6560-50-P

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 51

[EPA-HQ-OAR-2022-0872; FRL-10391-02-OAR]

RIN 2060-AV92

Guideline on Air Quality Models; Enhancements to the AERMOD Dispersion Modeling System

AGENCY: Environmental Protection Agency (EPA).

ACTION: Final rule.

SUMMARY: In this action, the Environmental Protection Agency (EPA) promulgates revisions to the *Guideline on Air Quality Models* ("*Guideline*"). The *Guideline* has been incorporated into the EPA's regulations, satisfying a requirement under the Clean Air Act (CAA), for the EPA to specify, with reasonable particularity, models to be used in the Prevention of Significant Deterioration (PSD) program. The *Guideline* provides EPA-preferred models and other recommended techniques, as well as guidance for their use in predicting ambient concentrations of air pollutants. The EPA is revising the *Guideline*, including enhancements to the formulation and application of the EPA's near-field dispersion modeling system, AERMOD, and updates to the recommendations for the development of appropriate background concentration for cumulative impact analyses.

DATES: This rule is effective **[INSERT DATE 60 DAYS AFTER DATE OF**

PUBLICATION IN THE FEDERAL REGISTER].

ADDRESSES: The EPA has established a docket for this action under Docket ID No. EPA-HQ-OAR-2022-0872. All documents in the docket are listed on the *https://www.regulations.gov* Web site. Although listed in the index, some information is not publicly available, *e.g.*, Confidential Business Information (CBI) or other information whose disclosure is restricted by statute. Certain other material, such as copyrighted material, is not placed on the Internet and will be publicly available only in hard copy form. Publicly available docket materials are available electronically through *https://www.regulations.gov*.

FOR FURTHER INFORMATION CONTACT: Mr. George M. Bridgers, Office of Air Quality Planning and Standards, Air Quality Assessment Division, Air Quality Modeling Group, U.S. Environmental Protection Agency, Mail code C439-01, Research Triangle Park, NC 27711; telephone: (919) 541-5563; email: *Bridgers.George@epa.gov* (and include "2024 Revisions to the Guideline on Air Quality Models" in the subject line of the message).

SUPPLEMENTARY INFORMATION:

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I. General Information

A. *Does this action apply to me*?

This action applies to Federal, State, territorial, and local air quality management programs that conduct or review air quality modeling as part of State Implementation Plan (SIP) submittals and revisions, New Source Review (NSR), including new or modifying industrial sources under Prevention of Significant Deterioration (PSD), Conformity, and other programs in which air quality assessments are required under EPA regulation. Categories and entities potentially regulated by this action include:

Category	NAICS[a] code
Federal/State/territorial/local/Tribal government	924110

[a]North American Industry Classification System

B. *Where can I get a copy of this document*?

In addition to being available in the docket, an electronic copy of this final rule and relative

supporting documentation will also be available on the EPA's Support Center for Regulatory

Atmospheric Modeling (SCRAM) Web site. Following signature, these materials will be posted

on SCRAM at the following address: *https://www.epa.gov/scram/2024-appendix-w-final-rule*.

C.   Judicial review

Under section 307(b)(1) of the Clean Air Act (CAA), this final rule is "nationally applicable"

because it revises the *Guideline on Air Quality Models*, 40 CFR part 51, Appendix W. Therefore,

petitions for judicial review of this final action must be filed in the U.S. Court of Appeals for the

District of Columbia Circuit by **[INSERT DATE 60 DAYS AFTER DATE OF**

PUBLICATION IN THE FEDERAL REGISTER]. Filing a petition for reconsideration by the

Administrator of this final action does not affect the finality of the action for the purposes of

judicial review, nor does it extend the time within which a petition for judicial review must be

filed, and shall not postpone the effectiveness of such action. 42 U.S.C. § 7607(b)(1). This rule is

also subject to section 307(d) of the CAA because it revises a regulation addressing a

requirement under section 165(e)(3)(D) of the CAA, which is included in part C of title I of the

CAA (relating to prevention of significant deterioration of air quality and protection of

visibility). 42 U.S.C. 7607(d)(1)(J).

D.   *List of acronyms*

AEDT	Aviation Environmental Design Tool
AERMET	Meteorological data preprocessor for AERMOD
AERMINUTE	Pre-processor to AERMET to read 1-minute ASOS data to calculate hourly average winds for input into AERMET
AERMOD	American Meteorological Society (AMS)/EPA Regulatory Model
AERSCREEN	Program to run AERMOD in screening mode
AERSURFACE	Land cover data tool in AERMET
AQRV	Air Quality Related Value
AQS	Air Quality System
ARM2	Ambient Ratio Method 2

ASOS   Automated Surface Observing Stations
ASTM   American Society for Testing and Materials
B_o Bowen ratio
BID   Buoyancy-induced dispersion
BLP   Buoyant Line and Point Source model
BOEM   Bureau of Ocean Energy Management
BPIPPRM   Building Profile Input Program for PRIME
CAA   Clean Air Act
CAL3QHC   Screening version of the CALINE3 model
CAL3QHCR   Refined version of the CALINE3 model
CALINE3   CAlifornia LINE Source Dispersion Model
CALMPRO   Calms Processor
CALPUFF   California Puff model
CAMx   Comprehensive Air Quality Model with Extensions
COARE   Coupled Ocean-Atmosphere Response Experiment
CFR   Code of Federal Regulations
CMAQ   Community Multiscale Air Quality
CO   Carbon monoxide
CTDMPLUS   Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations
CTSCREEN   Screening version of CTDMPLUS
CTM   Chemical transport model
$d\theta/dz$ Vertical potential temperature gradient
DT   Temperature difference
EPA   Environmental Protection Agency
FAA   Federal Aviation Administration
FHWA   Federal Highway Administration
FLAG   Federal Land Managers' Air Quality Related Values Work Group
            Phase I Report
FLM   Federal Land Manager
GEP   Good engineering practice
GRSM   Generic Reaction Set Method
GUI   Graphical user interface
IBL   Inhomogeneous boundary layer
ISC   Industrial Source Complex model
IWAQM   Interagency Workgroup on Air Quality Modeling
km   kilometer
L   Monin-Obukhov length
m   meter
m/s   meter per second
MAKEMET   Program that generates a site-specific matrix of meteorological conditions
            for input to AERMOD
MCH   Model Clearinghouse
MCHISRS   Model Clearinghouse Information Storage and Retrieval System
MERPs   Model Emissions Rates for Precursors
METPRO   Meteorological Processor for dispersion models

MM5	Mesoscale Model 5
MMIF	Mesoscale Model Interface program
MODELOPT	Model option keyword
MPRM	Meteorological Processor for Regulatory Models
NAAQS	National Ambient Air Quality Standards
NCEI	National Centers for Environmental Information
NH_3	Ammonia
NO	Nitric oxide
NO_x	Nitrogen oxides
NO_2	Nitrogen dioxide
NSR	New Source Review
NWS	National Weather Service
OCD	Offshore and Coastal Dispersion Model
OCS	Outer Continental Shelf
OLM	Ozone Limiting Method
PCRAMMET	Meteorological Processor for dispersion models
P-G stability	Pasquill-Gifford stability
$PM_{2.5}$	Particles less than or equal to 2.5 micrometers in diameter
PM_{10}	Particles less than or equal to 10 micrometers in diameter
PRIME	Plume Rise Model Enhancements algorithm
PSD	Prevention of Significant Deterioration
PVMRM	Plume Volume Molar Ratio Method
r	Albedo
RHC	Robust Highest Concentration
RLINE	Research LINE source model for near-surface releases
RLINEXT	Research LINE source model extended
SCICHEM	Second-order Closure Integrated Puff Model
SCRAM	Support Center for Regulatory Atmospheric Modeling
SCREEN3	A single source Gaussian plume model which provides maximum ground-level concentrations for point, area, flare, and volume sources
SDM	Shoreline Dispersion Model
SIP	State Implementation Plan
SO_2	Sulfur dioxide
SRDT	Solar radiation/delta-T method
TSD	Technical support document
u	Values for wind speed
u*	Surface friction velocity
VOC	Volatile organic compound
w*	Convective velocity scale
WRF	Weather Research and Forecasting model
z_i	Mixing height
Z_o	Surface roughness length
Z_{ic}	Convective mixing height
Z_{im}	Mechanical mixing height
σ_v, σ_w	Horizontal and vertical wind speeds

II.   Background

A.   *The Guideline on Air Quality Models and EPA Modeling Conferences*

The *Guideline* is used by the EPA, other Federal, State, territorial, and local air quality agencies, and industry to prepare and review preconstruction permit applications for new sources and modifications, SIP submittals and revisions, determinations that actions by Federal agencies are in conformity with SIPs, and other air quality assessments required under EPA regulation. The *Guideline* serves as a means by which national consistency is maintained in air quality analyses for regulatory activities under CAA regulations, including 40 CFR 51.112, 51.117, 51.150, 51.160, 51.165, 51.166, 52.21, 93.116, 93.123, and 93.150.

The EPA originally published the *Guideline* in April 1978 (EPA-450/2-78-027), and it was incorporated by reference in the regulations for the PSD program in June 1978. The EPA revised the *Guideline* in 1986 (51 FR 32176) and updated it with supplement A in 1987 (53 FR 32081), supplement B in July 1993 (58 FR 38816), and supplement C in August 1995 (60 FR 40465). The EPA published the *Guideline* as Appendix W to 40 CFR part 51 when the EPA issued supplement B. The EPA republished the *Guideline* in August 1996 (61 FR 41838) to adopt the Code of Federal Regulations (CFR) system for designating paragraphs. The publication and incorporation of the *Guideline* by reference into the EPA's PSD regulations satisfies the requirement under the CAA section 165(e)(3)(D) for the EPA to promulgate regulations that specify with reasonable particularity models to be used under specified sets of conditions for purposes of the PSD program.

To support the process of developing and revising the *Guideline* during the period of 1977 to 1988, we held the First, Second, and Third Conferences on Air Quality Modeling as required by CAA section 320 to help standardize modeling procedures. These modeling conferences

provided a forum for comments on the *Guideline* and associated revisions, thereby helping us introduce improved modeling techniques into the regulatory process. Between 1988 and 1995, we conducted the Fourth, Fifth, and Sixth Conferences on Air Quality Modeling to solicit comments from the stakeholder community to guide our consideration of further revisions to the *Guideline*, update the available modeling tools based on the current state-of-the-science, and advise the public on new modeling techniques.

The Seventh Conference was held in June 2000 and also served as a public hearing for the proposed revisions to the recommended air quality models in the *Guideline* (65 FR 21506). These changes included the CALPUFF modeling system, AERMOD Modeling System, and ISC-PRIME model. Subsequently, the EPA revised the *Guideline* on April 15, 2003 (68 FR 18440), to adopt CALPUFF as the preferred model for long-range transport of emissions from 50 to several hundred kilometers and to make various editorial changes to update and reorganize information and remove obsolete models.

We held the Eighth Conference on Air Quality Modeling in September 2005. This conference provided details on changes to the preferred air quality models, including available methods for model performance evaluation and the notice of data availability that the EPA published in September 2003, related to the incorporation of the PRIME downwash algorithm in the AERMOD dispersion model (in response to comments received from the Seventh Conference). Additionally, at the Eighth Conference, a panel of experts discussed the use of state-of-the-science prognostic meteorological data for informing the dispersion models. The EPA further revised the *Guideline* on November 9, 2005 (70 FR 68218), to adopt AERMOD as the preferred model for near-field dispersion of emissions for distances up to 50 kilometers.

The Ninth Conference on Air Quality Modeling was held in October 2008 and emphasized the

following topics: reinstituting the Model Clearinghouse, review of non-guideline applications of dispersion models, regulatory status updates of AERMOD and CALPUFF, continued discussions on the use of prognostic meteorological data for informing dispersion models, and presentations reviewing the available model evaluation methods. To further inform the development of additional revisions to the *Guideline*, we held the Tenth Conference on Air Quality Modeling in March 2012. The conference addressed updates on: the regulatory status and future development of AERMOD and CALPUFF, review of the Mesoscale Model Interface (MMIF) prognostic meteorological data processing tool for dispersion models, draft modeling guidance for compliance demonstrations of the fine particulate matter ($PM_{2.5}$) national ambient air quality standards (NAAQS), modeling for compliance demonstration of the 1-hour nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) NAAQS, and new and emerging models/techniques for future consideration under the *Guideline* to address single-source modeling for ozone and secondary $PM_{2.5}$, as well as long-range transport and chemistry.

The Eleventh Conference on Air Quality Modeling was held in August 2015 and included the public hearing for a 2015 proposed revision of the *Guideline*. The conference included presentations summarizing the proposed updates to the AERMOD Modeling System, replacement of CALINE3 with AERMOD for modeling of mobile sources, incorporation of prognostic meteorological data for use in dispersion modeling, the proposed screening approach for long-range transport for NAAQS and PSD increments assessments with use of CALPUFF as a screening technique rather than an EPA-preferred model, the proposed 2-tiered screening approach to address ozone and $PM_{2.5}$ in PSD compliance demonstrations, the status and role of the Model Clearinghouse, and updates to procedures for single-source and cumulative modeling analyses (*e.g.*, modeling domain, source input data, background data, and compliance

demonstration procedures).

Additionally, the 2015 proposed action included a reorganization of the *Guideline* to make it easier to use and to streamline the compliance assessment process (80 FR 45340), and also included additional clarity in distinguishing requirements from recommendations while noting the continued flexibilities provided within the *Guideline*, including but not limited to use and approval of alternative models (82 FR 45344). These proposed revisions were adopted and reflected in the most recent version of the *Guideline*, promulgated on January 17, 2017 (82 FR 5182).

B. *The Twelfth and Thirteenth Conferences on Air Quality Modeling*

Following the 2017 revision of the *Guideline*, the Twelfth Conference on Air Quality Modeling was held in August 2019 in continuing compliance with CAA section 320. While not associated with a regulatory action, the Twelfth Conference was held with the intent to inform the ongoing development of the EPA's preferred air quality models and potential revisions to the *Guideline*. The conference included expert panel discussions and invited presentations covering the following model/technique enhancements: treatment of low wind conditions, overwater modeling, mobile source modeling, building downwash, prognostic meteorological data, near-field and long-range model evaluation criteria, NO_2 modeling techniques, plume rise, deposition, and single source ozone and $PM_{2.5}$ modeling techniques. At the conclusion of the expert panels and invited presentations, there were several presentations given by the public, including industrial trade groups, on recommended areas for additional model development and future revision in the *Guideline*.

Based on the engagement and presentations from the Twelfth Conference and continuing model formulation research and development activities in the years since 2019, the EPA proposed new

revisions to the *Guideline* on October 12, 2023, including enhancements to the formulation and application of the EPA's near-field dispersion modeling system, AERMOD, updates to the recommendations for the development of appropriate background concentration for cumulative impact analyses, and various typographical updates to the existing regulation (88 FR 72826). The Thirteenth Conference on Air Quality Modeling, held on November 14-15, 2023, provided a formal venue for EPA presentations to the public on the October 2023 proposed revisions to the *Guideline* and AERMOD. The Thirteenth Modeling Conference also served as the public hearing for the October 2023 proposed rule.

Specific to the AERMOD Modeling System, the October 2023 *Guideline* proposed rule included an update to the AERMET meteorological preprocessor for AERMOD that would add the capability to process measured and prognostic marine-based meteorology for offshore applications. Additionally, the proposed rule had separate AERMOD updates that would incorporate a new Tier 3 screening method for the conversion of nitrogen oxides (NO_X) emissions to NO_2 and would add a new source type for modeling vehicle roadway emissions. Finally, the proposed rule suggested minor revisions to the recommendations regarding the determination of appropriate model input data, specifically background concentration, for use in NAAQS implementation modeling demonstrations in section 8.3 of the *Guideline*. In conjunction with the October 2023 *Guideline* proposed rule, the EPA developed the *Draft Guidance on Developing Background Concentrations for Use in Modeling Demonstrations*[1]. This draft guidance document detailed the EPA-recommended framework with stepwise

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[1] U.S. Environmental Protection Agency, 2023. Draft Guidance on Developing Background Concentrations for Use in Modeling Demonstrations. Publication No. EPA-454/P-23-001. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

considerations to assist permit applicants in characterizing a credible and appropriately

representative background concentration for cumulative impact analyses through qualitative and

semi-quantitative considerations within a transparent process using the variety of emissions and

air quality data including the contributions from nearby sources in multi-source areas.

All of the presentations, along with the transcript of the conference and public hearing

proceedings, are available in the docket for the Thirteenth Conference on Air Quality Models

(Docket ID No. EPA–HQ–OAR–2022–0872). Additionally, all the materials associated with the

Thirteenth Conference and the public hearing are available on the EPA's SCRAM Web site at

https://www.epa.gov/scram/13th-conference-air-quality-modeling.

C.   *Alpha and beta categorization of non-regulatory options*

With the release of AERMOD version 18181 in 2018, the EPA adopted a new paradigm for

engagement with the scientific community to facilitate the continued development of the

AERMOD Modeling System. Previously, updates to the scientific formulation of the model were

not made available to the public for review, testing, evaluation, and comment prior to the

proposal stage of the formal rulemaking process when an update was made to the *Guideline*. This

limited the public's engagement and feedback to a short, predefined comment period, typically

only one to two months. The new approach enables the EPA to release potential formulation

updates as non-regulatory "alpha" and "beta" options as they are being developed. As non-

regulatory options, they can be made available during any release cycle, thereby enabling

feedback as they are being developed. This approach allows for more robust testing and

evaluation during development, benefitting from the experience of a broad expert community. A

pathway such as this that facilitates more frequent and active engagement with the external

modeling community allows for a more informed and timely regulatory update process when the

EPA has determined an update has met the criteria required for consideration as a science formulation update to the regulatory version of the model.

In this alpha/beta construct, alpha options are updates to the scientific formulation that are thought to have merit but are considered experimental, still in the research and development stage. Alpha options require further testing, performance evaluation, and/or vetting through peer review and, thus, are not intended for regulatory applications of the model.

Beta options, on the other hand, have been demonstrated to be suitable and applicable to the modeling problem at hand on a theoretical basis, have undergone scientific peer review, and are supported with performance evaluations using available and adequate databases that demonstrate improved model performance and no inappropriate model biases. In general, beta options have met the necessary criteria to be formally proposed and adopted as updates to the regulatory version of the model but have not yet been proposed through the required rulemaking process, which includes a public hearing and formal comment period. Beta options are mature enough in the development process to be considered for use as an alternative model, provided an appropriate site-specific modeling demonstration is completed to show the alternative model is appropriate for the site and conditions where it will be applied and the requirements of the *Guideline*, section 3.2, are fully satisfied, including formal concurrence by the EPA's Model Clearinghouse. With the release of AERMOD version 24142, each of the beta options that existed in version 23132 are being promulgated as regulatory updates to the formulation of AERMOD. All previous alpha options in version 23132 are being retained as alpha options in version 24142. No options are being added as beta options and no alpha options are being updated to beta status.

III.   Discussion of final action on the revisions to the *Guideline*

In this action, the EPA is promulgating revisions to the *Guideline* corresponding to updates to the scientific formulation of the AERMOD Modeling System and updates to the recommendations for the development of appropriate background concentration for cumulative impact analyses. When and where appropriate, the EPA has engaged with our Federal partners, including the Bureau of Ocean Energy Management (BOEM) and the Federal Highway Administration (FHWA), to collaborate on these updates to the *Guideline.* There are additional editorial changes being made to the *Guideline* to correct minor typographical errors found in the 2017 *Guideline* and to update Web site links.

A.   *Final Action*

This section provides a detailed overview of the substantive changes being finalized in the *Guideline* to improve the science of the models and approaches used in regulatory assessments.

1.   Updates to EPA's AERMOD Modeling System

Based on studies presented and discussed at the Twelfth Conference on Air Quality Models held on October 2-3, 2019[2], and additional relevant research since 2017, the EPA and other researchers have conducted additional model evaluations and developed changes to the model formulation of the AERMOD Modeling System to improve model performance in its regulatory applications. One update is to the AERMET meteorological preprocessor for AERMOD. This update provides the capability to process measured and prognostic marine-based meteorology for offshore applications. Separate updates are related to the AERMOD dispersion model and include (1) a new Tier 3 screening method for the conversion of nitrogen oxides (NO_X)

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[2] *https://www.epa.gov/scram/12th-conference-air-quality-modeling.*

emissions to NO_2 and (2) a new source type for modeling vehicle roadway emissions.

