertical distribution of pollutant concentration.

l. Chemical Transformation

Chemical transformation is not treated by CTDMPLUS.

m. Physical Removal

Physical removal is not treated by CTDMPLUS (complete reflection at the ground/hill surface is assumed).

n. Evaluation Studies

Burns, D. J., L. H. Adams and S. G. Perry, 1990. Testing and Evaluation of the CTDMPLUS Dispersion Model: Daytime Convective Conditions. Environmental Protection Agency, Research Triangle Park, NC.

Paumier, J. O., S. G. Perry and D. J. Burns, 1990. An Analysis of CTDMPLUS Model Predictions with the Lovett Power Plant Data Base. Environmental Protection Agency, Research Triangle Park, NC.

Paumier, J. O., S. G. Perry and D. J. Burns, 1992. CTDMPLUS: A Dispersion Model for Sources near Complex Topography. Part II: Performance Characteristics. *Journal of Applied Meteorology*, 31(7): 646-660.

Catalano, J. A., 1986. Addendum to the User's Manual for the Single Source (CRSTER) Model. EPA Publication No. EPA-600/8-86-041. U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS No. PB 87-145843).

Gery, M. W., G. Z. Whitten and J. P. Killus, 1988. Development and Testing of CBM-IV for Urban and Regional Modeling. EPA Publication No. EPA-600/3-88-012. U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS No. PB 88-180039)

Petersen, W. B., 1980. User's Guide for HIWAY-2 A Highway Air Pollution Model. EPA Publication No. EPA-600/8-80-018. U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS PB 80-227556).

Rao, T. R. and M. T. Keenan, 1980. Suggestions for Improvement of the EPA-HIWAY Model. *Journal of the Air Pollution Control Association*, 30: 247-256 (and reprinted as Appendix C in Petersen, 1980).

Segal, H. M., 1983. Microcomputer Graphics in Atmospheric Dispersion Modeling. *Journal of the Air Pollution Control Association*, 23: 598-600.

APPENDIX B TO APPENDIX W OF PART 51

Table of Contents

B.0 INTRODUCTION AND AVAILABILITY

This appendix summarizes key features of refined air quality models that may be considered on a case-by-case basis for individual regulatory applications. For each model, information is provided on availability, approximate cost in 1990, regulatory use, data input, output format and options, simulation of atmospheric physics and accuracy. The models are listed by name in alphabetical order.

There are three separate conditions under which these models will normally be approved for use: first, if a demonstration can be made that the model produces concentration estimates equivalent to the estimates obtained using a preferred model (e.g., the maximum or high, second-high concentration is within 2% of the estimate using the comparable preferred model); second, if a statistical performance evaluation has been conducted using measured air quality data and the results of that evaluation indicate the model in Appendix B performs better for the application than a comparable model in Appendix A; and third, if there is no preferred model for the specific application but a refined model is needed to satisfy regulatory requirements. Any one of these three separate conditions may warrant use of these models. See Section 3.2, Use of Alternative Models, for additional details.

Many of these models have been subject to a performance evaluation by comparison with observed air quality data. A summary of such comparisons for models contained in this appendix is included in "A Survey of Statistical Measures of Model Performance and Accuracy for Several Air Quality Models", EPA-450/4-83-001. Where possible, several of the models contained herein have been subjected to rigorous evaluation exercises, including (1) statistical performance measures recommended by the American Meteorological Society and (2) peer scientific reviews.

Any availability statement for models in this appendix that refers to the User's Network for Applied Modeling of Air Pollution (UNAMAP) should be ignored since the UNAMAP is no longer operational. However, a source for some of these models and user's documentation is:

Computer Products
National Technical Information Service (NTIS)
U.S. Department of Commerce
Springfield, VA 22161
Phone: (703) 487-4650

A number of the model codes and selected, abridged user's guides are also available from the Support Center for Regulatory Air Models Bulletin Board System[19] (SCRAM BBS), Telephone (919) 541-5742. The SCRAM BBS is an electronic bulletin board system designed to be user friendly and accessible from anywhere in the country. Model users with personal computers are encouraged to use the SCRAM BBS to download current model codes and text files.

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B.6 ERT VISIBILITY MODEL

Reference: ENSR Consulting and Engineering, 1990. ERT Visibility Model: Version 4; Technical Description and User's Guide. Document M2020-003. ENSR Consulting and Engineering, 35 Nagog Park, Acton, MA 01720.

Availability: The user's guide and model code are available from the National Technical Information Service (see page B-1).

Abstract: The ERT Visibility Model is a Gaussian dispersion model designed to estimate visibility impairment for arbitrary lines of sight due to isolated point source emissions by simulating gas-to-particle conversion, dry deposition, NO to NO_2 conversion and linear radiative transfer.

a. Recommendations for Regulatory Use

There is no specific recommendation at the present time. The ERT Visibility Model may be used on a case-by-case basis.

b. Input Requirements

Source data requirements are: stack height, stack temperature, emissions of SO_2, NO_x, TSP, fraction of NO_x as NO_2, fraction of TSP which is carbonaceous, exit velocity, and exit radius.