Each of these formulation updates to the AERMOD Modeling System was provided as a non-regulatory beta option in the version 23132 release of the relevant AERMOD Modeling System components. With the release of the AERMOD Modeling System version 24142, the EPA has removed the non-regulatory beta restriction and is finalizing the following updates to the AERMOD Modeling System to address several technical concerns expressed by stakeholders.

a.   *Incorporation of COARE algorithms into AERMET for use in overwater marine boundary layer environments*

The EPA received a few specific comments in support of adding the Coupled Ocean-Atmosphere Response Experiment (COARE) into AERMET. Therefore, the EPA is finalizing the integration of the COARE[3, 4] algorithms to AERMET for meteorological data processing in applications using either observed or prognostic meteorological data in overwater marine boundary layer environments.

As discussed in the preamble to the proposed rule, the algorithms in COARE are better suited for overwater boundary layer calculations than the existing algorithms in AERMET that are better suited for land-based data. The addition of the COARE algorithms to AERMET replaces the need of the standalone AERCOARE program used for overwater applications and ensures that the COARE algorithms are updated regularly as part of routine AERMET updates. For

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[3] Fairall, C.W., E.F. Bradley, J.E. Hare, A.A. Grachev, and J.B. Edson, 2003: "Bulk Parameterization of Air-Sea Fluxes: Updates and Verification for the COARE Algorithm." *Journal of Climate*, **16**, 571-591.

[4] Evaluation of the Implementation of the Coupled Ocean-Atmosphere Response Experiment (COARE) algorithms into AERMET for Boundary Layer Environments. EPA-2023/R-23-008, Office of Air Quality Planning and Standards, RTP, NC.

prognostic applications processed through the Mesoscale Model Interface (MMIF), the addition of COARE algorithms to AERMET replaces the need to run MMIF for AERCOARE input, and the user can run MMIF for AERMET input for overwater applications. The COARE option is selected in AERMET by the user with the METHOD COARE RUN-COARE* record in the AERMET Stage 2 input file.

We are including the COARE algorithms into AERMET as a non-default regulatory option. This eliminates the previous alternative model demonstration requirements for use of AERMOD in marine environments, and its use is contingent upon consultation with the EPA Regional Office and appropriate reviewing authority to ensure that platform downwash and shoreline fumigation are adequately considered in the modeling demonstration. Also note that since COARE is a non-default regulatory option, the user no longer must include the BETA option with the MODELOPT keyword in the AERMOD input file to use AERMET data generated using the COARE algorithms.

b. *Addition of a new Tier 3 detailed screening technique for NO_2*

As supported by the discussions in the October 2023 proposed revisions to the *Guideline*, and based on the public comments received, the EPA is finalizing adoption of the Generic Reaction Set Method (GRSM) as a regulatory non-default, detailed Tier 3 NO_2 screening option in AERMOD version 24142.

As discussed in the preamble to the October 2023 proposed revisions to the *Guideline*, the functionality of the GRSM implementation in AERMOD is similar to that of the existing PVMRM and OLM Tier 3 NO_2 schemes, with exception to some additional input requirements necessary (i.e., hourly NO_X inputs) for treatment of the reverse NO_2 photolysis reaction during daytime hours. Background NO_2 concentrations are accounted for in the GRSM daytime

equilibrium NO_2 concentration estimates based on the chemical reaction balance between ozone entrainment and NO titration, photolysis of NO_2 to NO, and ambient background NO_2 participation in titration and photolysis reactions. Similar to PVMRM and OLM, nighttime GRSM NO_2 estimates are based on ozone entrainment and titration of available NO in the NO_X plume.

The EPA received several comments in support of the proposed adoption of GRSM as a Tier 3 NO_2 screening option in AERMOD. Several commenters requested further clarification and guidance from the EPA on the suitability and regulatory modeling application of GRSM, as well as the selection of GRSM instead of PVMRM and OLM for detailed Tier 3 NO_2 screening modeling demonstrations. The EPA plans to draft NO_2 modeling guidance in the future to respond to these comments.

One commenter notes that the GRSM supporting documentation is unclear on what assessment or evaluation was conducted that supports the assertion that updates to the GRSM code in AERMOD version 23132 address NO_2 model overpredictions farther downwind, thereby improving model performance. As discussed in the preamble of the October 2023 proposed revisions to the *Guideline*, updates to the GRSM formulation in AERMOD version 22112 were developed in late 2022 to address more realistic building effects on instantaneous plume spread, accounting of multiple plume effects on entrainment of ozone, and the tendency of GRSM to over-predict in the far-field (*e.g.*, beyond approximately 0.5 to 3 km for typical point source releases). In response to this comment, the GRSM Technical Support Document (TSD) has been

updated with clarifying information in an appendix.[5]

c.   *Addition of RLINE as mobile source type*

The EPA is finalizing RLINE as a new regulatory source type in AERMOD for mobile source

modeling. The inclusion of the RLINE source type is in addition to the AREA, LINE, and

VOLUME source types already available for mobile source modeling, giving additional

flexibility to users in characterizing transportation projects when modeling them with AERMOD.

As stated in the preamble to the proposed rule, the addition of RLINE as a regulatory source type

is an extension of the 2017 update to the *Guideline* in which AERMOD replaced CALINE3 as

the Addendum A model for mobile source modeling. The RLINE source type has undergone

significant evaluation by the EPA and FHWA as part of the Interagency Agreement between the

EPA and FHWA and, as noted in the preamble to the proposed rule, has shown improved

performance since its introduction into AERMOD in 2019.[6,7]

The EPA received several comments supporting the inclusion of RLINE as a regulatory option

into AERMOD. Several commenters also mentioned the need to update the EPA's guidance. The

EPA agrees that practitioners will need guidance for using RLINE, and we plan to update the

relevant guidance.

The EPA also received a comment supporting the retention of the RLINEXT source type as an

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[5] Environmental Protection Agency, 2024. Technical Support Document (TSD) for Adoption of the Generic Reaction Set Method (GRSM) as a Regulatory Non-Default Tier-3 NO_2 Screening Option, Publication No. EPA-454/R-24-005. Office of Air Quality Planning & Standards, Research Triangle Park, NC.

[6] Incorporation and Evaluation of the RLINE source type in AERMOD for Mobile Source Applications. EPA-2023/R-23-011, Office of Air Quality Planning and Standards, RTP, NC.

[7] Owen, R., *et al.*, 2024. Incorporation of RLINE into AERMOD: An update and evaluation for mobile source applications. *Journal of the Air & Waste Management Association*, Manuscript submitted for publication.

ALPHA option. As described below, the EPA has retained the RLINEXT as an ALPHA option

for further model development and evaluation.

Commenters also asked whether the CAL3QHC model could continue to be used for carbon

monoxide (CO) hot-spot analyses. The EPA confirms that the 1992 CO Guidance that employs

CAL3QHC for CO screening analyses is still an available screening approach for CO hot-spot

analyses of transportation projects.[8] In the EPA's January 17, 2017 final rule, section 4.2.3.1(b)

of the *Guideline* was modified, and the 1992 technical guidance (with CAL3QHC) remains in

place as the recommended approach for CO screening analyses (82 FR 5192).

The RLINE source type includes the ability to include terrain in AERMOD modeling as well as

the urban source algorithms in AERMOD. However, as stated in the preamble to the proposed

rule, the inclusion of RLINE with terrain use does not change the EPA's recommendation in the

PM Hot-spot Guidance[9] to model transportation projects with FLAT terrain. Since RLINE is

now a regulatory source type, the user no longer has to include the BETA flag with the

MODELOPT keyword in the AERMOD input file to use the RLINE source, including the use of

RLINE with the AERMOD urban option or RLINE with terrain.

The RLINEXT source type is based on the same algorithm as the RLINE source type but

includes additional parameters to allow modeling of other features of the source, such as solid

barriers and the source below grade. As these are not yet fully developed, the RLINEXT source

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[8] U.S. EPA, 1992: Guideline for modeling carbon monoxide from roadway intersections. EPA-454/R-92-005. U.S. EPA, Office of Air Quality Planning & Standards, RTP, NC.

[9] U.S. EPA, 2021: PM Hot-spot Guidance; Transportation Conformity Guidance for Quantitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Nonattainment and Maintenance Areas. EPA-42-B-21-037. U.S. EPA, Office of Transportation and Air Quality, Ann Arbor, MI.

type continues to be an ALPHA option. Therefore, the ALPHA flag must be included with MODELOPT keyword when using an RLINEXT source.

d. *Support information, documentation, and model code*

Model performance evaluation and peer-reviewed scientific references for each of these three updates to the AERMOD Modeling System are cited and placed in the docket for this action. An updated user's guide and model formulation documents for version 24142 have also been placed in the docket for this action. We have updated the summary description of the AERMOD Modeling System to Addendum A of the *Guideline* to reflect these updates. The essential codes, preprocessors, and test cases have been updated and posted to the EPA's SCRAM Web site, *https://www.epa.gov/scram*.

2. Updates to Recommendations on the Development of Background Concentration

Based on comments received on the 2023 proposed revisions to the *Guideline*, the EPA is finalizing revisions to section 8 of the *Guideline* to refine the recommendations regarding the determination of appropriate model input data, specifically background concentration, for use in NAAQS implementation modeling demonstrations (*e.g.*, PSD compliance demonstrations, SIP demonstrations for inert pollutants, and SO_2 designations). These revisions include the removal of the term "significant concentration gradient" and the associated recommendations which are replaced with a more robust framework for characterizing background concentrations for cumulative modeling with particular attention to identifying and modeling nearby sources in multi-source areas.

The EPA has revised the recommendations for the determination of background concentrations in constructing the design concentration, or total air quality concentration in multi-source areas (*see* section 8.3), as part of a cumulative impact analysis for NAAQS implementation modeling

demonstrations. The EPA is finalizing the proposed framework, which includes a stepwise set of considerations to replace the narrow recommendation of modeling nearby sources that cause a significant concentration gradient. This framework focuses the inherent discretion in defining representative background concentrations through qualitative and semi-quantitative considerations within a transparent process using the variety of emissions and air quality data available to the permit applicant. To construct a background concentration for model input under the framework, permit applicants should consider the representativeness of relevant emissions, air quality monitoring, and pre-existing air quality modeling to appropriately represent background concentrations for the cumulative impact analysis.

The EPA received numerous comments on the proposed revisions to section 8 of the *Guideline*. Multiple commenters expressed their support of the revisions to section 8.3 and the removal of the recommendation of identifying sources which cause a significant concentration gradient from the *Guideline*. Based on this support, the EPA is removing the recommendations which highlight the use of significant concentration gradients and finalizing the framework of stepwise considerations.

Several commenters expressed their perspective on the contents of the framework of stepwise considerations for developing background concentrations and its future implementation. Some commenters expressed their concern that the framework would limit the flexibility that has been afforded to permitting authorities, while other commenters stated that the framework documents steps that have been unofficially used by air agencies and modelers for many years. Additionally, some commenters feel that the steps detailed in the framework do not remove the ambiguity in the process of developing a representative background concentration. The EPA recognizes that preferred methods for developing background concentrations vary at both the State and permit-

specific level, which explains the variety of stances on the framework of stepwise considerations.

With this action, the EPA is finalizing the proposed revisions to section 8 of the *Guideline*. These

revisions strike an appropriate balance of the interests raised by comments by more clearly

documenting the general steps recommended for determining background concentrations while

leaving discretion for and recommending the exercise of professional judgement by the

reviewing authority to ensure that the background concentration is appropriately represented in

each cumulative impact analysis. In conjunction with the finalized revisions to section 8 of the

Guideline, the EPA is also finalizing the *Guidance on Developing Background Concentrations*

for Use in Modeling Demonstrations.[10] This guidance document details the EPA-recommended

framework with illustrative examples to assist permit applicants in characterizing a credible and

appropriately representative background concentration for cumulative impact analyses including

the contributions from nearby sources in multi-source areas. The EPA requested that the public

submit comment through the docket associated with the October 2023 proposed revisions to the

Guideline and received many comments requesting clarification or revisions which should be

incorporated in the finalized version of the guidance. A majority of the comments were generally

requests for the EPA to include examples and additional details in the finalized version of the

guidance. The requests for additional details ranged from minor sentence revisions to improve

clarity to requests for specific metrics that may be used in the process and requests for how to

implement the framework for specific modeling cases. The EPA agreed with the commenters

requesting examples and has incorporated hypothetical examples in the finalized version of the

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[10] U.S. Environmental Protection Agency, 2024. Guidance on Developing Background Concentrations for Use in Modeling Demonstrations. Publication No. EPA-454/R-24-003. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

guidance to help the stakeholder community implement the framework of stepwise considerations. Additionally, the EPA has revised the guidance to address many of the clarification concerns stated by commenters.

3. Transition Period for Applicability of Revisions to the *Guideline*

As noted in the DATES section above, this rule is effective **[INSERT DATE 30 DAYS AFTER PUBLICATION IN THE FEDERAL REGISTER]**. For all regulatory applications covered under the *Guideline*, the changes to the Addendum A preferred models and revisions to the requirements and recommendations of the *Guideline* should be integrated into the regulatory processes of respective reviewing authorities and followed by applicants as quickly as practicable. The EPA encourages the transition to the revised 2024 version of the *Guideline* by no later than **[INSERT DATE 1 YEAR AFTER PUBLICATION IN THE FEDERAL REGISTER]**. During the 1-year period following promulgation, protocols for modeling analyses based on the 2017 version of the *Guideline*, which are submitted in a timely manner, may be approved at the discretion of the appropriate reviewing authority.

The EPA notes that some States have approved SIP provisions that authorize the use of revised versions of the *Guideline*, whereas other States have SIP provisions that will require revision to provide for the use of a revised *Guideline*, such as the version addressed in this notice. States that have incorporated an older version of the *Guideline* into their SIPs in order to satisfy an infrastructure SIP requirement under CAA section 110(a)(2) should update their regulations as necessary to incorporate this latest version of the *Guideline* as soon as practicable into their SIPs, but must do so no later than February 7, 2027, which is the due date for 2024 $PM_{2.5}$ infrastructure SIP submittals. For States that have chosen to satisfy the modeling and permitting requirements of CAA section 110(a)(2) by adopting specific versions of the *Guideline* in their State

regulations, the EPA expects States to update their regulations to include this most recent version of the *Guideline* by the infrastructure SIP submittal due date. The EPA will at that time be evaluating infrastructure SIP submissions for compliance with applicable infrastructure SIP requirements under CAA section 110, including CAA sections 110(a)(2)(K), (C), (D)(i)(II), and (J). However, the need for such an update to a State or local regulation should not, in most cases, preclude regulatory application of the changes to the *Guideline* adopted in this rule in regulatory actions.

All applicants are encouraged to consult with their respective reviewing authority and EPA Regional office as soon as possible to assure acceptance of their modeling protocols and/or modeling demonstration during this period of regulatory transition.

4.   Revisions by Section

a. Throughout Appendix W to Part 51 – Guideline on Air Quality Models, the EPA is revising the phrase "Appendix A" to "Addendum A" in accordance with the requirements of the Government Printing Office (GPO).

b. *Section 1.0 - Introduction*

During publication, in the first sentence of paragraph (i), the phrase "Appendix A" was separated, thereby ending the sentence with "Appendix" and inadvertently creating a subparagraph (A). The EPA is correcting paragraph (i) so that the first sentence ends with the phrase "Addendum A," and including the rest of the text from the inadvertently created paragraph (A).

c. *Section 3.0 - Preferred and Alternative Air Quality Models*

The EPA is updating an outdated Web site link in section 3.0(b).

In sections 3.1.1(c) and 3.1.2(a), the phrase "Appendix A" was separated, ending the sentences with "Appendix" and inadvertently creating a subparagraph (A). The EPA is correcting these sections by combining the inadvertently created subparagraph (A) with the sentences that end with "Appendix," revising the phrase to "Addendum A," and including the rest of the text from the inadvertently created subparagraphs (A).

d. *Section 4.0 - Models for Carbon Monoxide, Lead, Sulfur Dioxide, Nitrogen Dioxide and Primary Particulate Matter*

The EPA is updating reference numbers where necessary due to added references.

In sections 4.1(b) and 4.2.2(a), the phrase "Appendix A" was separated, ending the sentences with "Appendix" and inadvertently creating a subparagraph (A). The EPA is correcting these sections combining the inadvertently created subparagraph (A) with the sentences that end with "Appendix," revising the phrase to "Addendum A," and including the rest of the text from the inadvertently created subparagraphs (A).

In section 4.2.2.1, the EPA is adding a new paragraph (f) regarding the use of AERMOD in certain overwater situations. A typographical correction is made in section 4.2.2.1(b).

The EPA is amending section 4.2.2.3 to account for circumstances where OCD is available to evaluate situations where shoreline fumigation and/or platform downwash are important.

In section 4.2.3.4, the EPA is revising paragraph (e) to adopt the Generic Reaction Set Method (GRSM) as a regulatory Tier 3 detailed screening technique for NO2 modeling demonstrations. Sentences in this section are being updated to incorporate GRSM with the existing regulatory Tier 3 screening techniques OLM and PVMRM. An additional statement is made indicating

GRSM model performance may be better than OLM and PVMRM under certain source characterization situations. The EPA also is adding two references to the section including one for the peer-reviewed paper on development and evaluation of GRSM, and a second reference to the EPA Technical Support Document (TSD) on GRSM.

The EPA is revising Table 4-1 in section 4.2.3.4(f) to include GRSM as a Tier 3 detailed screening option.

e. *Section 5.0 - Models for Ozone and Secondarily Formed Particulate Matter*

The EPA is updating reference numbers where necessary due to added references.

In section 5.2, the EPA is revising paragraph (c) to include a reference for guidance on the use of models to assess the impacts of emissions from single sources on secondarily formed ozone and $PM_{2.5}$.

f. *Section 6.0 - Modeling for Air Quality Related Values and Other Governmental Programs*

The EPA is updating reference numbers where necessary due to added references and is updating an outdated Web site link in section 6.3(a).

g. *Section 7.0 - General Modeling Considerations*

The EPA is updating reference numbers where necessary due to added references.

In section 7.2.3, the EPA is revising paragraph (b) to include the addition of RLINE as a source type for use in regulatory applications of AERMOD and remove references to specific distances that receptors can be placed from the roadway.

Also in section 7.2.3, the EPA is revising paragraph (c) to include RLINE as a source type that can be used to model mobile sources and clarify that an area source can be categorized in AERMOD using the AREA, LINE, or RLINE source type.

h. *Section 8.0 - Model Input Data*

The EPA is updating reference numbers where necessary due to added references.

The EPA is revising Table 8-1 and Table 8-2 to correct typographical errors and update the footnotes in each of the tables.

The EPA is revising section 8.3.1 to address current EPA practices and recommendations for determining the appropriate background concentration as model input data for a new or modifying source(s) or sources under consideration for a revised permit limit. This revision provides a stepwise framework for modeling isolated single sources and multi-source areas as part of a cumulative impact analysis. The EPA also is removing the term "significant concentration gradient" and its related content in section 8.3.1(a)(i) due to the ambiguity and lack of definition of this term in the context of modeling multi-source areas.

The EPA is removing paragraph (d) in section 8.3.2 and renumber paragraphs (e) and (f) to (d) and (e), respectively. The content of paragraph (d) is being included in the revisions of paragraph (a) in section 8.3.2.

In section 8.3.3, the EPA is revising the content in section 8.3.3(b) on the recommendations for determining nearby sources to explicitly model as part of a cumulative impact analysis. The EPA is removing the content related to the term "significant concentration gradient" in section 8.3.3(b)(i), section 8.3.3(b)(ii), and section 8.3.3(b)(iii) due to the lack of definition of this term in the context of modeling multi-source areas. The EPA is also removing an undefined acronym inadvertently included in the October 2023 *Guideline* proposal in section 8.3.3(b)(ii). Finally, the EPA is revising the example given in section 8.3.3(d) to be consistent with the discussion of other sources in section 8.3.1(a)(ii) and the revisions to Tables 8-1 and 8-2.

In section 8.4.1, the EPA is including buoy data as an example of site-specific data as a result of

the inclusion of the Coupled-Ocean Atmosphere Response Experiment (COARE) algorithms to AERMET for marine boundary layer processing. The EPA is also revising the heading for section 8.4.1(d) to correct a capitalization typographical error.

The EPA is revising paragraph (a) of section 8.4.2 to note that MMIF should be used to process prognostic meteorological data for both land-based and overwater applications, and is revising paragraph (b) to clarify that AERSURFACE should be used to calculate surface characteristics for land-based data and AERMET calculates surface characteristics for overwater applications. Also, the EPA is revising paragraph (e) of this section to clarify that at least 1 year of site-specific data applies to both land-based and overwater-based data.

The EPA is revising paragraph (a) of section 8.4.3.2 to remove references to specific Web links and to state that users should refer to the latest guidance documents for Web links.

The EPA is adding a new section 8.4.6 to discuss the implementation of COARE for marine boundary layer processing and to renumber the existing section 8.4.6 (in the 2017 *Guideline)* to a new section 8.4.7. References to specific wind speed thresholds are being replaced with guidance to consult the appropriate guidance documents for the latest thresholds.

i. *Section 9.0 - Regulatory Application of Models*

The EPA is updating reference numbers where necessary due to added references.

In section 9.2.3, the EPA is revising the example given in section 9.2.3(a)(ii) to be consistent with the discussion of other sources in section 8.3.1(a)(ii) and the revisions to Tables 8-1 and 8-2.

j. *Section 10.0 - References*

The EPA is updating references in section 10.0 to remove outdated Web site links and reflect

current versions of guidance documents, user's guides, and other supporting documentation

where applicable. The EPA also is adding references to support updates to the AERMOD

Modeling System described in this update to the *Guideline*.

5.   Revisions to Addendum A to Appendix W to Part 51

a. *Section A.0*

The EPA is revising section A.0 to remove references that indicate there are "many" preferred

models while the number is currently only three.

b. *Section A.1*

The EPA is revising the References section to include additional references that support our

updates to the AERMOD Modeling System consistent with our October 2023 proposed revisions

to the *Guideline* and AERMOD.

In the Abstract section, the EPA is adding line type sources as one of the source types AERMOD

can simulate.

The EPA is revising section A.1(a) to include overwater applications for regulatory modeling

where shoreline fumigation and/or platform downwash are not important to facilitate the use of

AERMOD with COARE processing. This revision removes the need to request an alternative

model demonstration for such applications. The EPA also is clarifying elevation data that can be

used in AERMOD, specifically the change in the name of the U.S. Geological Survey (USGS)

National Elevation Dataset (NED) to 3D Elevation Program (3DEP). For consistency, references

to NED are being updated to 3DEP throughout section A.1.

The EPA is revising section A.1(b) to include prognostic data as meteorological input to the

AERMOD Modeling System, as applicable.

The EPA is revising section A.1(l) to include the Generic Reaction Set Method in the discussion

on chemical transformation in AERMOD. We also are clarifying the status of the different

deposition options in A.1(l).

The EPA is revising section A.1(n) to include references to additional evaluation studies to

support our updates to the AERMOD Modeling System.

The EPA is updating a reference added in the October 2023 *Guideline* proposal in section A.1

from a manuscript to an existing EPA Technical Support Document.

c. *Section A.3*

In section A.3, the EPA is removing the reference to the Bureau of Ocean Energy Management's

(BOEM) outdated guidance.

IV. *Ongoing Model Development*

With the release of AERMOD version 24142, no additional beta options remain within

AERMOD. The alpha options in version 23132 have all been retained in version 24142. The

EPA is committed to the continued maintenance and development of AERMOD to expand the

model's capabilities and improve performance where needed. Ongoing model development

priorities for model improvement, many of which are represented in the version 24142 as alpha

options, are described below.

- Modifications to PRIME Building Downwash

   Beginning with AERMOD version 19191, two distinct sets of alpha options were added

   that modify the formulation of the building downwash algorithm, PRIME. The two sets

   of options, ORD_DWNW and AWMADWNW, were developed independently by the

EPA's Office of Development and Research (ORD) and the Air & Waste Management Association (A&WMA), respectively. With a couple of exceptions, the options within each set can be employed individually or combined with other options from each set. In addition to these alpha options that modify the formulation of PRIME, are the building input parameters required by the algorithm. In conjunction with the assessment and evaluation of these alpha options, the EPA is focused on improvement of the building preprocessor, BPIPPRM, and the parameterization of the buildings that is input to AERMOD.

- Offshore Modeling

  To enhance AERMOD's offshore modeling capabilities with the goal of replacing the Offshore Coastal Dispersion (OCD) dispersion model as the EPA's preferred model for offshore dispersion modeling applications, a platform downwash alpha option (PLATFORM), adapted from OCD, was incorporated into AERMOD version 22112. This model enhancement specifically treats building downwash effects from raised offshore drilling platforms. The PLATFORM option continues to undergo refinements and evaluation. In addition to the PLATFORM alpha option, the EPA is implementing a shoreline fumigation algorithm into AERMOD, also needed for the eventual goal of replacing the OCD model.

- Extended RLINE Source Type Including Barriers and Depressed Roadways

  The extended RLINE source type (RLINEXT) source type was implemented in AERMOD version 18181 as an alpha option that allows for a more refined characterization of an individual road segment. It accepts separate inputs for the elevations of each end of the road segment with added capability to model road segments

that include roadway barriers (RBARRIER) and/or are characterized as depressed roadways (RDEPRESS). RBARRIER and RDEPRESS are also alpha options and can only be used in conjunction with the RLINEXT source type. The development of the RLINEXT source type and accompanying options to account for barriers and depressed roadways is ongoing.

- Highly Buoyant Plume

  A Highly Buoyant Plume (HBP) option was implemented as an alpha option beginning with AERMOD version 23132 to explore and refine AERMOD's treatment of the penetrated plume. A penetrated plume occurs when a plume is released into the mixed layer, and a portion of the plume eventually penetrates the top of the mixed layer during convective hours as it continues to rise due to either buoyancy or momentum. The BLP alpha option is only applicable to POINT source types.

- Aircraft Plume Rise

  Beginning with AERMOD version 23132, the ARCFTOPT alpha option was added with the goal to extend the capabilities of AERMOD to appropriately model emissions from aircraft on the ground and during takeoffs and landings. The ARCFTOPT option extends the AREA and VOLUME source type inputs to account for the buoyancy and horizontal momentum of aircraft emissions.

- Low Wind Default Overrides (LOW_WIND)

  A LOW_WIND option was first implemented as a collection of non-regulatory beta test options in AERMOD version 12345 (LOWWIND1 and LOWWIND2) and expanded in version 15481(LOWWIND3), before the alpha/beta framework was implemented. Each of these options altered the default model values for minimum sigma-v, minimum wind

speed, and the minimum meander factor with different combinations of hardcoded values. Though the original LOW_WIND beta test options are no longer implemented in AERMOD, the LOW_WIND option was recategorized as an alpha option in AERMOD version 18181 to include a number of user defined default overrides for wind data parameters. The LOW_WIND option in version 24142 enables the user to override AERMOD default values with user-defined values for one or more of the following parameters:

o Minimum standard deviation of the lateral velocity to the average wind direction;

o Minimum mean wind speed;

o Minimum and maximum meander factor;

o Minimum standard deviation of the vertical wind speed; and

o Time scale for random dispersion.

V. *Statutory and Executive Order Reviews*

Additional information about these statutes and Executive Orders can be found at *https://www.epa.gov/laws-regulations/laws-and-executive-orders*.

A. *Executive Order 12866: Regulatory Planning and Review and Executive Order 14094: Modernizing Regulatory Review*

This action is not a significant regulatory action as defined in Executive Order 12866, as amended by Executive Order 14094, and was, therefore, not subject to a requirement for Executive Order 12866 review.

B. *Paperwork Reduction Act (PRA)*

This action does not impose an information collection burden under the PRA. This action does

not contain any information collection activities, nor does it add any information collection requirements beyond those imposed by existing New Source Review requirements.

C.   *Regulatory Flexibility Act (RFA)*

I certify that this action will not have a significant economic impact on a substantial number of small entities under the RFA. This action will not impose any requirements on small entities. This action finalizes revisions to the *Guideline*, including enhancements to the formulation and application of the EPA's near-field dispersion modeling system, AERMOD, and updates to the recommendations for the development of appropriate background concentration for cumulative impact analyses. Use of the models and/or techniques described in this action is not expected to pose any additional burden on small entities.

D.   *Unfunded Mandates Reform Act (UMRA)*

This action does not contain an unfunded mandate as described in UMRA, 2 U.S.C. 1531-1538. This action imposes no enforceable duty on any State, local or Tribal governments or the private sector.

E.   *Executive Order 13132: Federalism*

This action does not have federalism implications. It will not have substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government.

F.   *Executive Order 13175: Consultation and Coordination with Indian Tribal Governments*

This action does not have Tribal implications, as specified in Executive Order 13175. This action provides final revisions to the *Guideline* which is used by the EPA, other Federal, State,

territorial, local, and Tribal air quality agencies, and industry to prepare and review preconstruction permit applications, SIP submittals and revisions, determinations of conformity, and other air quality assessments required under EPA regulation. Separate from this action, the Tribal Air Rule implements the provisions of section 301(d) of the CAA authorizing eligible Tribes to implement their own Tribal air program. Thus, Executive Order 13175 does not apply to this action.

The EPA specifically solicited comments on the October 2023 proposed revisions to the *Guideline* from Tribal officials and did not formally receive any Tribal comments during the public comment period for the rule. Subsequently, the EPA provided information regarding this final action to the Tribes during a monthly National Tribal Air Association (NTAA) call earlier in 2024 and will continue to provide any new or subsequent updates to EPA modeling guidance and other regulatory compliance demonstration related topics upon request of the NTAA.

G.   *Executive Order 13045: Protection of Children from Environmental Health Risks and Safety Risks*

The EPA interprets Executive Order 13045 as applying only to those regulatory actions that concern environmental health or safety risks that the EPA has reason to believe may disproportionately affect children, per the definition of "covered regulatory action" in section 2-202 of the Executive Order. This action does not address an environmental health risk or safety risk that may disproportionately affect children. Therefore, this action is not subject to Executive Order 13045. The EPA's Policy on Children's Health also does not apply.

H.   *Executive Order 13211: Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use*

This action is not subject to Executive Order 13211, because it is not a significant regulatory action under Executive Order 12866.

I. *National Technology Transfer and Advancement Act*

This rulemaking does not involve technical standards.

J. *Executive Order 12898: Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations and Executive Order 14096: Revitalizing Our Nation's Commitment to Environmental Justice for All*

The EPA believes that this type of action cannot be evaluated with respect to potentially disproportionate and adverse effects on communities with environmental justice concerns because this final action does not regulate air pollutant emissions or establish an environmental health or safety standard. This action finalizes revisions to the *Guideline*, including enhancements to the formulations and application of EPA's near-field dispersion modeling system, AERMOD, that would assist and expand assessment of environmental considerations in required compliance demonstrations across various CAA programs.

The EPA identifies and addresses environmental justice concerns through continuing efforts to improve the scientific formulations of the EPA's air quality models, increase model overall performance, and reduce uncertainties of model projections for regulatory applications, which ultimately provides for protection of the environment and human health. While the EPA does not expect this action to directly impact air quality, the revisions are important because the *Guideline* is used by the EPA, other Federal, State, territorial, local, and Tribal air quality agencies, and industry to prepare and review preconstruction permit applications, SIP submittals and revisions, determinations of conformity, and other air quality assessments required under EPA regulation

and serves as a benchmark of consistency across the nation. This consistency has value to all communities including communities with environmental justice concerns.

K.   *Congressional Review Act (CRA)*

This action is subject to the Congressional Review Act (CRA), and the EPA will submit a rule report to each House of the Congress and to the Comptroller General of the United States. This action is not a "major rule" as defined by 5 U.S.C. 804(2).

List of Subjects in 40 CFR Part 51

Environmental protection, Administrative practice and procedure, Air pollution control, Carbon

monoxide, Criteria pollutants, Intergovernmental relations, Lead, Mobile sources, Nitrogen

oxides, Ozone, Particulate Matter, Reporting and recordkeeping requirements, Stationary

sources, Sulfur oxides.

Dated:

Michael S. Regan,
Administrator.

For the reasons stated in the preamble, the Environmental Protection Agency is amending title 40, chapter I of the Code of Federal Regulations as follows:

PART 51—REQUIREMENTS FOR PREPARATION, ADOPTION, AND SUBMITTAL OF IMPLEMENTATION PLANS

1. The authority citation for part 51 continues to read as follows:

Authority: 23 U.S.C. 101; 42 U.S.C. 7401-7671q.

2. Appendix W to part 51 is revised to read as follows:

APPENDIX W TO PART 51—GUIDELINE ON AIR QUALITY MODELS

Preface

a. 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 (CAA), Congress mandated such consistency and encouraged the standardization of model applications. The *Guideline on Air Quality Models* (hereafter, *Guideline*) was first published in April 1978 to satisfy these requirements by specifying models and providing guidance for their use. The *Guideline* provides a common basis for estimating the air quality concentrations of criteria pollutants used in assessing control strategies and developing emissions limits.

b. 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. Historically, three primary activities have provided direct input to revisions of the *Guideline*. The first is a series of periodic EPA workshops and modeling conferences conducted for the purpose of ensuring consistency and providing clarification in the application of models. The second

activity was 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 of privately developed models to the EPA. After extensive evaluation and scientific review, these models, as well as those made available by the EPA, have been considered for recognition in the *Guideline*. The third activity is the extensive on-going research efforts by the EPA and others in air quality and meteorological modeling.

c. Based primarily on these three activities, new sections and topics have been included as needed. The EPA does not make changes to the *Guideline* on a predetermined schedule, but rather on an as-needed basis. The EPA believes that revisions of the *Guideline* should be timely and responsive to user needs and should involve public participation to the greatest possible extent. All future changes to the *Guideline* will be proposed and finalized in the *Federal Register*. Information on the current status of modeling guidance can always be obtained from the EPA's Regional offices.

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9.2.4   Use of Measured Data in Lieu of Model Estimates

10.0   References

Addendum A to Appendix W of Part 51—Summaries of Preferred Air Quality Models

List of Tables

Table No.	Title
8-1………….	Point Source Model Emission Inputs for SIP Revisions of Inert Pollutants
8-2………….	Point Source Model Emission Inputs for NAAQS Compliance in PSD Demonstrations

1.0   Introduction

a. The *Guideline* provides air quality modeling techniques that should be applied to State

Implementation Plan (SIP) submittals and revisions, to New Source Review (NSR), including

new or modifying sources under Prevention of Significant Deterioration (PSD),[1, 2, 3] conformity

analyses,[4] and other air quality assessments required under EPA regulation. Applicable only to

criteria air pollutants, the *Guideline* is intended for use by the EPA Regional offices in judging

the adequacy of modeling analyses performed by the EPA, by State, local, and Tribal permitting

authorities, and by industry. It is appropriate for use by other Federal government agencies and

by State, local, and Tribal agencies with air quality and land management responsibilities. The

Guideline serves to identify, for all interested parties, those modeling techniques and databases

that the EPA considers acceptable. The *Guideline* is not intended to be a compendium of

modeling techniques. Rather, it should serve as a common measure of acceptable technical

analysis when supported by sound scientific judgment.

b. Air quality measurements[5] are routinely used to characterize ambient concentrations of criteria pollutants throughout the nation but are rarely sufficient for characterizing the ambient impacts of individual sources or demonstrating adequacy of emissions limits for an existing source due to limitations in spatial and temporal coverage of ambient monitoring networks. The impacts of new sources that do not yet exist, and modifications to existing sources that have yet to be implemented, can only be determined through modeling. Thus, models have become a primary analytical tool in most air quality assessments. Air quality measurements can be used in a complementary manner to air quality models, with due regard for the strengths and weaknesses of both analysis techniques, and are particularly useful in assessing the accuracy of model estimates.

c. It would be advantageous to categorize the various regulatory programs and to apply a designated model to each proposed source needing analysis under a given program. However, the diversity of the nation's topography and climate, and variations in source configurations and operating characteristics dictate against a strict modeling "cookbook." There is no one model capable of properly addressing all conceivable situations even within a broad category such as point sources. Meteorological phenomena associated with threats to air quality standards are rarely amenable to a single mathematical treatment; thus, case-by-case analysis and judgment are frequently required. As modeling efforts become more complex, it is increasingly important that they be directed by highly competent individuals with a broad range of experience and knowledge in air quality meteorology. Further, they should be coordinated closely with specialists in emissions characteristics, air monitoring and data processing. The judgment of experienced meteorologists, atmospheric scientists, and analysts is essential.

d. The model that most accurately estimates concentrations in the area of interest is always sought. However, it is clear from the needs expressed by the EPA Regional offices, by State, local, and Tribal agencies, by many industries and trade associations, and also by the deliberations of Congress, that consistency in the selection and application of models and databases should also be sought, even in case-by-case analyses. Consistency ensures that air quality control agencies and the general public have a common basis for estimating pollutant concentrations, assessing control strategies, and specifying emissions limits. Such consistency is not, however, promoted at the expense of model and database accuracy. The *Guideline* provides a consistent basis for selection of the most accurate models and databases for use in air quality assessments.

e. Recommendations are made in the *Guideline* concerning air quality models and techniques, model evaluation procedures, and model input databases and related requirements. The guidance provided here should be followed in air quality analyses relative to SIPs, NSR, and in supporting analyses required by the EPA and by State, local, and Tribal permitting authorities. Specific models are identified for particular applications. The EPA may approve the use of an alternative model or technique that can be demonstrated to be more appropriate than those recommended in the *Guideline*. In all cases, the model or technique 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 the *Guideline* should be carefully documented as part of the public record and fully supported by the appropriate reviewing authority, as discussed later.

f. From time to time, situations arise requiring clarification of the intent of the guidance on a specific topic. Periodic workshops are held with EPA headquarters, EPA Regional offices, and

State, local, and Tribal agency modeling representatives to ensure consistency in modeling guidance and to promote the use of more accurate air quality models, techniques, and databases. The workshops serve to provide further explanations of *Guideline* requirements to the EPA Regional offices and workshop materials are issued with this clarifying information. In addition, findings from ongoing research programs, new model development, or results from model evaluations and applications are continuously evaluated. Based on this information, changes in the applicable guidance may be indicated and appropriate revisions to the *Guideline* may be considered.

g. All changes to the *Guideline* must follow rulemaking requirements since the *Guideline* is codified in Appendix W to 40 Code of Federal Regulations (CFR) part 51. The EPA will promulgate rules in the *Federal Register* to amend this appendix. The EPA utilizes the existing procedures under CAA section 320 that requires the EPA to conduct a conference on air quality modeling at least every 3 years (CAA 320, 42 U.S.C. 7620). These modeling conferences are intended to develop standardized air quality modeling procedures and form the basis for associated revisions to this *Guideline* in support of the EPA's continuing effort to prescribe with "reasonable particularity" air quality models and meteorological and emission databases suitable for modeling national ambient air quality standards (NAAQS)[6] and PSD increments. Ample opportunity for public comment will be provided for each proposed change and public hearings scheduled.

h. A wide range of topics on modeling and databases are discussed in the *Guideline*. Section 2 gives an overview of models and their suitability for use in regulatory applications. Section 3 provides specific guidance on the determination of preferred air quality models and on the selection of alternative models or techniques. Sections 4 through 6 provide recommendations on

modeling techniques for assessing criteria pollutant impacts from single and multiple sources with specific modeling requirements for selected regulatory applications. Section 7 discusses general considerations common to many modeling analyses for stationary and mobile sources. Section 8 makes recommendations for data inputs to models including source, background air quality, and meteorological data. Section 9 summarizes how estimates and measurements of air quality are used in assessing source impact and in evaluating control strategies.

i. Appendix W to 40 CFR part 51 contains an addendum: Addendum A. Thus, when reference is made to "Addendum A" in this document, it refers to Addendum A to Appendix W to 40 CFR part 51. Addendum A contains summaries of refined air quality models that are "preferred" for particular applications; both EPA models and models developed by others are included.

2.0   Overview of Model Use

a. Increasing reliance has been placed on concentration estimates from air quality models as the primary basis for regulatory decisions concerning source permits and emission control requirements. In many situations, such as review of a proposed new source, no practical alternative exists. Before attempting to implement the guidance contained in this document, the reader should be aware of certain general information concerning air quality models and their evaluation and use. Such information is provided in this section.