Meteorological data requirements are: hourly ambient temperature, mixing depth, wind speed at stack height, stability class, potential temperature gradient, and wind direction.

Receptor data requirements are: observer coordinates with respect to source, latitude, longitude, time zone, date, time of day, elevation, relative humidity, background visual range, line-of-sight azimuth and elevation angle, inclination angle of the observed object, distance from observer to object, object and surface reflectivity, number and spacing of integral receptor points along line of sight.

Other data requirements are: ambient concentrations of O_3 and NO_x, deposition velocity of TSP, sulfate, nitrate, SO_2 and NO_x, first-order transformation rate for sulfate and nitrate.

c. Output

Printed output includes both summary and detailed results as follows: Summary output: page 1 - site, observer and object parameters; page 2 - optical pollutants and associated extinction coefficients; page 3 - plume model input parameters; page 4 - total calculated visual range reduction, and each pollutant's contribution; page 5 - calculated plume contrast, object contrast and object contrast degradation at the 550nm wavelength; page 6 - calculated blue/red ratio and ΔE (U*V*W*) values for both sky and object discoloration.

Detailed output: phase functions for each pollutant in four wavelengths (400, 450, 550, 650nm), concentrations for each pollutant along sight path, solar geometry, contrast parameters at all wavelengths, intensities, tristimulus values and chromaticity coordinates for views of the object, sun, background sky and plume.

d. Type of Model

ERT Visibility model is a Gaussian plume model for estimating visibility impairment.

e. Pollutant Types

Optical activity of sulfate, nitrate (derived from SO_2 and NO_x emissions), primary TSP and NO_2 is simulated.

f. Source Receptor Relationship

Single source and hour is simulated. Unlimited number of lines-of-sight (receptors) is permitted per model run.

g. Plume Behavior

Briggs (1971) plume rise equations for final rise are used.

h. Horizontal Wind Field

A single wind speed and direction is specified for each case study. The wind is assumed to be spatially uniform.

i. Vertical Wind Speed

Vertical wind speed is assumed equal to zero.

j. Horizontal Dispersion

Rural dispersion coefficients from Turner (1969) are used.

B.11 MESOSCALE PUFF MODEL (MESOPUFF II)

Reference: Scire, J. S., F. W. Lurmann, A. Bass, S. R. Hanna, 1984. User's Guide to the Mesopuff II Model and Related Processor Programs. EPA Publication No. EPA-600/8-84-013. U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS No. PB 84-181775)

A Modeling Protocol for Applying MESOPUFF II to Long Range Transport Problems, 1992. EPA Publication No. EPA-454/R-92-021. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Availability: This model code is available on the Support Center for Regulatory Air Models Bulletin Board System and also from the National Technical Information Service (see page B-1).

Abstract: MESOPUFF II is a short term, regional scale puff model designed to calculate concentrations of up to 5 pollutant species (SO_2, SO_4, NO_X, HNO_3, NO_3). Transport, puff growth, chemical transformation, and wet and dry deposition are accounted for in the model.

a. Recommendations for Regulatory Use

There is no specific recommendation at the present time. The model may be used on a case-by-case basis.

b. Input Requirements

Required input data include four types: 1) input control parameters and selected technical options, 2) hourly surface meteorological data and twice daily upper air measurements, hourly precipitation data are optional, 3) surface land use classification information, 4) source and emissions data.

Data from up to 25 surface National Weather Service stations and up to 10 upper air stations may be considered. Spatially variable fields at hour intervals of winds, mixing height, stability class, and relevant turbulence parameters are derived by MESOPAC II, the meteorological preprocessor program described in the User Guide.

Source and emission data for up to 25 point sources and/or up to 5 area sources can be included. Required information are: location in grid coordinates, stack height, exit velocity and temperature, and emission rates for the pollutant to me modeled.

Receptor data requirements: up to a 40 X 40 grid may be used and non-gridded receptor locations may be considered.

c. Output

Line printer output includes: all input parameters, optionally selected arrays of ground-level concentrations of pollutant species at specified time intervals.

Line printer contour plots output from MESOFILE II post-processor program. Computer readable output of concentration array to disk/tape for each hour.

d. Type of Model

MESOPUFF II is a Gaussian puff superposition model.

e. Pollutant types modeled

Up to five pollutant species may be modeled simultaneously and include: SO_2, SO_4, NO_x, HNO_3, NO_3.

f. Source-Receptor Relationship

Up to 25 point sources and/or up to 5 area sources are permitted.

g. Plume Behavior

Briggs (1975) plume rise equations are used, including plume penetration with bouyancy flux computed in the model.

Fumigation of puffs is considered and may produce immediate mixing or multiple reflection calculations at user option.

h. Horizontal Winds

Gridded wind fields are computed for 2 layers; boundary layer and above the mixed layer. Upper air rawinsonde data and hourly surface winds are used to obtain spatially variable u,v component fields at hourly intervals. The gridded fields are computed by interpolation between stations in the MESOPAC II preprocessor.

i. Vertical Wind Speed

Vertical winds are assumed to be zero.

j. Horizontal Dispersion

Incremental puff growth is computed over discrete time steps with horizontal growth parameters determined from power law equations fit to sigma y curves of Turner out to 100km. At distances greater than 100km, puff growth is determined by the rate given by Heffter (1965).