2.1   Suitability of Models

a. The extent to which a specific air quality model is suitable for the assessment of source impacts depends upon several factors. These include: (1) the topographic and meteorological complexities of the area; (2) the detail and accuracy of the input databases, *i.e.*, emissions inventory, meteorological data, and air quality data; (3) the manner in which complexities of

atmospheric processes are handled in the model; (4) the technical competence of those

undertaking such simulation modeling; and (5) the resources available to apply the model. Any

of these factors can have a significant influence on the overall model performance, which must

be thoroughly evaluated to determine the suitability of an air quality model to a particular

application or range of applications.

b. Air quality models are most accurate and reliable in areas that have gradual transitions of

land use and topography. Meteorological conditions in these areas are spatially uniform such that

observations are broadly representative and air quality model projections are not further

complicated by a heterogeneous environment. Areas subject to major topographic influences

experience meteorological complexities that are often difficult to measure and simulate. Models

with adequate performance are available for increasingly complex environments. However, they

are resource intensive and frequently require site-specific observations and formulations. Such

complexities and the related challenges for the air quality simulation should be considered when

selecting the most appropriate air quality model for an application.

c. Appropriate model input data should be available before an attempt is made to evaluate or

apply an air quality model. Assuming the data are adequate, the greater the detail with which a

model considers the spatial and temporal variations in meteorological conditions and permit-

enforceable emissions, the greater the ability to evaluate the source impact and to distinguish the

effects of various control strategies.

d. There are three types of models that have historically been used in the regulatory

demonstrations applicable in the *Guideline*, each having strengths and weaknesses that lend

themselves to particular regulatory applications.

i. Gaussian plume models use a "steady-state" approximation, which assumes that over the

model time step, the emissions, meteorology and other model inputs, are constant throughout the model domain, resulting in a resolved plume with the emissions distributed throughout the plume according to a Gaussian distribution. This formulation allows Gaussian models to estimate near-field impacts of a limited number of sources at a relatively high resolution, with temporal scales of an hour and spatial scales of meters. However, this formulation allows for only relatively inert pollutants, with very limited considerations of transformation and removal (*e.g.*, deposition), and further limits the domain for which the model may be used. Thus, Gaussian models may not be appropriate if model inputs are changing sharply over the model time step or within the desired model domain, or if more advanced considerations of chemistry are needed.

ii. Lagrangian puff models, on the other hand, are non-steady-state, and assume that model input conditions are changing over the model domain and model time step. Lagrangian models can also be used to determine near- and far-field impacts from a limited number of sources. Traditionally, Lagrangian models have been used for relatively inert pollutants, with slightly more complex considerations of removal than Gaussian models. Some Lagrangian models treat in-plume gas and particulate chemistry. However, these models require time and space varying concentration fields of oxidants and, in the case of fine particulate matter ($PM_{2.5}$), neutralizing agents, such as ammonia. Reliable background fields are critical for applications involving secondary pollutant formation because secondary impacts generally occur when in-plume precursors mix and react with species in the background atmosphere.[7, 8] These oxidant and neutralizing agents are not routinely measured, but can be generated with a three-dimensional photochemical grid model.

iii. Photochemical grid models are three-dimensional Eulerian grid-based models that treat chemical and physical processes in each grid cell and use diffusion and transport processes to

move chemical species between grid cells.[9] Eulerian models assume that emissions are spread evenly throughout each model grid cell. At coarse grid resolutions, Eulerian models have difficulty with fine scale resolution of individual plumes. However, these types of models can be appropriately applied for assessment of near-field and regional scale reactive pollutant impacts from specific sources7, [10, 11, 12] or all sources.[13, 14, 15] Photochemical grid models simulate a more realistic environment for chemical transformation,7, [12] but simulations can be more resource intensive than Lagrangian or Gaussian plume models.

e. Competent and experienced meteorologists, atmospheric scientists, and analysts are an essential prerequisite to the successful application of air quality models. The need for such specialists is critical when sophisticated models are used or the area has complicated meteorological or topographic features. It is important to note that a model applied improperly or with inappropriate data can lead to serious misjudgments regarding the source impact or the effectiveness of a control strategy.

f. The resource demands generated by use of air quality models vary widely depending on the specific application. The resources required may be important factors in the selection and use of a model or technique for a specific analysis. These resources depend on the nature of the model and its complexity, the detail of the databases, the difficulty of the application, the amount and level of expertise required, and the costs of manpower and computational facilities.

2.1.1   Model Accuracy and Uncertainty

a. The formulation and application of air quality models are accompanied by several sources of uncertainty. "Irreducible" uncertainty stems from the "unknown" conditions, which may not be explicitly accounted for in the model (*e.g.,* the turbulent velocity field). Thus, there are likely to be deviations from the observed concentrations in individual events due to variations in the

unknown conditions. "Reducible" uncertainties[16] are caused by: (1) uncertainties in the "known" input conditions (*e.g.,* emission characteristics and meteorological data); (2) errors in the measured concentrations; and (3) inadequate model physics and formulation.

b. Evaluations of model accuracy should focus on the reducible uncertainty associated with physics and the formulation of the model. The accuracy of the model is normally determined by an evaluation procedure which involves the comparison of model concentration estimates with measured air quality data.[17] The statement of model accuracy is based on statistical tests or performance measures such as bias, error, correlation, etc.[18, 19]

c. Since the 1980's, the EPA has worked with the modeling community to encourage development of standardized model evaluation methods and the development of continually improved methods for the characterization of model performance.[16, 18, 20, 21, 22] There is general consensus on what should be considered in the evaluation of air quality models. Namely, quality assurance planning, documentation and scrutiny should be consistent with the intended use and should include:

- Scientific peer review;

- Supportive analyses (diagnostic evaluations, code verification, sensitivity analyses);

- Diagnostic and performance evaluations with data obtained in trial locations; and

- Statistical performance evaluations in the circumstances of the intended applications.

Performance evaluations and diagnostic evaluations assess different qualities of how well a model is performing, and both are needed to establish credibility within the client and scientific community.

d. Performance evaluations allow the EPA and model users to determine the relative

performance of a model in comparison with alternative modeling systems. Diagnostic

evaluations allow determination of a model capability to simulate individual processes that affect

the results, and usually employ smaller spatial/temporal scale data sets (*e.g.,* field studies).

Diagnostic evaluations enable the EPA and model users to build confidence that model

predictions are accurate for the right reasons. However, the objective comparison of modeled

concentrations with observed field data provides only a partial means for assessing model

performance. Due to the limited supply of evaluation datasets, there are practical limits in

assessing model performance. For this reason, the conclusions reached in the science peer

reviews and the supportive analyses have particular relevance in deciding whether a model will

be useful for its intended purposes.

2.2   *Levels of Sophistication of Air Quality Analyses and Models*

a. It is desirable to begin an air quality analysis by using simplified and conservative methods

followed, as appropriate, by more complex and refined methods. The purpose of this approach is

to streamline the process and sufficiently address regulatory requirements by eliminating the

need of more detailed modeling when it is not necessary in a specific regulatory application. For

example, in the context of a PSD permit application, a simplified and conservative analysis may

be sufficient where it shows the proposed construction clearly will not cause or contribute to

ambient concentrations in excess of either the NAAQS or the PSD increments.[2, 3]

b. There are two general levels of sophistication of air quality models. The first level consists

of screening models that provide conservative modeled estimates of the air quality impact of a

specific source or source category based on simplified assumptions of the model inputs (*e.g.*,

preset, worst-case meteorological conditions). In the case of a PSD assessment, if a screening

model indicates that the increase in concentration attributable to the source could cause or

contribute to a violation of any NAAQS or PSD increment, then the second level of more

sophisticated models should be applied unless appropriate controls or operational restrictions are

implemented based on the screening modeling.

c. The second level consists of refined models that provide more detailed treatment of

physical and chemical atmospheric processes, require more detailed and precise input data, and

provide spatially and temporally resolved concentration estimates. As a result, they provide a

more sophisticated and, at least theoretically, a more accurate estimate of source impact and the

effectiveness of control strategies.

d. There are situations where a screening model or a refined model is not available such that

screening and refined modeling are not viable options to determine source-specific air quality

impacts. In such situations, a screening technique or reduced-form model may be viable options

for estimating source impacts.

i. Screening techniques are differentiated from a screening model in that screening

techniques are approaches that make simplified and conservative assumptions about the physical

and chemical atmospheric processes important to determining source impacts, while screening

models make assumptions about conservative inputs to a specific model. The complexity of

screening techniques ranges from simplified assumptions of chemistry applied to refined or

screening model output to sophisticated approximations of the chemistry applied within a refined

model.

ii. Reduced-form models are computationally efficient simulation tools for characterizing

the pollutant response to specific types of emission reductions for a particular geographic area or

background environmental conditions that reflect underlying atmospheric science of a refined

model but reduce the computational resources of running a complex, numerical air quality model such as a photochemical grid model.

In such situations, an attempt should be made to acquire or improve the necessary databases and to develop appropriate analytical techniques, but the screening technique or reduced-form model may be sufficient in conducting regulatory modeling applications when applied in consultation with the EPA Regional office.

e. Consistent with the general principle described in paragraph 2.2(a), the EPA may establish a demonstration tool or method as a sufficient means for a user or applicant to make a demonstration required by regulation, either by itself or as part of a modeling demonstration. To be used for such regulatory purposes, such a tool or method must be reflected in a codified regulation or have a well-documented technical basis and reasoning that is contained or incorporated in the record of the regulatory decision in which it is applied.

2.3   Availability of Models

a. For most of the screening and refined models discussed in the *Guideline*, codes, associated documentation and other useful information are publicly available for download from the EPA's Support Center for Regulatory Atmospheric Modeling (SCRAM) Web site at *https://www.epa.gov/scram*. This is a Web site with which air quality modelers should become familiar and regularly visit for important model updates and additional clarifications and revisions to modeling guidance documents that are applicable to EPA programs and regulations. Codes and documentation may also be available from the National Technical Information Service (NTIS), *https://www.ntis.gov*, and, when available, is referenced with the appropriate NTIS accession number.

3.0   Preferred and Alternative Air Quality Models

a. This section specifies the approach to be taken in determining preferred models for use in regulatory air quality programs. The status of models developed by the EPA, as well as those submitted to the EPA for review and possible inclusion in this *Guideline*, is discussed in this section. The section also provides the criteria and process for obtaining EPA approval for use of alternative models for individual cases in situations where the preferred models are not applicable or available. Additional sources of relevant modeling information are: the EPA's Model Clearinghouse[23] (section 3.3); EPA modeling conferences; periodic Regional, State, and Local Modelers' Workshops; and the EPA's SCRAM Web site (section 2.3).

b. When approval is required for a specific modeling technique or analytical procedure in this *Guideline*, we refer to the "*appropriate reviewing authority*." Many States and some local agencies administer NSR permitting under programs approved into SIPs. In some EPA regions, Federal authority to administer NSR permitting and related activities has been delegated to State or local agencies. In these cases, such agencies "*stand in the shoes*" of the respective EPA Region. Therefore, depending on the circumstances, the appropriate reviewing authority may be an EPA Regional office, a State, local, or Tribal agency, or perhaps the Federal Land Manager (FLM). In some cases, the *Guideline* requires review and approval of the use of an alternative model by the EPA Regional office (sometimes stated as "*Regional Administrator*"). For all approvals of alternative models or techniques, the EPA Regional office will coordinate and seek concurrence with the EPA's Model Clearinghouse. If there is any question as to the appropriate reviewing authority, you should contact the EPA Regional office modeling contact (*https://www.epa.gov/scram/air-modeling-regional-contacts*), whose jurisdiction generally includes the physical location of the source in question and its expected impacts.

c. In all regulatory analyses, early discussions among the EPA Regional office staff, State,

local, and Tribal agency staff, industry representatives, and where appropriate, the FLM, are invaluable and are strongly encouraged. Prior to the actual analyses, agreement on the databases to be used, modeling techniques to be applied, and the overall technical approach helps avoid misunderstandings concerning the final results and may reduce the later need for additional analyses. The preparation of a written modeling protocol that is vetted with the appropriate reviewing authority helps to keep misunderstandings and resource expenditures at a minimum.

d. The identification of preferred models in this *Guideline* should not be construed as a determination that the preferred models identified here are to be permanently used to the exclusion of all others or that they are the only models available for relating emissions to air quality. The model that most accurately estimates concentrations in the area of interest is always sought. However, designation of specific preferred models is needed to promote consistency in model selection and application.

3.1   *Preferred Models*

3.1.1   Discussion

a. The EPA has developed some models suitable for regulatory application, while other models have been submitted by private developers for possible inclusion in the *Guideline*. Refined models that are preferred and required by the EPA for particular applications have undergone the necessary peer scientific reviews[24, 25] and model performance evaluation exercises[26, 27] that include statistical measures of model performance in comparison with measured air quality data as described in section 2.1.1.

b. An American Society for Testing and Materials (ASTM) reference[28] provides a general philosophy for developing and implementing advanced statistical evaluations of atmospheric dispersion models, and provides an example statistical technique to illustrate the application of

this philosophy. Consistent with this approach, the EPA has determined and applied a specific

evaluation protocol that provides a statistical technique for evaluating model performance for

predicting peak concentration values, as might be observed at individual monitoring locations.[29]

c. When a single model is found to perform better than others, it is recommended for

application as a preferred model and listed in Addendum A. If no one model is found to clearly

perform better through the evaluation exercise, then the preferred model listed in Addendum A

may be selected on the basis of other factors such as past use, public familiarity, resource

requirements, and availability. Accordingly, the models listed in Addendum A meet these

conditions:

i. The model must be written in a common programming language, and the executable(s)

must run on a common computer platform.

ii. The model must be documented in a user's guide or model formulation report which

identifies the mathematics of the model, data requirements and program operating characteristics

at a level of detail comparable to that available for other recommended models in Addendum A.

iii. The model must be accompanied by a complete test dataset including input

parameters and output results. The test data must be packaged with the model in computer-

readable form.

iv. The model must be useful to typical users, *e.g.*, State air agencies, for specific air

quality control problems. Such users should be able to operate the computer program(s) from

available documentation.

v. The model documentation must include a robust comparison with air quality data

(and/or tracer measurements) or with other well-established analytical techniques.

vi. The developer must be willing to make the model and source code available to users

at reasonable cost or make them available for public access through the Internet or National

Technical Information Service. The model and its code cannot be proprietary.

d. The EPA's process of establishing a preferred model includes a determination of technical

merit, in accordance with the above six items, including the practicality of the model for use in

ongoing regulatory programs. Each model will also be subjected to a performance evaluation for

an appropriate database and to a peer scientific review. Models for wide use (not just an isolated

case) that are found to perform better will be proposed for inclusion as preferred models in future

Guideline revisions.

e. No further evaluation of a preferred model is required for a particular application if the

EPA requirements for regulatory use specified for the model in the *Guideline* are followed.

Alternative models to those listed in Addendum A should generally be compared with measured

air quality data when they are used for regulatory applications consistent with recommendations

in section 3.2.

3.1.2   Requirements

a. Addendum A identifies refined models that are preferred for use in regulatory applications.

If a model is required for a particular application, the user must select a model from Addendum

A or follow procedures in section 3.2.2 for use of an alternative model or technique. Preferred

models may be used without a formal demonstration of applicability as long as they are used as

indicated in each model summary in Addendum A. Further recommendations for the application

of preferred models to specific source applications are found in subsequent sections of the

Guideline.

b. If changes are made to a preferred model without affecting the modeled concentrations, the

preferred status of the model is unchanged. Examples of modifications that do not affect

concentrations are those made to enable use of a different computer platform or those that only affect the format or averaging time of the model results. The integration of a graphical user interface (GUI) to facilitate setting up the model inputs and/or analyzing the model results without otherwise altering the preferred model code is another example of a modification that does not affect concentrations. However, when any changes are made, the Regional Administrator must require a test case example to demonstrate that the modeled concentrations are not affected.

c. A preferred model must be operated with the options listed in Addendum A for its intended regulatory application. If the regulatory options are not applied, the model is no longer "preferred." Any other modification to a preferred model that would result in a change in the concentration estimates likewise alters its status so that it is no longer a preferred model. Use of the modified model must then be justified as an alternative model on a case-by-case basis to the appropriate reviewing authority and approved by the Regional Administrator.

d. Where the EPA has not identified a preferred model for a particular pollutant or situation, the EPA may establish a multi-tiered approach for making a demonstration required under PSD or another CAA program. The initial tier or tiers may involve use of demonstration tools, screening models, screening techniques, or reduced-form models; while the last tier may involve the use of demonstration tools, refined models or techniques, or alternative models approved under section 3.2.

3.2 Alternative Models

3.2.1   Discussion

a. Selection of the best model or 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 *Guideline* cannot alone achieve that consistency nor can it necessarily provide the best model for all possible situations. As discussed in section 3.1.1, the EPA has determined and applied a specific evaluation protocol that provides a statistical technique for evaluating model performance for predicting peak concentration values, as might be observed at individual monitoring locations.[29] This protocol is available to assist in developing a consistent approach when justifying the use of other-than-preferred models recommended in the *Guideline* (*i.e.*, alternative models). The procedures in this protocol provide a general framework for objective decision-making on the acceptability of an alternative model for a given regulatory application. These objective procedures may be used for conducting both the technical evaluation of the model and the field test or performance evaluation.

   b. This subsection discusses the use of alternate models and defines three situations when alternative models may be used. This subsection also provides a procedure for implementing 40 CFR 51.166(l)(2) in PSD permitting. This provision requires written approval of the Administrator for any modification or substitution of an applicable model. An applicable model for purposes of 40 CFR 51.166(l) is a preferred model in Addendum A to the *Guideline*. Approval to use an alternative model under section 3.2 of the *Guideline* qualifies as approval for the modification or substitution of a model under 40 CFR 51.166(l)(2). The Regional Administrators have delegated authority to issue such approvals under section 3.2 of the *Guideline*, provided that such approval is issued after consultation with the EPA's Model Clearinghouse and formally documented in a concurrence memorandum from the EPA's Model Clearinghouse which demonstrates that the requirements within section 3.2 for use of an alternative model have been met.

3.2.2   Requirements

a. Determination of acceptability of an alternative model is an EPA Regional office responsibility in consultation with the EPA's Model Clearinghouse as discussed in paragraphs 3.0(b) and 3.2.1(b). Where the Regional Administrator finds that an alternative model is more appropriate than a preferred model, that model may be used subject to the approval of the EPA Regional office based on the requirements of this subsection. 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 technique is available and applicable.

b. An alternative model shall 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 may be approved for use:

i. If a demonstration can be made that the model produces concentration estimates equivalent to the estimates obtained using a preferred model;

ii. 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 given application than a comparable model in Addendum A; or

iii. If there is no preferred model.

Any one of these three separate conditions may justify use of an alternative model. Some known alternative models that are applicable for selected situations are listed on the EPA's SCRAM Web site (section 2.3). However, inclusion there does not confer any unique status relative to other alternative models that are being or will be developed in the future.

c. Equivalency, condition (1) in paragraph (b) of this subsection, is established by demonstrating that the appropriate regulatory metric(s) 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 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. However, notwithstanding this demonstration, models that are not equivalent may be used when one of the two other conditions described in paragraphs (d) and (e) of this subsection are satisfied.

d. For condition (2) in paragraph (b) of this subsection, established statistical performance evaluation procedures and techniques[28, 29] for determining the acceptability of a model for an individual case based on superior performance should be followed, as appropriate. Preparation and implementation of an evaluation protocol that is acceptable to both control agencies and regulated industry is an important element in such an evaluation.

e. Finally, for condition (3) in paragraph (b) of this subsection, an alternative model or technique may be approved for use provided that:

i. The model or technique has received a scientific peer review;

ii. The model or technique can be demonstrated to be applicable to the problem on a theoretical basis;

iii. The databases which are necessary to perform the analysis are available and adequate;

iv. Appropriate performance evaluations of the model or technique have shown that the model or technique is not inappropriately biased for regulatory application[a]; and

v. A protocol on methods and procedures to be followed has been established.

f. To formally document that the requirements of section 3.2 for use of an alternative model

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[a] For PSD and other applications that use the model results in an absolute sense, the model should not be biased toward underestimates. Alternatively, for ozone and $PM_{2.5}$ SIP attainment demonstrations and other applications that use the model results in a relative sense, the model should not be biased toward overestimates.

are satisfied for a particular application or range of applications, a memorandum will be prepared by the EPA's Model Clearinghouse through a consultative process with the EPA Regional office.