Puff growth is a function of stability class and changes in stability are treated. Optionally, user input plume growth coefficients may be considered.

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B.19 PLUME VISIBILITY MODEL (PLUVUE II)

Reference: Environmental Protection Agency, 1992. User's Manual for the Plume Visibility Model, PLUVUE II (Revised). EPA Publication No. EPA-454/B-92-008. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Availability: This model code is available on the Support Center for Regulatory Air Models Bulletin Board System and also from the National Technical Information Service (see page B-1).

Abstract: The Plume Visibility Model (PLUVUE II) is a computerized model used for estimating visual range reduction and atmospheric discoloration caused by plumes resulting from the emissions of particles, nitrogen oxides and sulfur oxides from a single emission source. PLUVUE II predicts the transport, dispersion, chemical reactions, optical effects and surface deposition of point or area source emissions. Addenda to the User's Manual were prepared in February 1985 to allow execution of PLUVUE II and the test cases on the UNIVAC computer.

a. Recommendations for Regulatory Use

The Plume Visibility Model (PLUVUE II) may be used on a case-by-case basis. When applying PLUVUE II to assess the visual impact of a plume, the following precautions should be taken to avoid the possibility of error:

1. Treat the optical effects of NO_2 and particles separately as well as together to avoid cancellation of NO_2 absorption with particle scattering.

2. Examine the visual impact of the plume in 0.1 (or 0), 0.5, and 1.0 times the expected level of particulate matter in the background air.

3. Examine the visual impact of the plume over the full range of observer - plume - sun angles.

b. Input Requirements

Source data requirements are: location and elevation; emission rates of SO_2, NO_x, and particulates; flue gas flow rate, exit velocity, and exit temperature; flue gas oxygen content; properties (including density, mass median and standard geometric deviation of radius) of the emitted aerosols in the accumulation (0.1-1.0μm) and coarse (1.0-10.μm) size modes; and deposition velocities for SO_2, NO_x, coarse mode aerosol, and accumulations mode aerosol.

Meteorological data requirements are: stability class, wind direction (for an observer-based run), wind speed, lapse rate, air temperature, relative humidity, and mixing height.

Other data requirements are: ambient background concentrations of NO_x, NO_2, O_3, and SO_2, background visual range or sulfate and nitrate concentrations.

Receptor (observer) data requirements are: location, elevation, terrain which will be observed through the plume (for observer based run with white, gray, and black viewing backgrounds).

c. Output

Printed output includes:

plume concentrations and visual effects at specified downwind distances for calculated or specified lines of sight.

d. Type of Model

PLUVUE is a Gaussian plume model.

e. Pollutant Types

PLUVUE II treats NO, NO_2, SO_2, H_2SO_4, HNO_3, O_3, primary and secondary particles to calculate effects on visibility.

f. Source Receptor Relationship

PLUVUE treats a single point or area source.

Predicted concentrations and visual effects are obtained at user specified downwind distances.

g. Plume Behavior

PLUVUE uses Briggs (1969, 1971, 1972) final plume rise equations.

h. Horizontal Winds

User-specified wind speed (and direction for an observer-based run) are assumed constant for the calculation.

i. Vertical Wind Speed

Vertical wind speed is assumed equal to zero.

j. Horizontal Dispersion

User specified plume widths, or widths computed from either Pasquill-Gifford-Turner curves (Turner, 1969) or TVA curves (Carpenter, et al., 1971) are used in PLUVUE.

B.29 SHORELINE DISPERSION MODEL (SDM)

Reference: PEI Associates, 1988. User's Guide to SDM - A Shoreline Dispersion Model. EPA Publication No. EPA-450/4-88-017. U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS No. PB 89-164305)

Availability: The user's guide is available from the National Technical Information Service. The model code is available on the Support Center for Regulatory Air Models Bulletin Board System (see page B-1).

Abstract: SDM is a hybrid multipoint Gaussian dispersion model that calculates source impact for those hours during the year when fumigation events are expected using a special fumigation algorithm and the MPTER regulatory model for the remaining hours (see Appendix A).

a. Recommendations for Regulatory Use

SDM may be used on a case-by-case basis for the following applications:

- tall stationary point sources located at a shoreline of any large body of water;
- rural or urban areas;
- flat terrain;
- transport distances less than 50 km;
- 1-hour to 1-year averaging times.

b. Input Requirements

Source data: location, emission rate, physical stack height, stack gas exit velocity, stack inside diameter, stack gas temperature and shoreline coordinates.

Meteorological data: hourly values of mean wind speed within the Thermal Internal Boundary Layer (TIBL) and at stack height; mean potential temperature over land and over water; over water lapse rate; and surface sensible heat flux. In addition to these meteorological data, SDM access standard NWS surface and upper air meteorological data through the RAMMET preprocessor.