3.3 EPA's Model Clearinghouse

a. The Regional Administrator has the authority to select models that are appropriate for use in a given situation. However, there is a need for assistance and guidance in the selection process so that fairness, consistency, and transparency in modeling decisions are fostered among the EPA Regional offices and the State, local, and Tribal agencies. To satisfy that need, the EPA established the Model Clearinghouse[23] to serve a central role of coordination and collaboration between EPA headquarters and the EPA Regional offices. Additionally, the EPA holds periodic workshops with EPA Headquarters, EPA Regional offices, and State, local, and Tribal agency modeling representatives.

b. The appropriate EPA Regional office should always be consulted for information and guidance concerning modeling methods and interpretations of modeling guidance, and to ensure that the air quality model user has available the latest most up-to-date policy and procedures. As appropriate, the EPA Regional office may also request assistance from the EPA's Model Clearinghouse on other applications of models, analytical techniques, or databases or to clarify interpretation of the *Guideline* or related modeling guidance.

c. The EPA Regional office will coordinate with the EPA's Model Clearinghouse after an initial evaluation and decision has been developed concerning the application of an alternative model. The acceptability and formal approval process for an alternative model is described in section 3.2.

4.0 Models for Carbon Monoxide, Lead, Sulfur Dioxide, Nitrogen Dioxide and Primary Particulate Matter

4.1   Discussion

a. This section identifies modeling approaches generally used in the air quality impact analysis of sources that emit the criteria pollutants carbon monoxide (CO), lead, sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and primary particulates ($PM_{2.5}$ and PM_{10}).

b. The guidance in this section is specific to the application of the Gaussian plume models identified in Addendum A. Gaussian plume models assume that emissions and meteorology are in a steady-state, which is typically based on an hourly time step. This approach results in a plume that has an hourly-averaged distribution of emission mass according to a Gaussian curve through the plume. Though Gaussian steady-state models conserve the mass of the primary pollutant throughout the plume, they can still take into account a limited consideration of first-order removal processes (*e.g.*, wet and dry deposition) and limited chemical conversion (*e.g.*, OH oxidation).

c. Due to the steady-state assumption, Gaussian plume models are generally considered applicable to distances less than 50 km, beyond which, modeled predictions of plume impact are likely conservative. The locations of these impacts are expected to be unreliable due to changes in meteorology that are likely to occur during the travel time.

d. The applicability of Gaussian plume models may vary depending on the topography of the modeling domain, *i.e.*, simple or complex. Simple terrain is considered to be an area where terrain features are all lower in elevation than the top of the stack(s) of the source(s) in question. Complex terrain is defined as terrain exceeding the height of the stack(s) being modeled.

e. Gaussian models determine source impacts at discrete locations (receptors) for each meteorological and emission scenario, and generally attempt to estimate concentrations at specific sites that represent an ensemble average of numerous repetitions of the same "event."

Uncertainties in model estimates are driven by this formulation, and as noted in section 2.1.1, evaluations of model accuracy should focus on the reducible uncertainty associated with physics and the formulation of the model. The "irreducible" uncertainty associated with Gaussian plume models may be responsible for variation in concentrations of as much as +/- 50 percent.[30] "Reducible" uncertainties[16] can be on a similar scale. For example, Pasquill [31] estimates that, apart from data input errors, maximum ground-level concentrations at a given hour for a point source in flat terrain could be in error by 50 percent due to these uncertainties. Errors of 5 to 10 degrees in the measured wind direction can result in concentration errors of 20 to 70 percent for a particular time and location, depending on stability and station location. Such uncertainties do not indicate that an estimated concentration does not occur, only that the precise time and locations are in doubt. Composite errors in highest estimated concentrations of 10 to 40 percent are found to be typical.[32, 33] However, estimates of concentrations paired in time and space with observed concentrations are less certain.

f. Model evaluations and inter-comparisons should take these aspects of uncertainty into account. For a regulatory application of a model, the emphasis of model evaluations is generally placed on the highest modeled impacts. Thus, the Cox-Tikvart model evaluation approach, which compares the highest modeled impacts on several timescales, is recommended for comparisons of models and measurements and model inter-comparisons. The approach includes bootstrap techniques to determine the significance of various modeled predictions and increases the robustness of such comparisons when the number of available measurements are limited.[34, 35] Because of the uncertainty in paired modeled and observed concentrations, any attempts at calibration of models based on these comparisons is of questionable benefit and shall not be done.

4.2 Requirements

a. For NAAQS compliance demonstrations under PSD, use of the screening and preferred models for the pollutants listed in this subsection shall be limited to the near-field at a nominal distance of 50 km or less. Near-field application is consistent with capabilities of Gaussian plume models and, based on the EPA's assessment, is sufficient to address whether a source will cause or contribute to ambient concentrations in excess of a NAAQS. In most cases, maximum source impacts of inert pollutants will occur within the first 10 to 20 km from the source. Therefore, the EPA does not consider a long-range transport assessment beyond 50 km necessary for these pollutants if a near-field NAAQS compliance demonstration is required.[36]

b. For assessment of PSD increments within the near-field distance of 50 km or less, use of the screening and preferred models for the pollutants listed in this subsection shall be limited to the same screening and preferred models approved for NAAQS compliance demonstrations.

c. To determine if a compliance demonstration for NAAQS and/or PSD increments may be necessary beyond 50 km (*i.e.*, long-range transport assessment), the following screening approach shall be used to determine if a significant ambient impact will occur with particular focus on Class I areas and/or the applicable receptors that may be threatened at such distances.

i. Based on application in the near-field of the appropriate screening and/or preferred model, determine the significance of the ambient impacts at or about 50 km from the new or modifying source. If a near-field assessment is not available or this initial analysis indicates there may be significant ambient impacts at that distance, then further assessment is necessary.

ii. For assessment of the significance of ambient impacts for NAAQS and/or PSD increments, there is not a preferred model or screening approach for distances beyond 50 km. Thus, the appropriate reviewing authority (paragraph 3.0(b)) and the EPA Regional office shall

be consulted in determining the appropriate and agreed upon screening technique to conduct the second level assessment. Typically, a Lagrangian model is most appropriate to use for these second level assessments, but applicants shall reach agreement on the specific model and modeling parameters on a case-by-case basis in consultation with the appropriate reviewing authority (paragraph 3.0(b)) and EPA Regional office. When Lagrangian models are used in this manner, they shall not include plume-depleting processes, such that model estimates are considered conservative, as is generally appropriate for screening assessments.

d. In those situations where a cumulative impact analysis for NAAQS and/or PSD increments analysis beyond 50 km is necessary, the selection and use of an alternative model shall occur in agreement with the appropriate reviewing authority (paragraph 3.0(b)) and approval by the EPA Regional office based on the requirements of paragraph 3.2.2(e).

4.2.1   Screening Models and Techniques

a. Where a preliminary or conservative estimate is desired, point source screening techniques are an acceptable approach to air quality analyses.

b. As discussed in paragraph 2.2(a), screening models or techniques are designed to provide a conservative estimate of concentrations. The screening models used in most applications are the screening versions of the preferred models for refined applications. The two screening models, AERSCREEN[37, 38] and CTSCREEN, are screening versions of AERMOD (American Meteorological Society (AMS)/EPA Regulatory Model) and CTDMPLUS (Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations), respectively. AERSCREEN is the recommended screening model for most applications in all types of terrain and for applications involving building downwash. For those applications in complex terrain where the application involves a well-defined hill or ridge, CTSCREEN[39] can be used.

c. Although AERSCREEN and CTSCREEN are designed to address a single-source scenario, there are approaches that can be used on a case-by-case basis to address multi-source situations using screening meteorology or other conservative model assumptions. However, the appropriate reviewing authority (paragraph 3.0(b)) shall be consulted, and concurrence obtained, on the protocol for modeling multiple sources with AERSCREEN or CTSCREEN to ensure that the worst case is identified and assessed.

d. As discussed in section 4.2.3.4, there are also screening techniques built into AERMOD that use simplified or limited chemistry assumptions for determining the partitioning of NO and NO_2 for NO_2 modeling. These screening techniques are part of the EPA's preferred modeling approach for NO_2 and do not need to be approved as an alternative model. However, as with other screening models and techniques, their usage shall occur in agreement with the appropriate reviewing authority (paragraph 3.0(b)).

e. As discussed in section 4.2(c)(ii), there are screening techniques needed for long-range transport assessments that will typically involve the use of a Lagrangian model. Based on the long-standing practice and documented capabilities of these models for long-range transport assessments, the use of a Lagrangian model as a screening technique for this purpose does not need to be approved as an alternative model. However, their usage shall occur in consultation with the appropriate reviewing authority (paragraph 3.0(b)) and the EPA Regional office.

f. All screening models and techniques shall be configured to appropriately address the site and problem at hand. Close attention must be paid to whether the area should be classified urban or rural in accordance with section 7.2.1.1. The climatology of the area must be studied to help define the worst-case meteorological conditions. Agreement shall be reached between the model user and the appropriate reviewing authority (paragraph 3.0(b)) on the choice of the screening

model or technique for each analysis, on the input data and model settings, and the appropriate metric for satisfying regulatory requirements.

4.2.1.1   AERSCREEN

a. Released in 2011, AERSCREEN is the EPA's recommended screening model for simple and complex terrain for single sources including point sources, area sources, horizontal stacks, capped stacks, and flares. AERSCREEN runs AERMOD in a screening mode and consists of two main components: 1) the MAKEMET program which generates a site-specific matrix of meteorological conditions for input to the AERMOD model; and 2) the AERSCREEN command-prompt interface.

b. The MAKEMET program generates a matrix of meteorological conditions, in the form of AERMOD-ready surface and profile files, based on user-specified surface characteristics, ambient temperatures, minimum wind speed, and anemometer height. The meteorological matrix is generated based on looping through a range of wind speeds, cloud covers, ambient temperatures, solar elevation angles, and convective velocity scales (w*, for convective conditions only) based on user-specified surface characteristics for surface roughness (Z_o), Bowen ratio (B_o), and albedo (r). For unstable cases, the convective mixing height (Z_{ic}) is calculated based on w*, and the mechanical mixing height (Z_{im}) is calculated for unstable and stable conditions based on the friction velocity, u*.

c. For applications involving simple or complex terrain, AERSCREEN interfaces with AERMAP. AERSCREEN also interfaces with BPIPPRM to provide the necessary building parameters for applications involving building downwash using the Plume Rise Model Enhancements (PRIME) downwash algorithm. AERSCREEN generates inputs to AERMOD via MAKEMET, AERMAP, and BPIPPRM and invokes AERMOD in a screening mode. The

screening mode of AERMOD forces the AERMOD model calculations to represent values for the plume centerline, regardless of the source-receptor-wind direction orientation. The maximum concentration output from AERSCREEN represents a worst-case 1-hour concentration. Averaging-time scaling factors of 1.0 for 3-hour, 0.9 for 8-hour, 0.60 for 24-hour, and 0.10 for annual concentration averages are applied internally by AERSCREEN to the highest 1-hour concentration calculated by the model for non-area type sources. For area type source concentrations for averaging times greater than one hour, the concentrations are equal to the 1-hour estimates.[37, 40]

4.2.1.2 CTSCREEN

a. CTSCREEN[39, 41] can 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 terrain data must be digitized in the same manner as for CTDMPLUS and a terrain processor is available.[42] CTSCREEN is designed to execute a fixed matrix of meteorological values for wind speed (u), standard deviation of horizontal and vertical wind speeds (σv, σw), 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. 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.

4.2.1.3 Screening in Complex Terrain

a. For applications utilizing AERSCREEN, AERSCREEN automatically generates a polar-

grid receptor network with spacing determined by the maximum distance to model. If the application warrants a different receptor network than that generated by AERSCREEN, it may be necessary to run AERMOD in screening mode with a user-defined network. For CTSCREEN applications or AERMOD in screening mode outside of AERSCREEN, 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. Under such conditions, the plume 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.

b. For applications involving AERSCREEN, AERSCREEN interfaces with AERMAP to generate the receptor elevations. For applications involving CTSCREEN, digitized contour data must be preprocessed[42] to provide hill shape parameters in suitable input format. The user then supplies receptor locations either through an interactive program that is part of the model or directly, by using a text editor; using both methods to select receptor locations 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.

c. Other screening techniques may be acceptable for complex terrain cases where established procedures[43] are used. The user is encouraged to confer with the appropriate reviewing authority (paragraph 3.0(b)) if any unforeseen problems are encountered, *e.g.*, applicability, meteorological data, receptor siting, or terrain contour processing issues.

4.2.2   Refined Models

a. Addendum A provides a brief description of each preferred model for refined applications. Also listed in that addendum are availability, the model input requirements, the standard options that shall be selected when running the program, and output options.

4.2.2.1   AERMOD

a. For a wide range of regulatory applications in all types of terrain, and for aerodynamic building downwash, the required model is AERMOD.[44, 45] The AERMOD regulatory modeling system consists of the AERMOD dispersion model, the AERMET meteorological processor, and the AERMAP terrain processor. AERMOD is a steady-state Gaussian plume model applicable to directly emitted air pollutants that employs best state-of-practice parameterizations for characterizing the meteorological influences and dispersion. Differentiation of simple versus complex terrain is unnecessary with AERMOD. In complex terrain, AERMOD employs the well-known dividing-streamline concept in a simplified simulation of the effects of plume-terrain interactions.

b. The AERMOD Modeling System has been extensively evaluated across a wide range of scenarios based on numerous field studies, including tall stacks in flat and complex terrain settings, sources subject to building downwash influences, and low-level non-buoyant sources.[27] These evaluations included several long-term field studies associated with operating plants as well as several intensive tracer studies. Based on these evaluations, AERMOD has shown consistently good performance, with "errors" in predicted versus observed peak concentrations, based on the Robust Highest Concentration (RHC) metric, consistently within the range of 10 to 40 percent (cited in paragraph 4.1(e)).

c. AERMOD incorporates the PRIME algorithm to account for enhanced plume growth and

restricted plume rise for plumes affected by building wake effects.[46] The PRIME algorithm

accounts for entrainment of plume mass into the cavity recirculation region, including re-

entrainment of plume mass into the wake region beyond the cavity.

d. AERMOD incorporates the Buoyant Line and Point Source (BLP) Dispersion model to

account for buoyant plume rise from line sources. The BLP option utilizes the standard

meteorological inputs provided by the AERMET meteorological processor.

e. The state-of-the-science for modeling atmospheric deposition is evolving, new modeling

techniques are continually being assessed, and their results are being compared with

observations. Consequently, while deposition treatment is available in AERMOD, the approach

taken for any purpose shall be coordinated with the appropriate reviewing authority (paragraph

3.0(b)).

f. The AERMET meteorological processor incorporates the COARE algorithms to derive

marine boundary layer parameters for overwater applications of AERMOD.[47, 48] AERMOD is

applicable for some overwater applications when platform downwash and shoreline fumigation

are adequately considered in consultation with the Regional office and appropriate reviewing

authority. Where the effects of shoreline fumigation and platform downwash need to be assessed,

the Offshore and Coastal Dispersion (OCD) model is the applicable model (paragraph 4.2.2.3).

4.2.2.2   CTDMPLUS

a. If the modeling application involves an elevated point source with a well-defined hill or

ridge and a detailed dispersion analysis of the spatial pattern of plume impacts is of interest,

CTDMPLUS is available. CTDMPLUS provides greater resolution of concentrations about the

contour of the hill feature than does AERMOD through a different plume-terrain interaction

algorithm.

4.2.2.3   OCD

a. The OCD (Offshore and Coastal Dispersion) model is a straight-line Gaussian model that incorporates overwater plume transport and dispersion as well as changes that occur as the plume crosses the shoreline. The OCD model can determine the impact of offshore emissions from point, area, or line sources on the air quality of coastal regions. The OCD model is also applicable for situations that involve platform building downwash.

4.2.3   Pollutant Specific Modeling Requirements

4.2.3.1   Models for Carbon Monoxide

a. Models for assessing the impact of CO emissions are needed to meet NSR requirements to address compliance with the CO NAAQS and to determine localized impacts from transportations projects. Examples include evaluating effects of point sources, congested roadway intersections and highways, as well as the cumulative effect of numerous sources of CO in an urban area.

b. The general modeling recommendations and requirements for screening models in section 4.2.1 and refined models in section 4.2.2 shall be applied for CO modeling. Given the relatively low CO background concentrations, screening techniques are likely to be adequate in most cases. In applying these recommendations and requirements, the existing 1992 EPA guidance for screening CO impacts from highways may be consulted.[49]

4.2.3.2   Models for Lead

a. In January 1999 (40 CFR part 58, appendix D), the EPA gave notice that concern about ambient lead impacts was being shifted away from roadways and toward a focus on stationary point sources. Thus, models for assessing the impact of lead emissions are needed to meet NSR requirements to address compliance with the lead NAAQS and for SIP attainment

demonstrations. The EPA has also issued guidance on siting ambient monitors in the vicinity of stationary point sources.[50] For lead, the SIP should contain an air quality analysis to determine the maximum rolling 3-month average lead concentration resulting from major lead point sources, such as smelters, gasoline additive plants, etc. The EPA has developed a post-processor to calculate rolling 3-month average concentrations from model output.[51] General guidance for lead SIP development is also available.[52]

b. For major lead point sources, such as smelters, which contribute fugitive emissions and for which deposition is important, professional judgment should be used, and there shall be coordination with the appropriate reviewing authority (paragraph 3.0(b)). For most applications, the general requirements for screening and refined models of section 4.2.1 and 4.2.2 are applicable to lead modeling.

4.2.3.3   Models for Sulfur Dioxide

a. Models for SO_2 are needed to meet NSR requirements to address compliance with the SO_2 NAAQS and PSD increments, for SIP attainment demonstrations,[53] and for characterizing current air quality via modeling.[54] SO_2 is one of a group of highly reactive gases known as "oxides of sulfur" with largest emissions sources being fossil fuel combustion at power plants and other industrial facilities.

b. Given the relatively inert nature of SO_2 on the short-term time scales of interest (*i.e.*, 1-hour) and the sources of SO_2 (*i.e.,* stationary point sources), the general modeling requirements for screening models in section 4.2.1 and refined models in section 4.2.2 are applicable for SO_2 modeling applications. For urban areas, AERMOD automatically invokes a half-life of 4 hours[55] to SO_2. Therefore, care must be taken when determining whether a source is urban or rural (*see* section 7.2.1.1 for urban/rural determination methodology).

4.2.3.4   Models for Nitrogen Dioxide

a. Models for assessing the impact of sources on ambient NO_2 concentrations are needed to meet NSR requirements to address compliance with the NO_2 NAAQS and PSD increments. Impact of an individual source on ambient NO_2 depends, in part, on the chemical environment into which the source's plume is to be emitted. This is due to the fact that NO_2 sources co-emit NO along with NO_2 and any emitted NO may react with ambient ozone to convert to additional NO_2 downwind. Thus, comprehensive modeling of NO_2 would need to consider the ratio of emitted NO and NO_2, the ambient levels of ozone and subsequent reactions between ozone and NO, and the photolysis of NO_2 to NO.

b. Due to the complexity of NO_2 modeling, a multi-tiered screening approach is required to obtain hourly and annual average estimates of NO_2.[56] Since these methods are considered screening techniques, their usage shall occur in agreement with the appropriate reviewing authority (paragraph 3.0(b)). Additionally, since screening techniques are conservative by their nature, there are limitations to how these options can be used. Specifically, modeling of negative emissions rates should only be done after consultation with the EPA Regional office to ensure that decreases in concentrations would not be overestimated. Each tiered approach (*see* Figure 4-1) accounts for increasingly complex considerations of NO_2 chemistry and is described in paragraphs c through e of this subsection. The tiers of NO_2 modeling include:

i. A first-tier (most conservative) "full" conversion approach;

ii. A second-tier approach that assumes ambient equilibrium between NO and NO_2; and

iii. A third-tier consisting of several detailed screening techniques that account for ambient ozone and the relative amount of NO and NO_2 emitted from a source.

c. For Tier 1, use an appropriate refined model (section 4.2.2) to estimate nitrogen oxides

(NO_x) concentrations and assume a total conversion of NO to NO_2.

d. For Tier 2, multiply the Tier 1 result(s) by the Ambient Ratio Method 2 (ARM2), which provides estimates of representative equilibrium ratios of NO_2/NO_x value based ambient levels of NO_2 and NO_x derived from national data from the EPA's Air Quality System (AQS).[57] The national default for ARM2 includes a minimum ambient NO_2/NO_x ratio of 0.5 and a maximum ambient ratio of 0.9. The reviewing agency may establish alternative minimum ambient NO_2/NO_x values based on the source's in-stack emissions ratios, with alternative minimum ambient ratios reflecting the source's in-stack NO_2/NO_x ratios. Preferably, alternative minimum ambient NO_2/NO_x ratios should be based on source-specific data which satisfies all quality assurance procedures that ensure data accuracy for both NO_2 and NO_x within the typical range of measured values. However, alternate information may be used to justify a source's anticipated NO_2/NO_x in-stack ratios, such as manufacturer test data, State or local agency guidance, peer-reviewed literature, and/or the EPA's NO_2/NO_x ratio database.

e. For Tier 3, a detailed screening technique shall be applied on a case-by-case basis. Because of the additional input data requirements and complexities associated with the Tier 3 options, their usage shall occur in consultation with the EPA Regional office in addition to the appropriate reviewing authority. The Ozone Limiting Method (OLM)[58], the Plume Volume Molar Ratio Method (PVMRM)[59], and the Generic Set Reaction Method (GRSM)[60, 61] are three detailed screening techniques that may be used for most sources. These three techniques use an appropriate section 4.2.2 model to estimate NO_x concentrations and then estimate the conversion of primary NO emissions to NO_2 based on the ambient levels of ozone and the plume characteristics. OLM only accounts for NO_2 formation based on the ambient levels of ozone while PVMRM and GRSM also accommodate distance-dependent conversion ratios based on

ambient ozone. GRSM, PVMRM and OLM require explicit specification of the NO_2/NO_x in-stack ratios and that ambient ozone concentrations be provided on an hourly basis. GRSM requires hourly ambient NO_x concentrations in addition to hourly ozone.

f. Alternative models or techniques may be considered on a case-by-case basis and their usage shall be approved by the EPA Regional office (section 3.2). Such models or techniques should consider individual quantities of NO and NO_2 emissions, atmospheric transport and dispersion, and atmospheric transformation of NO to NO_2. Dispersion models that account for more explicit photochemistry may also be considered as an alternative model to estimate ambient impacts of NO_x sources.