Receptor data: coordinates for each receptor.

c. Output

Printed output includes the MPTER model output as well as: special shoreline fumigation applicability report for each day and source; high-five tables on the standard output with "F" designation next to the concentration if that averaging period includes a fumigation event.

d. Type of Model

SDM is hybrid Gaussian model.

e. Pollutant Types

SDM may be used to model primary pollutants. Settling and deposition are not treated.

f. Source-Receptor Relationships

SDM applies user-specified locations of stationary point sources and receptors. User input stack height, shoreline orientation and source characteristics for each source. No topographic elevation is input; flat terrain is assumed.

g. Plume Behavior

SDM uses Briggs (1975) plume rise for final rise. SDM does not treat stack tip or building downwash.

h. Horizontal Winds

Constant, uniform (steady-state) wind is assumed for an hour. Straight line plume transport is assumed to all downwind distances. Separate wind speed profile exponents (EPA, 1980) for both rural and urban cases are assumed.

i. Vertical Wind Speed

Vertical wind speed is assumed equal to zero.

j. Horizontal Dispersion

For the fumigation algorithm coefficients based on Misra (1980) and Misra and McMillan (1980) are used for plume transport in stable air above TIBL and based on Lamb (1978) for transport in the unstable air below the TIBL. An effective horizontal dispersion coefficient based on Misra and Onlock (1982) is used. For nonfumigation periods, algorithms contained in the MPTER model are used (see Appendix A).

k. Vertical Dispersion

For the fumigation algorithm, coefficients based on Misra (1980) and Misra and McMillan (1980) are used.

l. Chemical Transformation

Chemical transformation is not included in the fumigation algorithm.

m. Physical Removal

Physical removal is not explicitly treated.

n. Evaluation Studies

Environmental Protection Agency, 1987. Analysis and Evaluation of Statistical Coastal Fumigation Models. EPA Publication No. EPA-450/4-87-002. U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS PB 87-175519)

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B.30 WYNDvalley Model

Reference: Harrison, Halstead, 1992. "A User's Guide to WYNDvalley 3.11, an Eulerian-Grid Air-Quality Dispersion Model with Versatile Boundaries, Sources, and Winds," WYNDsoft Inc., Mercer Island, WA.

Availability: Copies of the user's guide and the executable model computer codes are available at a cost of $295.00 from:

WYNDsoft, Incorporated
6333 77th Avenue SE
Mercer Island, WA 98040
Phone: (206) 232-1819

Abstract: WYNDvalley 3.11 is a multi-layer (up to five vertical layers) Eulerian grid dispersion model that permits users flexibility in defining borders around the areas to be modeled, the boundary conditions at these borders, the intensities and locations of emissions sources, and the winds and diffusivities that affect the dispersion of atmospheric pollutants. The model's output includes gridded contour plots of pollutant concentrations for the highest brief episodes (during any single time step), the highest and second-highest 24-hour averages, averaged dry and wet deposition fluxes, and a colored 'movie' showing evolving dispersal of pollutant concentrations, together with temporal plots of the concentrations at specified receptor sites and statistical inference of the probabilities that standards will be exceeded at those sites. WYNDvalley is implemented on IBM® compatible microcomputers, with interactive data input and color graphics display.

a. Recommendations for Regulatory Use

WYNDvalley may be used on a case-by-case basis to estimate concentrations during valley stagnation periods of 24 hours or longer. Recommended inputs are listed below.

Variable	Recommended Value
Horizontal cell dimension	250 to 500 meters
Vertical layers	3 to 5
Layer depth	50 to 100 meters
Background (internal to model)	zero (background should be added externally to model estimates)
Lateral meander velocity	default
Diffusivities	default
Ventilation parameter (upper boundary condition)	default
Dry deposition velocity	zero (site-specific)
Washout ratio	zero (site-specific)

b. Input Requirements

Input data, including model options, modeling domain boundaries, boundary conditions, receptor locations, source locations, and emission rates, may be entered interactively, or through existing template files from a previous run. Meteorological data, including wind speeds, wind directions, rain rates (optionally, for wet deposition calculations), and time of day and year, may be of arbitrary time increment (usually an hour) and are entered into the model through an external meteorological data file. Optionally, users may specify diffusivities and upper boundary conditions for each time increment. Source emission rates may be constant or modulated on a daily, weekly, and/or seasonal basis.

c. Output

Output from WYNDvalley includes gridded contour maps of the highest pollutant concentrations at each time step and the highest and second-highest 24-hour average concentrations. Output also includes the deposition patterns for wet, dry, and total fluxes of the pollutants to the surface, integrated over the simulation period. A running "movie" of the concentration patterns is displayed on the screen (with optional printout) as they evolve during the simulation. Output files include tables of daily-averaged pollutant concentrations at every modeled grid cell, and of hourly concentrations at up to eight specified receptors. Statistical analyses are performed on the hourly and daily data to estimate the probabilities that specified levels will be exceeded more than once during an arbitrary number of days with similar weather.

d. Type of Model

WYNDvalley is a three dimensional Eulerian grid model.

e. Pollutant Types

WYNDvalley may be used to model any inert pollutant.

f. Source-Receptor Relationships

Source and receptors may be located anywhere within the user-defined modeling domain. All point and area sources, or portions of an area source, within a given grid cell are summed to define a representative emission rate for that cell. Concentrations are calculated for each and every grid cell in the modeling domain. Up to eight grid cells may be selected as receptors, for which time histories of concentration and deposition fluxes are determined, and probabilities of exceedance are calculated.

g. Plume Behavior

Emissions for buoyant point sources are placed by the user in a grid cell which best reflects the expected effective plume height during stagnation conditions. Five vertical layers are available to the user.

h. Horizontal Winds

During each time step in the model, the winds are assumed to be uniform throughout the modeling domain. Numerical diffusion is minimized in the advection algorithm. To account for terrain effects on winds and dispersion, an ad hoc algorithm is employed in the model to distribute concentrations near boundaries.

i. Vertical Wind Speed

Winds are assumed to be constant with height.

j. Horizontal Dispersion

Horizontal eddy diffusion coefficients may be entered explicitly by the user at every time step. Alternatively, a default algorithm may be invoked to estimate these coefficients from the wind velocities and their variances.

k. Vertical Dispersion

Vertical eddy diffusion coefficients and a top-of-model boundary condition may be entered explicitly by the user at every time step. Alternatively, a default algorithm may be invoked to estimate these coefficients from the horizontal wind velocities and their variances, and from an empirical time-of-day correction derived from temperature gradient measurements and Monin-Obukhov similarities.

l. Chemical Transformation

Chemical transformation is not explicitly treated by WYNDvalley.

m. Physical Removal

WYNDvalley optionally simulates both wet and dry deposition. Dry deposition is proportional to concentration in the lowest layer, while wet deposition is proportional to rain rate and concentration in each layer. Appropriate coefficients (deposition velocities and washout ratios) are input by the user.

n. Evaluation Studies

Harrison, H., G. Pade, C. Bowman and R. Wilson, 1990. Air Quality During Stagnations: A Comparison of RAM and WYNDvalley with PM-10 Measurements at Five Sites. *Journal of the Air & Waste Management Association*, 40: 47-52.

Yoshida, C., 1990. A Comparison of WYNDvalley Versions 2.12 and 3.0 with PM-10 Measurements in Six Cities in the Pacific Northwest, Lane Regional Air Pollution Authority, Springfield, OR.

Maykut, N. et al., 1990. Evaluation of the Atmospheric Deposition of Toxic Contaminants to Puget Sound, State of Washington, Puget Sound Water Quality Authority, Seattle, WA.

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B.31 DENSE GAS DISPERSION MODEL (DEGADIS)

Reference: Environmental Protection Agency, 1989. User's Guide for the DEGADIS 2.1 - Dense Gas Dispersion Model. EPA Publication No. EPA-450/4-89-019. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711. (NTIS No. PB 90-213893)

Availability: The model code is only available on the Support Center for Regulatory Air Models Bulletin Board System (see page B-1).

Abstract: DEGADIS 2.1 is a mathematical dispersion model that can be used to model the transport of toxic chemical releases into the atmosphere. Its range of applicability includes continuous, instantaneous, finite duration, and time-variant releases; negatively-buoyant and neutrally-buoyant releases; ground-level, low-momentum area releases; ground-level or elevated upwardly-directed stack releases of gases or aerosols. The model simulates only one set of meteorological conditions, and therefore should not be considered applicable over time periods much longer than 1 or 2 hours. The simulations are carried out over flat, level, unobstructed terrain for which the characteristic surface roughness is not a significant fraction of the depth of the dispersion layer. The model does not characterize the density of aerosol-type releases; rather, the user must assess that independently prior to the simulation.

a. Recommendations for Regulatory Use

DEGADIS can be used as a refined modeling approach to estimate short-term ambient concentrations (1-hour or less averaging times) and the expected area of exposure to concentrations above specified threshold values for toxic chemical releases. It is especially useful in situations where density effects are suspected to be important and where screening estimates of ambient concentrations are above levels of concern.

b. Input Requirements

Data may be input directly from an external input file or via keyboard using an interactive program module. The model is not set up to accept real-time meteorological data or convert units of input values. Chemical property data must be input by the user. Such data for a few selected species are available within the model. Additional data may be added to this data base by the user.

Source data requirements are: emission rate and release duration; emission chemical and physical properties (molecular weight, density vs. concentration profile in the case of aerosol releases, and contaminant heat capacity in the case of a nonisothermal gas release; stack parameters (i.e., diameter, elevation above ground level, temperature at release point).

Meteorological data requirements are: wind speed at designated height above ground, ambient temperature and pressure, surface roughness, relative humidity, and ground surface temperature (which in most cases can be adequately approximated by the ambient temperature).