Tier 1: Full Conversion	Assume total conversion of NO to NO_2
	↓
Tier 2: Ambient Ratio Method	Multiply Tier 1 results by an appropriate ambient ratio
	↓
Tier 3: Detailed Screening	Detailed analysis with OLM, PVMRM, GRSM or other alternative screening model or technique
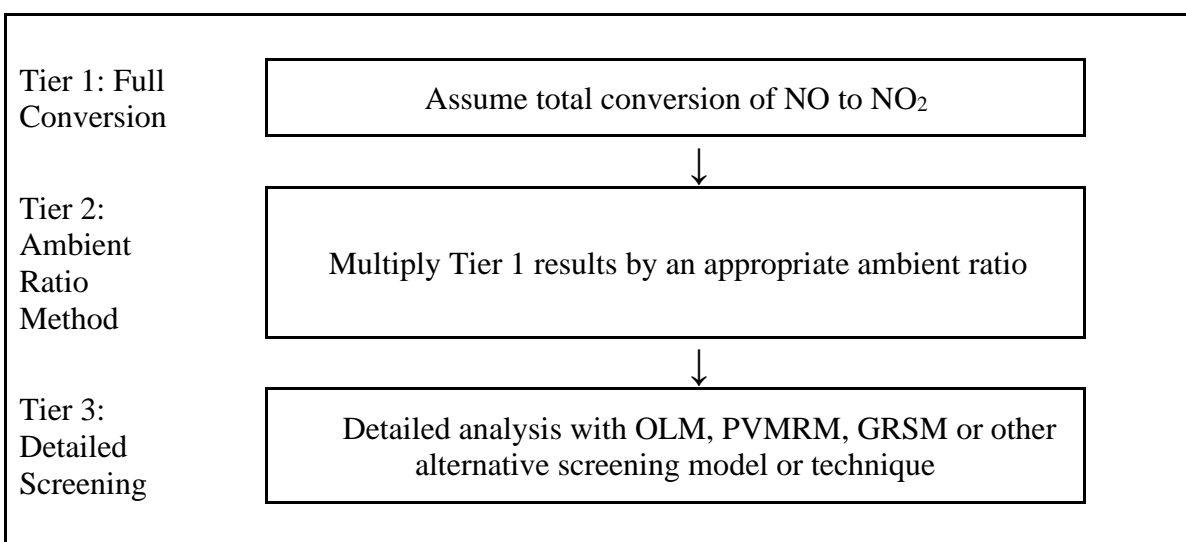
Figure 4-1: Multi-tiered Approach for Estimating NO2 Concentrations

4.2.3.5   Models for $PM_{2.5}$

a. $PM_{2.5}$ is a mixture consisting of several diverse components.[62] Ambient $PM_{2.5}$ generally consists of two components: 1) the primary component, emitted directly from a source; and 2) the secondary component, formed in the atmosphere from other pollutants emitted from the source. Models for $PM_{2.5}$ are needed to meet NSR requirements to address compliance with the $PM_{2.5}$ NAAQS and PSD increments and for SIP attainment demonstrations.

b. For NSR modeling assessments, the general modeling requirements for screening models in section 4.2.1 and refined models in section 4.2.2 are applicable for the primary component of $PM_{2.5}$, while the methods in section 5.4 are applicable for addressing the secondary component of $PM_{2.5}$. Guidance for PSD assessments is available for determining the best approach to handling sources of primary and secondary $PM_{2.5}$.[63]

c. For SIP attainment demonstrations and regional haze reasonable progress goal analyses, effects of a control strategy on $PM_{2.5}$ are estimated from the sum of the effects on the primary and secondary components composing $PM_{2.5}$. Model users should refer to section 5.4.1 and associated SIP modeling guidance[64] for further details concerning appropriate modeling approaches.

d. The general modeling requirements for the refined models discussed in section 4.2.2 shall be applied for $PM_{2.5}$ hot-spot modeling for mobile sources. Specific guidance is available for analyzing direct $PM_{2.5}$ impacts from highways, terminals, and other transportation projects.[65]

4.2.3.6   Models for PM_{10}

a. Models for PM_{10} are needed to meet NSR requirements to address compliance with the PM_{10} NAAQS and PSD increments and for SIP attainment demonstrations.

b. For most sources, the general modeling requirements for screening models in section 4.2.1 and refined models in section 4.2.2 shall be applied for PM_{10} modeling. In cases where the particle size and its effect on ambient concentrations need to be considered, particle deposition may be used on a case-by-case basis and their usage shall be coordinated with the appropriate reviewing authority. A SIP development guide[66] is also available to assist in PM_{10} analyses and control strategy development.

c. Fugitive dust usually refers to dust put into the atmosphere by the wind blowing over

plowed fields, dirt roads, or desert or sandy areas with little or no vegetation. Fugitive emissions include the emissions resulting from the industrial process that are not captured and vented through a stack, but may be released from various locations within the complex. In some unique cases, a model developed specifically for the situation may be needed. Due to the difficult nature of characterizing and modeling fugitive dust and fugitive emissions, the proposed procedure shall be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)) for each specific situation before the modeling exercise is begun. Re-entrained dust is created by vehicles driving over dirt roads (*e.g.*, haul roads) and dust-covered roads typically found in arid areas. Such sources can be characterized as line, area or volume sources.[65, 67] Emission rates may be based on site-specific data or values from the general literature.

d. Under certain conditions, recommended dispersion models may not be suitable to appropriately address the nature of ambient PM_{10}. In these circumstances, the alternative modeling approach shall be approved by the EPA Regional office (section 3.2).

e. The general modeling requirements for the refined models discussed in section 4.2.2 shall be applied for PM_{10} hot-spot modeling for mobile sources. Specific guidance is available for analyzing direct PM_{10} impacts from highways, terminals, and other transportation projects.[65]

5.0 Models for Ozone and Secondarily Formed Particulate Matter

5.1 Discussion

a. Air pollutants formed through chemical reactions in the atmosphere are referred to as secondary pollutants. For example, ground-level ozone and a portion of $PM_{2.5}$ are secondary pollutants formed through photochemical reactions. Ozone and secondarily formed particulate matter are closely related to each other in that they share common sources of emissions and are formed in the atmosphere from chemical reactions with similar precursors.

b. Ozone formation is driven by emissions of NO_x and volatile organic compounds (VOCs). Ozone formation is a complicated nonlinear process that requires favorable meteorological conditions in addition to VOC and NO_x emissions. Sometimes complex terrain features also contribute to the build-up of precursors and subsequent ozone formation or destruction.

c. $PM_{2.5}$ can be either primary (*i.e.*, emitted directly from sources) or secondary in nature. The fraction of $PM_{2.5}$ which is primary versus secondary varies by location and season. In the United States, $PM_{2.5}$ is dominated by a variety of chemical species or components of atmospheric particles, such as ammonium sulfate, ammonium nitrate, organic carbon mass, elemental carbon, and other soil compounds and oxidized metals. $PM_{2.5}$ sulfate, nitrate, and ammonium ions are predominantly the result of chemical reactions of the oxidized products of SO_2 and NO_x emissions with direct ammonia emissions.[68]

d. Control measures reducing ozone and $PM_{2.5}$ precursor emissions may not lead to proportional reductions in ozone and $PM_{2.5}$. Modeled strategies designed to reduce ozone or $PM_{2.5}$ levels typically need to consider the chemical coupling between these pollutants. This coupling is important in understanding processes that control the levels of both pollutants. Thus, when feasible, it is important to use models that take into account the chemical coupling between ozone and $PM_{2.5}$. In addition, using such a multi-pollutant modeling system can reduce the resource burden associated with applying and evaluating separate models for each pollutant and promotes consistency among the strategies themselves.

e. $PM_{2.5}$ is a mixture consisting of several diverse chemical species or components of atmospheric particles. Because chemical and physical properties and origins of each component differ, it may be appropriate to use either a single model capable of addressing several of the important components or to model primary and secondary components using different models.

Effects of a control strategy on $PM_{2.5}$ is estimated from the sum of the effects on the specific

components comprising $PM_{2.5}$.

5.2   Recommendations

a. Chemical transformations can play an important role in defining the concentrations and

properties of certain air pollutants. Models that take into account chemical reactions and physical

processes of various pollutants (including precursors) are needed for determining the current

state of air quality, as well as predicting and projecting the future evolution of these pollutants. It

is important that a modeling system provide a realistic representation of chemical and physical

processes leading to secondary pollutant formation and removal from the atmosphere.

b. Chemical transport models treat atmospheric chemical and physical processes such as

deposition and motion. There are two types of chemical transport models, Eulerian (grid based)

and Lagrangian. These types of models are differentiated from each other by their frame of

reference. Eulerian models are based on a fixed frame of reference and Lagrangian models use a

frame of reference that moves with parcels of air between the source and receptor point.[9]

Photochemical grid models are three-dimensional Eulerian grid-based models that treat chemical

and physical processes in each grid cell and use diffusion and transport processes to move

chemical species between grid cells.[9] These types of models are appropriate for assessment of

near-field and regional scale reactive pollutant impacts from specific sources[7, 10, 11, 12] or all

sources.[13, 14, 15] In some limited cases , the secondary processes can be treated with a box model,

ideally in combination with a number of other modeling techniques and/or analyses to treat

individual source sectors.

c. Regardless of the modeling system used to estimate secondary impacts of ozone and/or

$PM_{2.5}$, model results should be compared to observation data to generate confidence that the

modeling system is representative of the local and regional air quality. For ozone related projects, model estimates of ozone should be compared with observations in both time and space. For $PM_{2.5}$, model estimates of speciated $PM_{2.5}$ components (such as sulfate ion, nitrate ion, etc.) should be compared with observations in both time and space.[69]

d. Model performance metrics comparing observations and predictions are often used to summarize model performance. These metrics include mean bias, mean error, fractional bias, fractional error, and correlation coefficient.[69] There are no specific levels of any model performance metric that indicate "acceptable" model performance. The EPA's preferred approach for providing context about model performance is to compare model performance metrics with similar contemporary applications.[64, 69] Because model application purpose and scope vary, model users should consult with the appropriate reviewing authority (paragraph 3.0(b)) to determine what model performance elements should be emphasized and presented to provide confidence in the regulatory model application.

e. There is no preferred modeling system or technique for estimating ozone or secondary $PM_{2.5}$ for specific source impacts or to assess impacts from multiple sources. For assessing secondary pollutant impacts from single sources, the degree of complexity required to assess potential impacts varies depending on the nature of the source, its emissions, and the background environment. The EPA recommends a two-tiered approach where the first tier consists of using existing technically credible and appropriate relationships between emissions and impacts developed from previous modeling that is deemed sufficient for evaluating a source's impacts. The second tier consists of more sophisticated case-specific modeling analyses. The appropriate tier for a given application should be selected in consultation with the appropriate reviewing authority (paragraph 3.0(b)) and be consistent with EPA guidance.[70]

5.3   Recommended Models and Approaches for Ozone

a. Models that estimate ozone concentrations are needed to guide the choice of strategies for the purposes of a nonattainment area demonstrating future year attainment of the ozone NAAQS. Additionally, models that estimate ozone concentrations are needed to assess impacts from specific sources or source complexes to satisfy requirements for NSR and other regulatory programs. Other purposes for ozone modeling include estimating the impacts of specific events on air quality, ozone deposition impacts, and planning for areas that may be attaining the ozone NAAQS.

5.3.1   Models for NAAQS Attainment Demonstrations and Multi-Source Air Quality Assessments

a. Simulation of ozone formation and transport is a complex exercise. Control agencies with jurisdiction over areas with ozone problems should use photochemical grid models to evaluate the relationship between precursor species and ozone. Use of photochemical grid models is the recommended means for identifying control strategies needed to address high ozone concentrations in such areas. Judgment on the suitability of a model for a given application should consider factors that include use of the model in an attainment test, development of emissions and meteorological inputs to the model, and choice of episodes to model. Guidance on the use of models and other analyses for demonstrating attainment of the air quality goals for ozone is available.[63, 64] Users should consult with the appropriate reviewing authority (paragraph 3.0(b)) to ensure the most current modeling guidance is applied.

5.3.2   Models for Single-Source Air Quality Assessments

a. Depending on the magnitude of emissions, estimating the impact of an individual source's emissions of NO_x and VOC on ambient ozone is necessary for obtaining a permit. The

simulation of ozone formation and transport requires realistic treatment of atmospheric chemistry and deposition. Models (*e.g.*, Lagrangian and photochemical grid models) that integrate chemical and physical processes important in the formation, decay, and transport of ozone and important precursor species should be applied. Photochemical grid models are primarily designed to characterize precursor emissions and impacts from a wide variety of sources over a large geographic area but can also be used to assess the impacts from specific sources.[7, 11, 12]

b. The first tier of assessment for ozone impacts involves those situations where existing technical information is available (*e.g.*, results from existing photochemical grid modeling, published empirical estimates of source specific impacts, or reduced-form models) in combination with other supportive information and analysis for the purposes of estimating secondary impacts from a particular source. The existing technical information should provide a credible and representative estimate of the secondary impacts from the project source. The appropriate reviewing authority (paragraph 3.0(b)) and appropriate EPA guidance[70, 71] should be consulted to determine what types of assessments may be appropriate on a case-by-case basis.

c. The second tier of assessment for ozone impacts involves those situations where existing technical information is not available or a first tier demonstration indicates a more refined assessment is needed. For these situations, chemical transport models should be used to address single-source impacts. Special considerations are needed when using these models to evaluate the ozone impact from an individual source. Guidance on the use of models and other analyses for demonstrating the impacts of single sources for ozone is available.[70] This guidance document provides a more detailed discussion of the appropriate approaches to obtaining estimates of ozone impacts from a single source. Model users should use the latest version of the guidance in consultation with the appropriate reviewing authority (paragraph 3.0(b)) to determine the most

suitable refined approach for single-source ozone modeling on a case-by-case basis.

5.4   Recommended Models and Approaches for Secondarily Formed PM$_{2.5}$

a. Models that estimate PM$_{2.5}$ concentrations are needed to guide the choice of strategies for

the purposes of a nonattainment area demonstrating future year attainment of the PM$_{2.5}$ NAAQS.

Additionally, models that estimate PM$_{2.5}$ concentrations are needed to assess impacts from

specific sources or source complexes to satisfy requirements for NSR and other regulatory

programs. Other purposes for PM$_{2.5}$ modeling include estimating the impacts of specific events

on air quality, visibility, deposition impacts, and planning for areas that may be attaining the

PM$_{2.5}$ NAAQS.

5.4.1   Models for NAAQS Attainment Demonstrations and Multi-Source Air Quality

Assessments

a. Models for PM$_{2.5}$ are needed to assess the adequacy of a proposed strategy for meeting the

annual and 24-hour PM$_{2.5}$ NAAQS. Modeling primary and secondary PM$_{2.5}$ can be a multi-

faceted and complex problem, especially for secondary components of PM$_{2.5}$ such as sulfates and

nitrates. Control agencies with jurisdiction over areas with secondary PM$_{2.5}$ problems should use

models that integrate chemical and physical processes important in the formation, decay, and

transport of these species (*e.g.*, photochemical grid models). Suitability of a modeling approach

or mix of modeling approaches for a given application requires technical judgment as well as

professional experience in choice of models, use of the model(s) in an attainment test,

development of emissions and meteorological inputs to the model, and selection of days to

model. Guidance on the use of models and other analyses for demonstrating attainment of the air

quality goals for PM$_{2.5}$ is available.[63, 64] Users should consult with the appropriate reviewing

authority (paragraph 3.0(b)) to ensure the most current modeling guidance is applied.

5.4.2   Models for Single-Source Air Quality Assessments

a. Depending on the magnitude of emissions, estimating the impact of an individual source's emissions on secondary particulate matter concentrations may be necessary for obtaining a permit. Primary $PM_{2.5}$ components shall be simulated using the general modeling requirements in section 4.2.3.5. The simulation of secondary particulate matter formation and transport is a complex exercise requiring realistic treatment of atmospheric chemistry and deposition. Models should be applied that integrate chemical and physical processes important in the formation, decay, and transport of these species (*e.g.*, Lagrangian and photochemical grid models). Photochemical grid models are primarily designed to characterize precursor emissions and impacts from a wide variety of sources over a large geographic area and can also be used to assess the impacts from specific sources.[7, 10] For situations where a project source emits both primary $PM_{2.5}$ and $PM_{2.5}$ precursors, the contribution from both should be combined for use in determining the source's ambient impact. Approaches for combining primary and secondary impacts are provided in appropriate guidance for single source permit related demonstrations.[70]

b. The first tier of assessment for secondary $PM_{2.5}$ impacts involves those situations where existing technical information is available (*e.g.*, results from existing photochemical grid modeling, published empirical estimates of source specific impacts, or reduced-form models) in combination with other supportive information and analysis for the purposes of estimating secondary impacts from a particular source. The existing technical information should provide a credible and representative estimate of the secondary impacts from the project source. The appropriate reviewing authority (paragraph 3.0(b)) and appropriate EPA guidance[70, 71] should be consulted to determine what types of assessments may be appropriate on a case-by-case basis.

c. The second tier of assessment for secondary $PM_{2.5}$ impacts involves those situations where

existing technical information is not available or a first tier demonstration indicates a more refined assessment is needed. For these situations, chemical transport models should be used for assessments of single-source impacts. Special considerations are needed when using these models to evaluate the secondary particulate matter impact from an individual source. Guidance on the use of models and other analyses for demonstrating the impacts of single sources for secondary $PM_{2.5}$ is available.[70] This guidance document provides a more detailed discussion of the appropriate approaches to obtaining estimates of secondary particulate matter concentrations from a single source. Model users should use the latest version of this guidance in consultation with the appropriate reviewing authority (paragraph 3.0(b)) to determine the most suitable single-source modeling approach for secondary $PM_{2.5}$ on a case-by-case basis.

6.0 Modeling for Air Quality Related Values and Other Governmental Programs

6.1 Discussion

a. Other Federal government agencies and State, local, and Tribal agencies with air quality and land management responsibilities have also developed specific modeling approaches for their own regulatory or other requirements. Although such regulatory requirements and guidance have come about because of EPA rules or standards, the implementation of such regulations and the use of the modeling techniques is under the jurisdiction of the agency issuing the guidance or directive. This section covers such situations with reference to those guidance documents, when they are available.

b. When using the model recommended or discussed in the *Guideline* in support of programmatic requirements not specifically covered by EPA regulations, the model user should consult the appropriate Federal, State, local, or Tribal agency to ensure the proper application and use of the models and/or techniques. These agencies have developed specific modeling

approaches for their own regulatory or other requirements. Most of the programs have, or will have when fully developed, separate guidance documents that cover the program and a discussion of the tools that are needed. The following paragraphs reference those guidance documents, when they are available.