Receptor data requirements are: averaging time of interest, above-ground height of receptors, and maximum distance between receptors (since the model computes downwind receptor distances to optimize model performance, this parameter is used only for nominal control of the output listing, and is of secondary importance). No indoor concentrations are calculated by the model.

c. Output

Printed output includes in tabular form:

- listing of model input data;
- plume centerline elevation, mole fraction, concentration, density, and temperature at each downwind distance;
- σ_y and σ_z values at each downwind distance;
- off-centerline distances to 2 specified concentration values at a specified receptor height at each downwind distance (these values can be used to draw concentration isopleths after model execution);
- concentration vs. time histories for finite-duration releases (if specified by user).

The output print file is automatically saved and must be sent to the appropriate printer by the user after program execution.

No graphical output is generated by the current version of this program.

d. Type of Model

DEGADIS estimates plume rise and dispersion for vertically-upward jet releases using mass and momentum balances with air entrainment based on laboratory and field-scale data. These balances assume Gaussian similarity profiles for velocity, density, and concentration within the jet. Ground-level denser-than-air phenomena is treated using a power law concentration distribution profile in the vertical and a hybrid top hat-Gaussian concentration distribution profile in the horizontal. A power law specification is used for the vertical wind profile. Ground-level cloud slumping phenomena and air entrainment are based on laboratory measurements and field-scale observations.

e. Pollutant Types

Neutrally- or negatively-buoyant gases and aerosols. Pollutants are assumed to be non-reactive and non-depositing.

f. Source-Receptor Relationships

Only one source can be modeled at a time.

There is no limitation to the number of receptors; the downwind receptor distances are internally-calculated by the model. The DEGADIS calculation is carried out until the plume centerline concentration is 50% below the lowest concentration level specified by the user.

The model contains no modules for source calculations or release characterization.

g. Plume Behavior

Jet/plume trajectory is estimated from mass and momentum balance equations. Surrounding terrain is assumed to be flat, and stack tip downwash, building wake effects, and fumigation are not treated.

h. Horizontal Winds

Constant logarithmic velocity profile which accounts for stability and surface roughness is used.

The wind speed profile exponent is determined from a least squares fit of the logarithmic profile from ground level to the wind speed reference height. Calm winds can be simulated for ground-level low-momentum releases.

Along-wind dispersion of transient releases is treated using the methods of Colenbrander (1980) and Beals (1971).

i. Vertical Wind Speed

Not treated.

j. Horizontal Dispersion

When the plume centerline is above ground level, horizontal dispersion coefficients are based upon Turner (1969) and Slade (1968) with adjustments made for averaging time and plume density.

When the plume centerline is at ground level, horizontal dispersion also accounts for entrainment due to gravity currents as parameterized from laboratory experiments.

k. Vertical Dispersion

When the plume centerline is above ground level, vertical dispersion coefficients are based upon Turner (1969) and Slade (1968). Perfect ground reflection is applied.

In the ground-level dense-gas regime, vertical dispersion is also based upon results from laboratory experiments in density-stratified fluids.

l. Chemical Transformation

Not specifically treated.

m. Physical Removal

Not treated.

n. Evaluation Studies

Spicer, T. O. and J. A. Havens, 1986. Development of Vapor Dispersion Models for Nonneutrally Buoyant Gas Mixtures - Analysis of USAF/N_2O_4 Test Data. USAF Engineering and Services Laboratory, Final Report ESL-TR-86-24.

Spicer, T. O. and J. A. Havens, 1988. Development of Vapor Dispersion Models for Nonneutrally Buoyant Gas Mixtures - Analysis of TFI/NH_3 Test Data. USAF Engineering and Services Laboratory, Final Report.

o. Operating Information

The model requires either a VAX computer or an IBM® - compatible PC for its execution.

The model currently does not require supporting software. A FORTRAN compiler is required to generate program executables in the VAX computing environment. PC executables are provided within the source code; however, a PC FORTRAN compiler may be used to tailor a PC executable to the user's PC environment.

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EXAMPLE AIR QUALITY ANALYSIS CHECKLIST[1]

1. Source location map(s) showing location with respect to:

   - Urban areas[2]
   - PSD Class I areas
   - Nonattainment areas[2]
   - Topographic features (terrain, lakes, river valleys, etc.)[2]
   - Other major existing sources[2]
   - Other major sources subject to PSD requirements
   - NWS meteorological observations (surface and upper air)
   - On-site/local meteorological observations (surface and upper air)
   - State/local/on-site air quality monitoring locations[2]
   - Plant layout on a topographic map covering a 1km radius of the source with information sufficient to determine GEP stack heights

2. Information on urban/rural characteristics:

   - Land use within 3km of source classified according to Auer (1978): Correlation of land use and cover with meteorological anomalies. *Journal of Applied Meteorology*, 17: 636-643.
   - Population
     - -> total
     - -> density
   - Based on current guidance determination of whether the area should be addressed using urban or rural modeling methodology

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[1]The "Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised", October 1992 (EPA-450/R-92-019), should be used as a screening tool to determine whether modeling analyses are required. Screening procedures should be refined by the user to be site/problem specific.

[2]Within 50km or distance to which source has a significant impact, whichever is less.