6.2   Air Quality Related Values

a. The 1990 CAA Amendments give FLMs an "affirmative responsibility" to protect the natural and cultural resources of Class I areas from the adverse impacts of air pollution and to provide the appropriate procedures and analysis techniques. The CAA identifies the FLM as the Secretary of the department, or their designee, with authority over these lands. Mandatory Federal Class I areas are defined in the CAA as international parks, national parks over 6,000 acres, and wilderness areas and memorial parks over 5,000 acres, established as of 1977. The FLMs are also concerned with the protection of resources in federally managed Class II areas because of other statutory mandates to protect these areas. Where State or Tribal agencies have successfully petitioned the EPA and lands have been redesignated to Class I status, these agencies may have equivalent responsibilities to that of the FLMs for these non-Federal Class I areas as described throughout the remainder of section 6.2.

b. The FLM agency responsibilities include the review of air quality permit applications from proposed new or modified major pollution sources that may affect these Class I areas to determine if emissions from a proposed or modified source will cause or contribute to adverse impacts on air quality related values (AQRVs) of a Class I area and making recommendations to the FLM. AQRVs are resources, identified by the FLM agencies, that have the potential to be affected by air pollution. These resources may include visibility, scenic, cultural, physical, or ecological resources for a particular area. The FLM agencies take into account the particular

resources and AQRVs that would be affected; the frequency and magnitude of any potential impacts; and the direct, indirect, and cumulative effects of any potential impacts in making their recommendations.

c. While the AQRV notification and impact analysis requirements are outlined in the PSD regulations at 40 CFR 51.166(p) and 40 CFR 52.21(p), determination of appropriate analytical methods and metrics for AQRV's are determined by the FLM agencies and are published in guidance external to the general recommendations of this paragraph.

d. To develop greater consistency in the application of air quality models to assess potential AQRV impacts in both Class I areas and protected Class II areas, the FLM agencies have developed the Federal Land Managers' Air Quality Related Values Work Group Phase I Report (FLAG).[72] FLAG focuses upon specific technical and policy issues associated with visibility impairment, effects of pollutant deposition on soils and surface waters, and ozone effects on vegetation. Model users should consult the latest version of the FLAG report for current modeling guidance and with affected FLM agency representatives for any application specific guidance which is beyond the scope of the *Guideline*.

6.2.1   Visibility

a. Visibility in important natural areas (*e.g.*, Federal Class I areas) is protected under a number of provisions of the CAA, including sections 169A and 169B (addressing impacts primarily from existing sources) and section 165 (new source review). Visibility impairment is caused by light scattering and light absorption associated with particles and gases in the atmosphere. In most areas of the country, light scattering by $PM_{2.5}$ is the most significant component of visibility impairment. The key components of $PM_{2.5}$ contributing to visibility impairment include sulfates, nitrates, organic carbon, elemental carbon, and crustal material.[72]

b. Visibility regulations (40 CFR 51.300 through 51.309) require State, local, and Tribal agencies to mitigate current and prevent future visibility impairment in any of the 156 mandatory Federal Class I areas where visibility is considered an important attribute. In 1999, the EPA issued revisions to the regulations to address visibility impairment in the form of regional haze, which is caused by numerous, diverse sources (*e.g.*, stationary, mobile, and area sources) located across a broad region (40 CFR 51.308 through 51.309). The state of relevant scientific knowledge has expanded significantly since that time. A number of studies and reports[73, 74] have concluded that long-range transport (*e.g.*, up to hundreds of kilometers) of fine particulate matter plays a significant role in visibility impairment across the country. Section 169A of the CAA requires States to develop SIPs containing long-term strategies for remedying existing and preventing future visibility impairment in the 156 mandatory Class I Federal areas, where visibility is considered an important attribute. In order to develop long-term strategies to address regional haze, many State, local, and Tribal agencies will need to conduct regional-scale modeling of fine particulate concentrations and associated visibility impairment.

c. The FLAG visibility modeling recommendations are divided into two distinct sections to address different requirements for: 1) near field modeling where plumes or layers are compared against a viewing background, and 2) distant/multi-source modeling for plumes and aggregations of plumes that affect the general appearance of a scene.[72] The recommendations separately address visibility assessments for sources proposing to locate relatively near and at farther distances from these areas.[72]

6.2.1.1   Models for Estimating Near-Field Visibility Impairment

a. To calculate the potential impact of a plume of specified emissions for specific transport and dispersion conditions ("plume blight") for source-receptor distances less than 50 km, a

screening model and guidance are available.[72, 75] If a more comprehensive analysis is necessary, a refined model should be selected. The model selection, procedures, and analyses should be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)) and the affected FLM(s).

6.2.1.2   Models for Estimating Visibility Impairment for Long-Range Transport

a. Chemical transformations can play an important role in defining the concentrations and properties of certain air pollutants. Models that take into account chemical reactions and physical processes of various pollutants (including precursors) are needed for determining the current state of air quality, as well as predicting and projecting the future evolution of these pollutants. It is important that a modeling system provide a realistic representation of chemical and physical processes leading to secondary pollutant formation and removal from the atmosphere.

b. Chemical transport models treat atmospheric chemical and physical processes such as deposition and motion. There are two types of chemical transport models, Eulerian (grid based) and Lagrangian. These types of models are differentiated from each other by their frame of reference. Eulerian models are based on a fixed frame of reference and Lagrangian models use a frame of reference that moves with parcels of air between the source and receptor point.[9] Photochemical grid models are three-dimensional Eulerian grid-based models that treat chemical and physical processes in each grid cell and use diffusion and transport processes to move chemical species between grid cells.[9] These types of models are appropriate for assessment of near-field and regional scale reactive pollutant impacts from specific sources[7, 10, 11, 12] or all sources.[13, 14, 15]

c. Development of the requisite meteorological and emissions databases necessary for use of photochemical grid models to estimate AQRVs should conform to recommendations in section 8

and those outlined in the EPA's *Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, PM₂.₅, and Regional Haze*.[64] Demonstration of the adequacy of prognostic meteorological fields can be established through appropriate diagnostic and statistical performance evaluations consistent with recommendations provided in the appropriate guidance.[64] Model users should consult the latest version of this guidance and with the appropriate reviewing authority (paragraph 3.0(b)) for any application-specific guidance that is beyond the scope of this subsection.

6.2.2   Models for Estimating Deposition Impacts

a. For many Class I areas, AQRVs have been identified that are sensitive to atmospheric deposition of air pollutants. Emissions of NO_x, sulfur oxides, NH_3, mercury, and secondary pollutants such as ozone and particulate matter affect components of ecosystems. In sensitive ecosystems, these compounds can acidify soils and surface waters, add nutrients that change biodiversity, and affect the ecosystem services provided by forests and natural areas.[72] To address the relationship between deposition and ecosystem effects, the FLM agencies have developed estimates of critical loads. A critical load is defined as, "A quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge."[76]

b. The FLM deposition modeling recommendations are divided into two distinct sections to address different requirements for: 1) near field modeling, and 2) distant/multi-source modeling for cumulative effects. The recommendations separately address deposition assessments for sources proposing to locate relatively near and at farther distances from these areas.[72] Where the source and receptors are not in close proximity, chemical transport (*e.g.*, photochemical grid) models generally should be applied for an assessment of deposition impacts due to one or a small

group of sources. Over these distances, chemical and physical transformations can change atmospheric residence time due to different propensity for deposition to the surface of different forms of nitrate and sulfate. Users should consult the latest version of the FLAG report[72] and relevant FLM representatives for guidance on the use of models for deposition. Where source and receptors are in close proximity, users should contact the appropriate FLM for application-specific guidance.

6.3 Modeling Guidance for Other Governmental Programs

a. Dispersion and photochemical grid modeling may need to be conducted to ensure that individual and cumulative offshore oil and gas exploration, development, and production plans and activities do not significantly affect the air quality of any State as required under the Outer Continental Shelf Lands Act (OCSLA). Air quality modeling requires various input datasets, including emissions sources, meteorology, and pre-existing pollutant concentrations. For sources under the reviewing authority of the Department of Interior, Bureau of Ocean Energy Management (BOEM), guidance for the development of all necessary Outer Continental Shelf (OCS) air quality modeling inputs and appropriate model selection and application is available from the BOEM's Web site: *https://www.boem.gov/about-boem/regulations-guidance/guidance-portal*.

b. The Federal Aviation Administration (FAA) is the appropriate reviewing authority for air quality assessments of primary pollutant impacts at airports and air bases. The Aviation Environmental Design Tool (AEDT) is developed and supported by the FAA, and is appropriate for air quality assessment of primary pollutant impacts at airports or air bases. AEDT has adopted AERMOD for treating dispersion. Application of AEDT is intended for estimating the change in emissions for aircraft operations, point source, and mobile source emissions on airport

property and quantify the associated pollutant level- concentrations. AEDT 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 unrelated to airport operations. The latest version of AEDT may be obtained from the FAA at: *https://aedt.faa.gov*.

7.0   General Modeling Considerations

7.1   Discussion

a. This section contains recommendations concerning a number of different issues not explicitly covered in other sections of the *Guideline*. The topics covered here are not specific to any one program or modeling area, but are common to dispersion modeling analyses for criteria pollutants.

7.2   Recommendations

7.2.1   All sources

7.2.1.1   Dispersion Coefficients

a. For any dispersion modeling exercise, the urban or rural determination of a source is critical in determining the boundary layer characteristics that affect the model's prediction of downwind concentrations. Historically, steady-state Gaussian plume models used in most applications have employed dispersion coefficients based on Pasquill-Gifford[77] in rural areas and McElroy- Pooler[78] in urban areas. These coefficients are still incorporated in the BLP and OCD models. However, the AERMOD model incorporates a more up-to-date characterization of the atmospheric boundary layer using continuous functions of parameterized horizontal and vertical turbulence based on Monin-Obukhov similarity (scaling) relationships.[44] Another key feature of AERMOD's formulation is the option to use directly observed variables of the boundary layer to parameterize dispersion.[44, 45]

b. The selection of rural or urban dispersion coefficients in a specific application should follow one of the procedures suggested by Irwin[79] to determine whether the character of an area is primarily urban or rural (of the two methods, the land use procedure is considered more definitive.):

i. Land Use Procedure: (1) Classify the land use within the total area, A_o, circumscribed by a 3 km radius circle about the source using the meteorological land use typing scheme proposed by Auer;[80] (2) if land use types I1, I2, C1, R2, and R3 account for 50 percent or more of A_o, use urban dispersion coefficients; otherwise, use appropriate rural dispersion coefficients.

ii. Population Density Procedure: (1) Compute the average population density, $\bar{p}$ per square kilometer with A_o as defined above; (2) If $\bar{p}$ is greater than 750 people per square kilometer, use urban dispersion coefficients; otherwise use appropriate rural dispersion coefficients.

c. Population density should be used with caution and generally not be applied to highly industrialized areas where the population density may be low and, thus, a rural classification would be indicated. However, the area is likely to be sufficiently built-up so that the urban land use criteria would be satisfied. Therefore, in this case, the classification should be ''urban'' and urban dispersion parameters should be used.

d. For applications of AERMOD in urban areas, under either the Land Use Procedure or the Population Density Procedure, the user needs to estimate the population of the urban area affecting the modeling domain because the urban influence in AERMOD is scaled based on a user-specified population. For non-population oriented urban areas, or areas influenced by both population and industrial activity, the user will need to estimate an equivalent population to

adequately account for the combined effects of industrialized areas and populated areas within the modeling domain. Selection of the appropriate population for these applications should be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)) and the latest version of the AERMOD Implementation Guide.[81]

e. It should be noted that AERMOD allows for modeling rural and urban sources in a single model run. For analyses of whole urban complexes, the entire area should be modeled as an urban region if most of the sources are located in areas classified as urban. For tall stacks located within or adjacent to small or moderate sized urban areas, the stack height or effective plume height may extend above the urban boundary layer and, therefore, may be more appropriately modeled using rural coefficients. Model users should consult with the appropriate reviewing authority (paragraph 3.0(b)) and the latest version of the AERMOD Implementation Guide[81] when evaluating this situation.

f. Buoyancy-induced dispersion (BID), as identified by Pasquill,[82] is included in the preferred models and should be used where buoyant sources (*e.g.*, those involving fuel combustion) are involved.

7.2.1.2   Complex Winds

a. *Inhomogeneous local winds*. In many parts of the United States, the ground is neither flat nor is the ground cover (or land use) uniform. These geographical variations can generate local winds and circulations, and modify the prevailing ambient winds and circulations. Typically, geographic effects are more apparent when the ambient winds are light or calm, as stronger synoptic or mesoscale winds can modify, or even eliminate the weak geographic circulations.[83] In general, these geographically induced wind circulation effects are named after the source location of the winds, *e.g.*, lake and sea breezes, and mountain and valley winds. In very rugged

hilly or mountainous terrain, along coastlines, or near large land use variations, the characteristics of the winds are a balance of various forces, such that the assumptions of steady-state straight-line transport both in time and space are inappropriate. In such cases, a model should be chosen to fully treat the time and space variations of meteorology effects on transport and dispersion. The setup and application of such a model should be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)) consistent with limitations of paragraph 3.2.2(e). The meteorological input data requirements for developing the time and space varying three-dimensional winds and dispersion meteorology for these situations are discussed in paragraph 8.4.1.2(c). Examples of inhomogeneous winds include, but are not limited to, situations described in the following paragraphs:

i. *Inversion breakup fumigation*. Inversion breakup 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 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[40] that may be used to approximate the concentrations. Considerable care should be exercised in using the results obtained from the screening techniques.

ii. *Shoreline fumigation*. Fumigation can be 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 EPA has evaluated several coastal fumigation models, and the evaluation results of

these models are available for their possible application on a case-by-case basis when air quality estimates under shoreline fumigation conditions are needed.[84] Selection of the appropriate model for applications where shoreline fumigation is of concern should be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)).

   iii. *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. If point sources are of interest, users should note the guidance provided in paragraph (a) of this subsection. Selection of the appropriate model for applications where stagnation is of concern should be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)).

7.2.1.3   Gravitational Settling and Deposition

   a. Gravitational settling and deposition may be directly included in a model if either is a significant factor. When particulate matter sources can be quantified and settling and dry deposition are problems, use professional judgment along with coordination with the appropriate reviewing authority (paragraph 3.0(b)). AERMOD contains algorithms for dry and wet deposition of gases and particles.[85] For other Gaussian plume models, an "infinite half-life" may be used for estimates of particle concentrations when only exponential decay terms are used for treating settling and deposition. Lagrangian models have varying degrees of complexity for dealing with settling and deposition and the selection of a parameterization for such should be included in the approval process for selecting a Lagrangian model. Eulerian grid models tend to have explicit parameterizations for gravitational settling and deposition as well as wet deposition

parameters already included as part of the chemistry scheme.

7.2.2   Stationary Sources

7.2.2.1   Good Engineering Practice Stack Height

a. 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 emissions limits by 40 CFR 51.118 and 40 CFR 51.164. The definition 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 several references,[86, 87, 88, 89] that provide a great deal of additional information for evaluating and describing building cavity and wake effects.

b. If stacks for new or existing major sources are found to be less than the height defined by the EPA's refined formula for determining GEP height, then air quality impacts associated with cavity or wake effects due to the nearby building structures should be determined. The EPA refined formula height is defined as H + 1.5L.[88] Since the definition of GEP stack height defines excessive concentrations as a maximum ground-level concentration due in whole or in part to downwash of at least 40 percent in excess of the maximum concentration without downwash, the potential air quality impacts associated with cavity and wake effects should also be considered for stacks that equal or exceed the EPA formula height for GEP. The AERSCREEN model can be used to obtain screening estimates of potential downwash influences, based on the PRIME downwash algorithm incorporated in the AERMOD model. If more refined concentration estimates are required, AERMOD should be used (section 4.2.2).

7.2.2.2   Plume Rise

a. The plume rise methods of Briggs[90, 91] are incorporated in many of the preferred models

and are recommended for use in many modeling applications. In AERMOD,[44, 45] for the stable boundary layer, plume rise is estimated using an iterative approach, similar to that in the CTDMPLUS model. In the convective boundary layer, plume rise is superposed on the displacements by random convective velocities.[92] In AERMOD, plume rise is computed using the methods of Briggs, except in cases involving building downwash, in which a numerical solution of the mass, energy, and momentum conservation laws is performed.[93] No explicit provisions in these models are made for multistack plume rise enhancement or the handling of such special plumes as flares.

b. Gradual plume rise is generally recommended where its use is appropriate: (1) in AERMOD; (2) in complex terrain screening procedures to determine close-in impacts; and (3) when calculating the effects of building wakes. The building wake algorithm in AERMOD incorporates and exercises the thermodynamically based gradual plume rise calculations as described in paragraph (a) of this subsection. 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. Plumes captured by the near wake are re-emitted to the far wake as a ground-level volume source.

c. 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[91] is the recommended technique for this situation and is used in preferred models for point sources.

d. On a case-by-case basis, refinements to the preferred model may be considered for plume rise and downwash effects and shall occur in agreement with the appropriate reviewing authority (paragraph 3.0(b)) and approval by the EPA Regional office based on the requirements of section 3.2.2.

7.2.3   Mobile Sources

a. Emissions of primary pollutants from mobile sources can be modeled with an appropriate model identified in section 4.2. Screening of mobile sources can be accomplished by using screening meteorology, *e.g.*, worst-case meteorological conditions. Maximum hourly concentrations computed from screening modeling can be converted to longer averaging periods using the scaling ratios specified in the AERSCREEN User's Guide.[37]

b. Mobile sources can be modeled in AERMOD as either line (*i.e.*, elongated area) sources or as a series of volume sources. Line sources can be represented in AERMOD with the following source types: LINE, AREA, VOLUME or RLINE. However, since mobile source modeling usually includes an analysis of very near-source impacts, the results can be highly sensitive to the characterization of the mobile emissions. Important characteristics for both line/area and volume sources include the plume release height, source width, and initial dispersion characteristics, and should also take into account the impact of traffic-induced turbulence that can cause roadway sources to have larger initial dimensions than might normally be used for representing line sources.

c. The EPA's quantitative PM hot-spot guidance[65] and Haul Road Workgroup Final Report[67] provide guidance on the appropriate characterization of mobile sources as a function of the roadway and vehicle characteristics. The EPA's quantitative PM hot-spot guidance includes important considerations and should be consulted when modeling roadway links. Area and line sources, which can be characterized as AREA, LINE, and RLINE source types in AERMOD, or volume sources, may be used for modeling mobile sources. However, experience in the field has shown that area sources (characterized as AREA, LINE, or RLINE source types) may be easier to characterize correctly compared to volume sources. If volume sources are used, it is

particularly important to ensure that roadway emissions are appropriately spaced when using

volume source so that the emissions field is uniform across the roadway. Additionally, receptor

placement is particularly important for volume sources that have "exclusion zones" where

concentrations are not calculated for receptors located "within" the volume sources, *i.e.*, less than

2.15 times the initial lateral dispersion coefficient from the center of the volume.[65] Therefore,

placing receptors in these "exclusion zones" will result in underestimates of roadway impacts.

8.0 Model Input Data

a. Databases and related procedures for estimating input parameters are an integral part of the

modeling process. The most appropriate input data available should always be selected for use in

modeling analyses. Modeled concentrations can vary widely depending on the source data or

meteorological data used. This section attempts to minimize the uncertainty associated with

database selection and use by identifying requirements for input data used in modeling. More

specific data requirements and the format required for the individual models are described in

detail in the user's guide and/or associated documentation for each model.

8.1 Modeling Domain

8.1.1 Discussion

a. The modeling domain is the geographic area for which the required air quality analyses for

the NAAQS and PSD increments are conducted.