3. Emission inventory and operating/design parameters for major sources within region of significant impact of proposed site (same as required for applicant)

- Actual and allowable annual emission rates (g/s) and operating rates[3]
- Maximum design load short-term emission rate (g/s)[3]
- Associated emissions/stack characteristics as a function of load for maximum, average, and nominal operating conditions if stack height is less than GEP or located in complex terrain. Screening analyses as footnoted on page 1 or detailed analyses, if necessary, must be employed to determine the constraining load condition (e.g., 50%, 75%, or 100% load) to be relied upon in the short-term modeling analysis.

  - location (UTM's)
  - height of stack (m) and grade level above MSL
  - stack exit diameter (m)
  - exit velocity (m/s)
  - exit temperature (°K)

- Area source emissions (rates, size of area, height of area source)[3]
- Location and dimensions of buildings (plant layout drawing)

  - to determine GEP stack height
  - to determine potential building downwash considerations for stack heights less than GEP

- Associated parameters

  - boiler size (megawatts, pounds/hr. steam, fuel consumption, etc.)
  - boiler parameters (% excess air, boiler type, type of firing, etc.)
  - operating conditions (pollutant content in fuel, hours of operation, capacity factor, % load for winter, summer, etc.)
  - pollutant control equipment parameters (design efficiency, operation record, e.g., can it be bypassed?, etc.)

- Anticipated growth changes

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[3]Particulate emissions should be specified as a function of particulate diameter and density ranges.

4. Air quality monitoring data:

- Summary of existing observations for latest five years (including any additional quality assured measured data which can be obtained from any state or local agency or company)[4]

- Comparison with standards

- Discussion of background due to uninventoried sources and contributions from outside the inventoried area and description of the method used for determination of background (should be consistent with the Guideline on Air Quality Models)

5. Meteorological data:

- Five consecutive years of the most recent representative sequential hourly National Weather Service (NWS) data, or one or more years of hourly sequential on-site data

- Discussion of meteorological conditions observed (as applied or modified for the site-specific area, i.e., identify possible variations due to difference between the monitoring site and the specific site of the source)

- Discussion of topographic/land use influences

6. Air quality modeling analyses:

- Model each individual year for which data are available with a recommended model or model demonstrated to be acceptable on a case-by-case basis

    - urban dispersion coefficients for urban areas
    - rural dispersion coefficients for rural areas

- Evaluate downwash if stack height is less than GEP

- Define worst case meteorology

- Determine background and document method

    - long-term
    - short-term

[4]See footnote 2 of this checklist.

- Provide topographic map(s) of receptor network with respect to location of all sources

- Follow current guidance on selection of receptor sites for refined analyses

- Include receptor terrain heights (if applicable) used in analyses

- Compare model estimates with measurements considering the upper ends of the frequency distribution

- Determine extent of significant impact; provide maps

- Define areas of maximum and highest, second-highest impacts due to applicant source (refer to format suggested in Air Quality Summary Tables)

  -> long-term
  -> short-term

7. Comparison with acceptable air quality levels:

   - NAAQS

   - PSD increments

   - Emission offset impacts if nonattainment

8. Documentation and guidelines for modeling methodology:

   - Follow guidance documents

     -> "Guideline on Air Quality Models, Revised" (EPA-450/2-78-027R)

     -> "Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised" (EPA-450/R-92-019), 1992

     -> "Guideline for Determination of Good Engineering Practice Stack Height (Technical Support Document for the Stack Height Regulations)" (EPA-450/4-80-023R), 1985

     -> "Ambient Monitoring Guidelines for PSD" (EPA-450/4-87-007), 1987

     -> "Requirements for Preparation, Adoption and Submittal of Implementation Plans: Approval and Promulgation of Implementation Plans", 40 CFR Parts 40 and 51 (Prevention of Significant Deterioration), 1982

AIR QUALITY SUMMARY

For New Source Alone

Pollutant: ______________[1] ______________[2] ______________[2]

	Highest	Highest 2nd High	Highest	Highest 2nd High	Annual
Concentration Due to Modeled Source ($\mu g/m^3$)					
Background Concentration ($\mu g/m^3$)					
Total Concentration ($\mu g/m^3$)					
Receptor Distance (km) (or UTM Easting)					
Receptor Direction (°) (or UTM Northing)					
Receptor Elevation (m)					
Wind Speed (m/s)					
Wind Direction (°)					
Mixing Depth (m)					
Temperature (°K)					
Stability					
Day/Month/Year of Occurrence					

Surface Air Data From __________ Surface Station Elevation (m) __________

Anemometer Height Above Local Ground Level (m) __________

Upper Air Data From ______________________________

Period of Record Analyzed ______________________________

Model Used ______________________________

Recommended Model ______________________________

[1]Use separate sheet for each pollutant (SO_2, TSP, CO, NO_x, HC, Pb, Hg, Asbestos, etc.)

[2]List all appropriate averaging periods (1-hr, 3-hr, 8-hr, 24-hr, 30-day, 90-day, etc.) for which an air quality standard exists

AIR QUALITY SUMMARY

For All New Sources

Pollutant: ______________[1] ______________[2] ______________[2]

	Highest	Highest 2nd High	Highest	Highest 2nd High	Annual
Concentration Due to Modeled Source ($\mu g/m^3$)					
Background Concentration ($\mu g/m^3$)					
Total Concentration ($\mu g/m^3$)					
Receptor Distance (km) (or UTM Easting)					
Receptor Direction (°) (or UTM Northing)					
Receptor Elevation (m)					
Wind Speed (m/s)					
Wind Direction (°)					
Mixing Depth (m)					
Temperature (°K)					
Stability					
Day/Month/Year of Occurrence					

Surface Air Data From __________ Surface Station Elevation (m) __________

Anemometer Height Above Local Ground Level (m) __________

Upper Air Data From ______________________

Period of Record Analyzed ______________________

Model Used ______________________

Recommended Model ______________________

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[1]Use separate sheet for each pollutant (SO_2, TSP, CO, NO_x, HC, Pb, Hg, Asbestos, etc.)

[2]List all appropriate averaging periods (1-hr, 3-hr, 8-hr, 24-hr, 30-day, 90-day, etc.) for which an air quality standard exists

AIR QUALITY SUMMARY

For All Sources

Pollutant: ______________[1] ______________[2] ______________[2]

	Highest	Highest 2nd High	Highest	Highest 2nd High	Annual
Concentration Due to Modeled Source ($\mu g/m^3$)					
Background Concentration ($\mu g/m^3$)					
Total Concentration ($\mu g/m^3$)					
Receptor Distance (km) (or UTM Easting)					
Receptor Direction (°) (or UTM Northing)					
Receptor Elevation (m)					
Wind Speed (m/s)					
Wind Direction (°)					
Mixing Depth (m)					
Temperature (°K)					
Stability					
Day/Month/Year of Occurrence					

Surface Air Data From ___________ Surface Station Elevation (m) ___________

Anemometer Height Above Local Ground Level (m) ___________

Upper Air Data From ______________________________

Period of Record Analyzed ________________________

Model Used ______________________________

Recommended Model ______________________________

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[1]Use separate sheet for each pollutant (SO_2, TSP, CO, NO_x, HC, Pb, Hg, Asbestos, etc.)

[2]List all appropriate averaging periods (1-hr, 3-hr, 8-hr, 24-hr, 30-day, 90-day, etc.) for which an air quality standard exists.

STACK PARAMETERS FOR ANNUAL MODELING

Stack No.	Serving	Emission Rate for each Pollutant (g/s)	Stack Exit Diameter (m)	Stack Exit Velocity (m/s)	Stack Exit Temperature (°K)	Physical Stack Height (m)	GEP Stack Ht. (m)	Stack Base Elevation (m)	Building Dimensions (m)		
									Height	Width	Length

STACK PARAMETERS FOR SHORT-TERM MODELING[1]

Stack No.	Serving	Emission Rate for each Pollutant (g/s)	Stack Exit Diameter (m)	Stack Exit Velocity (m/s)	Stack Exit Temperature (°K)	Physical Stack Height (m)	GEP Stack Ht. (m)	Stack Base Elevation (m)	Building Dimensions (m)		
									Height	Width	Length

[1]Separate tables for 50%, 75%, 100% of full operating condition (and any other operating conditions as determined by screening or detailed modeling analyses to represent constraining operating conditions) should be provided.

TECHNICAL REPORT DATA

(Please read Instructions on reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA-450/2-78-027R (Supp. B)		

4. TITLE AND SUBTITLE	5. REPORT DATE
Supplement B to the Guideline on Air Quality Models (Revised)	February 1993
	6. PERFORMING ORGANIZATION CODE
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12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The Guideline (published as Appendix W to 40 CFR Part 51) serves as the basis by which air quality models are to be used for demonstrations associated with SIP (State Implementation Plan) revisions, AQMA (Air Quality Maintenance Area) analyses, regional classifications for episode planning, new source review, including that pertaining to PSD (Prevention of Significant Deterioration). It is intended for use by EPA Regional Offices in judging the adequacy of modeling analyses performed by EPA, by State and local agencies, and by industry and its consultants. It also identifies modeling techniques and data bases that EPA considers acceptable. The Guideline makes specific recommendations concerning air quality models, data bases, and general requirements for making concentration estimates.

This is Supplement B to the Guideline. Supplement B: (1) adds several models, including CTDMPLUS (Complex Terrain Dispersion Model PLus Algorithms for Unstable Situations), CTSCREEN, EDMS (Emissions and Dispersion Modeling System) for airports, SDM (Shoreline Dispersion Model), WYNDvalley for valley stagnation, and DEGADIS (DEnse GAs DISpersion Model); (2) updates several other models, i.e., OCD (Offshore and Coastal Dispersion Model), ISC and SCREEN (now ISC2 and SCREEN2, resp.); (3) deletes several models (ERTAQ and MPSDM); and (4) improves several existing techniques and clarifies the appropriate input data for various regulatory compliance demonstrations.

17 KEY WORDS AND DOCUMENT ANALYSIS

a DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c COSATI Field/Group
Air Pollution Atmospheric Dispersion Modeling Atmospheric Diffusion Meteorology	Dispersion Modeling Gaussian Plume Models Clean Air Act	

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