8.1.2 Requirements

a. For a NAAQS or PSD increments assessment, the modeling domain or project's impact

area shall include all locations where the emissions of a pollutant from the new or modifying

source(s) may cause a significant ambient impact. This impact area is defined as an area with a

radius extending from the new or modifying source to: (1) the most distant location where air

quality modeling predicts a significant ambient impact will occur, or (2) the nominal 50 km distance considered applicable for Gaussian dispersion models, whichever is less. The required air quality analysis shall be carried out within this geographical area with characterization of source impacts, nearby source impacts, and background concentrations, as recommended later in this section.

b. For SIP attainment demonstrations for ozone and PM2.5, or regional haze reasonable progress goal analyses, the modeling domain is determined by the nature of the problem being modeled and the spatial scale of the emissions that impact the nonattainment or Class I area(s). The modeling domain shall be designed so that all major upwind source areas that influence the downwind nonattainment area are included in addition to all monitor locations that are currently or recently violating the NAAQS or close to violating the NAAQS in the nonattainment area. Similarly, all Class I areas to be evaluated in a regional haze modeling application shall be included and sufficiently distant from the edge of the modeling domain. Guidance on the determination of the appropriate modeling domain for photochemical grid models in demonstrating attainment of these air quality goals is available.[64] Users should consult the latest version of this guidance for the most current modeling guidance and the appropriate reviewing authority (paragraph 3.0(b)) for any application specific guidance that is beyond the scope of this section.

8.2 Source Data

8.2.1 Discussion

a. Sources of pollutants can be classified as point, line, area, and volume sources. Point sources are defined in terms of size and may vary between regulatory programs. The line sources most frequently considered are roadways and streets along which there are well-defined

movements of motor vehicles. They may also be lines of roof vents or stacks, such as in aluminum refineries. Area and volume sources are often collections of a multitude of minor sources with individually small emissions that are impractical to consider as separate point or line sources. Large area sources are typically treated as a grid network of square areas, with pollutant emissions distributed uniformly within each grid square. Generally, input data requirements for air quality models necessitate the use of metric units. As necessary, any English units common to engineering applications should be appropriately converted to metric.

b. For point sources, there are many source characteristics and operating conditions that may be needed to appropriately model the facility. For example, the plant layout (*e.g.*, location of stacks and buildings), stack parameters (*e.g.*, height and diameter), boiler size and type, potential operating conditions, and pollution control equipment parameters. Such details are required inputs to air quality models and are needed to determine maximum potential impacts.

c. Modeling mobile emissions from streets and highways requires data on the road layout, including the width of each traveled lane, the number of lanes, and the width of the median strip. Additionally, traffic patterns should be taken into account (*e.g.*, daily cycles of rush hour, differences in weekday and weekend traffic volumes, and changes in the distribution of heavy-duty trucks and light-duty passenger vehicles), as these patterns will affect the types and amounts of pollutant emissions allocated to each lane and the height of emissions.

d. Emission factors can be determined through source-specific testing and measurements (*e.g.*, stack test data) from existing sources or provided from a manufacturing association or vendor. Additionally, emissions factors for a variety of source types are compiled in an EPA publication commonly known as AP-42.[94] AP-42 also provides an indication of the quality and amount of data on which many of the factors are based. Other information concerning emissions

is available in EPA publications relating to specific source categories. The appropriate reviewing authority (paragraph 3.0(b)) should be consulted to determine appropriate source definitions and for guidance concerning the determination of emissions from and techniques for modeling the various source types.

8.2.2   Requirements

a. For SIP attainment demonstrations for the purpose of projecting future year NAAQS attainment for ozone, $PM_{2.5}$, and regional haze reasonable progress goal analyses, emissions which reflect actual emissions during the base modeling year time period should be input to models for base year modeling. Emissions projections to future years should account for key variables such as growth due to increased or decreased activity, expected emissions controls due to regulations, settlement agreements or consent decrees, fuel switches, and any other relevant information. Guidance on emissions estimation techniques (including future year projections) for SIP attainment demonstrations is available.[64, 95]

b. For the purpose of SIP revisions for stationary point sources, the regulatory modeling of inert pollutants shall use the emissions input data shown in Table 8-1 for short-term and long-term NAAQS. To demonstrate compliance and/or establish the appropriate SIP emissions limits, Table 8-1 generally provides for the use of "allowable" emissions in the regulatory dispersion modeling of the stationary point source(s) of interest. In such modeling, these source(s) should be modeled sequentially with these loads for every hour of the year. As part of a cumulative impact analysis, Table 8-1 allows for the model user to account for actual operations in developing the emissions inputs for dispersion modeling of nearby sources, while other sources are best represented by air quality monitoring data. Consultation with the appropriate reviewing authority (paragraph 3.0(b)) is advisable on the establishment of the appropriate emissions inputs

for regulatory modeling applications with respect to SIP revisions for stationary point sources.

c. For the purposes of demonstrating NAAQS compliance in a PSD assessment, the regulatory modeling of inert pollutants shall use the emissions input data shown in Table 8-2 for short and long-term NAAQS. The new or modifying stationary point source shall be modeled with "allowable" emissions in the regulatory dispersion modeling. As part of a cumulative impact analysis, Table 8-2 allows for the model user to account for actual operations in developing the emissions inputs for dispersion modeling of nearby sources, while other sources are best represented by air quality monitoring data. For purposes of situations involving emissions trading, refer to current EPA policy and guidance to establish input data. Consultation with the appropriate reviewing authority (paragraph 3.0(b)) is advisable on the establishment of the appropriate emissions inputs for regulatory modeling applications with respect to PSD assessments for a proposed new or modifying source.

d. For stationary source applications, changes in operating conditions that affect the physical emission parameters (*e.g.*, release height, initial plume volume, and exit velocity) shall be considered to ensure that maximum potential impacts are appropriately determined in the assessment. For example, the load or operating condition for point sources that causes maximum ground-level concentrations shall 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 NAAQS or PSD increments, this load 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. 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. 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.

e. Emissions from mobile sources also have physical and temporal characteristics that should be appropriately accounted. For example, an appropriate emissions model shall be used to determine emissions profiles. Such emissions should include speciation specific for the vehicle types used on the roadway (*e.g.*, light duty and heavy duty trucks), and subsequent parameterizations of the physical emissions characteristics (*e.g.*, release height) should reflect those emissions sources. For long-term standards, annual average emissions may be appropriate, but for short-term standards, discrete temporal representation of emissions should be used (*e.g.*, variations in weekday and weekend traffic or the diurnal rush-hour profile typical of many cities). 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.[65, 67]

Table 8-1. - Point Source Model Emission Inputs for SIP Revisions of Inert Pollutants[1]

Averaging time	Emissions limit (lb/MMBtu)[2]	X	Operating level (MMBtu/hr)[2]	X	Operating factor (*e.g.*, hr/yr, hr/day)
Stationary Point Source(s) Subject to SIP Emissions 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.[3]		Actual operating factor averaged over the most recent 2 years.[4]
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 database).[5]
Nearby Source(s) [6]					
Annual & quarterly	Maximum allowable emission limit or federally enforceable permit limit.[6]		Annual level when actually operating, averaged over the most recent 2 years.[4]		Actual operating factor averaged over the most recent 2 years.[4, 8]
Short term (≤ 24 hours)	Maximum allowable emission limit or federally enforceable permit limit.[6]		Temporally representative level when actually operating, reflective of the most recent 2 years.[4, 7]		Continuous operation, i.e., all hours of each time period under consideration (for all hours of the meteorological database).[5]
Other Source(s) [6, 9]					

The ambient impacts from Non-nearby or Other Sources (*e.g.*, natural, minor, distant major, and unidentified sources) can be represented by air quality monitoring data unless adequate data do not exist.

1. For purposes of emissions trading, NSR, or PSD, other model input criteria may apply. See Section 8.2 for more information regarding attainment demonstrations of primary PM2.5.

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

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. Unless it is determined that this period is not representative.

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 a.m. to 4 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.)

6. See Section 8.3.3.

7. Temporally representative operating level could be based on Continuous Emissions Monitoring (CEM) data or other information and should be determined through consultation with the appropriate reviewing authority (Paragraph 3.0(b)).

8. For those permitted sources not in operation or that have not established an appropriate factor, continuous operation (*i.e.*, 8760) should be used.

9. See Section 8.3.2.

Table 8-2. - Point Source Model Emission Inputs for NAAQS Compliance in PSD Demonstrations

Averaging time	Emissions limit (lb/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.[2]		Continuous operation (i.e., 8760 hours).[3]
Short term (≤ 24 hours)	Maximum allowable emission limit or federally enforceable permit limit.		Design capacity or federally enforceable permit condition.[2]		Continuous operation, i.e., all hours of each time period under consideration (for all hours of the meteorological database).[3]
Nearby Source(s) [4,5]					
Annual & quarterly	Maximum allowable emission limit or federally enforceable permit limit.[5]		Annual level when actually operating, averaged over the most recent 2 years.[6]		Actual operating factor averaged over the most recent 2 years.[6,8]
Short term (≤ 24 hours)	Maximum allowable emission limit or federally enforceable permit limit.[5]		Temporally representative level when actually operating, reflective of the most recent 2 years.[6,7]		Continuous operation, i.e., all hours of each time period under consideration (for all hours of the meteorological database).[3]
Other Source(s) [5,9]					

The ambient impacts from Non-nearby or Other Sources (e.g. , natural, minor, distant major, and unidentified sources) can be represented by air quality monitoring data unless adequate data do not exist.

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

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

3. 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 a.m. to 4 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.

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. See Section 8.3.3.

6. Unless it is determined that this period is not representative.

7. Temporally representative operating level could be based on Continuous Emissions Monitoring (CEM) data or other information and should be determined through consultation with the appropriate reviewing authority (Paragraph 3.0(b)).

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

9. See Section 8.3.2.

8.3 *Background Concentrations*

8.3.1 Discussion

a. Background concentrations are essential in constructing the design concentration, or total

air quality concentration, as part of a cumulative impact analysis for NAAQS and PSD

increments (section 9.2.3). To assist applicants and reviewing authorities with appropriately

characterizing background concentrations, the EPA has developed the *Draft Guidance on*

Developing Background Concentrations for Use in Modeling Demonstrations.[96] The guidance

provides a recommended framework composed of steps that should be used in parallel with the

recommendations made in this section. Generally, background air quality should not include the

ambient impacts of the project source under consideration. Instead, it should include:

i. Nearby sources: These are individual sources located in the vicinity of the source(s)

under consideration for emissions limits that are not adequately represented by ambient

monitoring data. The ambient contributions from these nearby sources are thereby accounted for

by explicitly modeling their emissions (section 8.2).

ii. Other sources: That portion of the background attributable to natural sources, other

unidentified sources in the vicinity of the project, and regional transport contributions from more

distant sources (domestic and international). The ambient contributions from these sources are

typically accounted for through use of ambient monitoring data or, in some cases, regional-scale

photochemical grid modeling results.

b. The monitoring network used for developing background concentrations is expected to

conform to the same quality assurance and other requirements as those networks established for

PSD purposes.[97] Accordingly, the air quality monitoring data should be of sufficient

completeness and follow appropriate data validation procedures. These data should be

adequately representative of the area to inform calculation of the design concentration for

comparison to the applicable NAAQS (section 9.2.2).

c. For photochemical grid modeling conducted in SIP attainment demonstrations for ozone,

$PM_{2.5}$ and regional haze, the emissions from nearby and other sources are included as model

inputs and fully accounted for in the modeling application and predicted concentrations. The concept of adding individual components to develop a design concentration, therefore, do not apply in these SIP applications. However, such modeling results may then be appropriate for consideration in characterizing background concentrations for other regulatory applications. Also, as noted in section 5, this modeling approach does provide for an appropriate atmospheric environment to assess single-source impacts for ozone and secondary $PM_{2.5}$.

d. For NAAQS assessments and SIP attainment demonstrations for inert pollutants, the development of the appropriate background concentration for a cumulative impact analysis involves proper accounting of each contribution to the design concentration and will depend upon whether the project area's situation consists of either an isolated single source(s) or a multitude of sources. For PSD increment assessments, all impacts after the appropriate baseline dates (*i.e.*, trigger date, major source baseline date, and minor source baseline date) from all increment-consuming and increment-expanding sources should be considered in the design concentration (section 9.2.2).

8.3.2   Recommendations for Isolated Single Sources

a. In areas with an isolated source(s), determining the appropriate background concentration should focus on characterization of contributions from all other sources through adequately representative ambient monitoring data. The application of the EPA's recommended framework for determining an appropriate background concentration should be consistent with appropriate EPA modeling guidance[63, 96] and justified in the modeling protocol that is vetted with the appropriate reviewing authority (paragraph 3.0(b)).

b. The EPA recommends use of the most recent quality assured air quality monitoring data collected in the vicinity of the source to determine the background concentration for the

averaging times of concern. In most cases, the EPA recommends using data from the monitor closest to and upwind of the project area. If several monitors are available, preference should be given to the monitor with characteristics that are most similar to the project area. If there are no monitors located in the vicinity of the new or modifying source, a "regional site" may be used to determine background concentrations. A regional site is one that is located away from the area of interest but is impacted by similar or adequately representative sources.

c. Many of the challenges related to cumulative impact analyses arise in the context of defining the appropriate metric to characterize background concentrations from ambient monitoring data and determining the appropriate method for combining this monitor-based background contribution to the modeled impact of the project and other nearby sources. For many cases, the best starting point would be use of the current design value for the applicable NAAQS as a uniform monitored background contribution across the project area. However, there are cases in which the current design value may not be appropriate. Such cases include but are not limited to:

i. For situations involving a modifying source where the existing facility is determined to impact the ambient monitor, the background concentration at each monitor can be determined by excluding values when the source in question is impacting the monitor. In such cases, monitoring sites inside a 90° sector downwind of the source may be used to determine the area of impact.

ii. There may be other circumstances which would necessitate modifications to the ambient data record. Such cases could include removal of data from specific days or hours when a monitor is being impacted by activities that are not typical or not expected to occur again in the future (*e.g.*, construction, roadway repairs, forest fires, or unusual agricultural activities). There may also be cases where it may be appropriate to scale (multiplying the monitored

concentrations with a scaling factor) or adjust (adding or subtracting a constant value the

monitored concentrations) data from specific days or hours. Such adjustments would make the

monitored background concentrations more temporally and/or spatially representative of the area

around the new or modifying source for the purposes of the regulatory assessment.

iii. For short-term standards, the diurnal or seasonal patterns of the air quality monitoring

data may differ significantly from the patterns associated with the modeled concentrations. When

this occurs, it may be appropriate to pair the air quality monitoring data in a temporal manner

that reflects these patterns (*e.g.*, pairing by season and/or hour of day).[98]

iv. For situations where monitored air quality concentrations vary across the modeling

domain, it may be appropriate to consider air quality monitoring data from multiple monitors

within the project area.

d. Considering the spatial and temporal variability throughout a typical modeling domain on

an hourly basis and the complexities and limitations of hourly observations from the ambient

monitoring network, the EPA does not recommend hourly or daily pairing of monitored

background and modeled concentrations except in rare cases of relatively isolated sources where

the available monitor can be shown to be representative of the ambient concentration levels in

the areas of maximum impact from the proposed new source. The implicit assumption

underlying hourly pairing is that the background monitored levels for each hour are spatially

uniform and that the monitored values are fully representative of background levels at each

receptor for each hour. Such an assumption clearly ignores the many factors that contribute to the

temporal and spatial variability of ambient concentrations across a typical modeling domain on

an hourly basis. In most cases, the seasonal (or quarterly) pairing of monitored and modeled

concentrations should sufficiently address situations to which the impacts from modeled emissions are not temporally correlated with background monitored levels.

e. In those cases where adequately representative monitoring data to characterize background concentrations are not available, it may be appropriate to use results from a regional-scale photochemical grid model, or other representative model application, as background concentrations consistent with the considerations discussed above and in consultation with the appropriate reviewing authority (paragraph 3.0(b)).

8.3.3   Recommendations for Multi-Source Areas

a. In multi-source areas, determining the appropriate background concentration involves: (1) characterization of contributions from other sources through adequately representative ambient monitoring data, and (2) identification and characterization of contributions from nearby sources through explicit modeling. A key point here is the interconnectedness of each component in that the question of which nearby sources to include in the cumulative modeling is inextricably linked to the question of what the ambient monitoring data represents within the project area.

b. *Nearby sources:* All sources in the vicinity of the source(s) under consideration for emissions limits that are not adequately represented by ambient monitoring data should be explicitly modeled. The EPA's recommended framework for determining an appropriate background concentration[96] should be applied to identify such sources and accurately account for their ambient impacts through explicit modeling.

i. The determination of nearby sources relies on the selection of adequately representative ambient monitoring data (section 8.3.2). The EPA recommends determining the representativeness of the monitoring data through a visual assessment of the modeling domain considering any relevant nearby sources and their respective air quality data. The visual

assessment should consider any relevant air quality data such as the proximity of nearby sources to the project source and the ambient monitor, the nearby source's level of emissions with respect to the ambient data, and the dispersion environment (*i.e.*, meteorological patterns, terrain, etc.) of the modeling domain.

ii. Nearby sources not adequately represented by the ambient monitor through visual assessment should undergo further qualitative and quantitative analysis before being explicitly modeled. The EPA recommends evaluating any modeling, monitoring, or emissions data that may be available for the identified nearby sources with respect to possible violations to the NAAQS.

iii. The number of nearby sources to be explicitly modeled in the air quality analysis is expected to be few except in unusual situations. The determination of nearby sources through the application of the EPA's recommended framework calls for the exercise of professional judgment by the appropriate reviewing authority (paragraph 3.0(b)) and should be consistent with appropriate EPA modeling guidance.[63, 96] This guidance is not intended to alter the exercise of that judgment or to comprehensively prescribe which sources should be included as nearby sources.

c. For cumulative impact analyses of short-term and annual ambient standards, the nearby sources as well as the project source(s) must be evaluated using an appropriate Addendum A model or approved alternative model with the emission input data shown in Table 8-1 or 8-2.

i. When modeling a nearby source that does not have a permit and the emissions limits contained in the SIP for a particular source category is greater than the emissions possible given the source's maximum physical capacity to emit, the "maximum allowable emissions limit" for such a nearby source may be calculated as the emissions rate representative of the nearby

source's maximum physical capacity to emit, considering its design specifications and allowable fuels and process materials. However, the burden is on the permit applicant to sufficiently document what the maximum physical capacity to emit is for such a nearby source.

ii. It is appropriate to model nearby sources only during those times when they, by their nature, operate at the same time as the primary source(s) or could have impact on the averaging period of concern. Accordingly, it is not necessary to model impacts of a nearby source that does not, by its nature, operate at the same time as the primary source or could have impact on the averaging period of concern, regardless of an identified significant concentration gradient from the nearby source. The burden is on the permit applicant to adequately justify the exclusion of nearby sources to the satisfaction of the appropriate reviewing authority (paragraph 3.0(b)). The following examples illustrate two cases in which a nearby source may be shown not to operate at the same time as the primary source(s) being modeled: (1) Seasonal sources (only used during certain seasons of the year). Such sources would not be modeled as nearby sources during times in which they do not operate; and (2) Emergency backup generators, to the extent that they do not operate simultaneously with the sources that they back up. Such emergency equipment would not be modeled as nearby sources.

d. *Other sources*. That portion of the background attributable to all other sources (*e.g.*, natural, minor, distant major, and unidentified sources) should be accounted for through use of ambient monitoring data and determined by the procedures found in section 8.3.2 in keeping with eliminating or reducing the source-oriented impacts from nearby sources to avoid potential double-counting of modeled and monitored contributions.

8.4   Meteorological Input Data

8.4.1   Discussion

a. This subsection covers meteorological input data for use in dispersion modeling for regulatory applications and is separate from recommendations made for photochemical grid modeling. Recommendations for meteorological data for photochemical grid modeling applications are outlined in the latest version of the EPA's *Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, PM$_{2.5}$, and Regional Haze.*[64] In cases where Lagrangian models are applied for regulatory purposes, appropriate meteorological inputs should be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)).

b. The meteorological data used as input to a dispersion model should be selected on the basis of spatial and climatological (temporal) representativeness as well as the ability of the individual parameters selected to characterize the transport and dispersion conditions in the area of concern. The representativeness of the measured data is dependent on numerous factors including, but not limited to: (1) the proximity of the meteorological monitoring site to the area under consideration; (2) the complexity of the terrain; (3) the exposure of the meteorological monitoring site; and (4) the period of time during which data are collected. The spatial representativeness of the data can be adversely affected by large distances between the source and receptors of interest and the complex topographic characteristics of the area. Temporal representativeness is a function of the year-to-year variations in weather conditions. Where appropriate, data representativeness should be viewed in terms of the appropriateness of the data for constructing realistic boundary layer profiles and, where applicable, three-dimensional meteorological fields, as described in paragraphs (c) and (d) of this subsection.

c. The meteorological data should be adequately representative and may be site-specific data (land-based or buoy data for overwater applications), data from a nearby National Weather

Service (NWS) or comparable station, or prognostic meteorological data. The implementation of NWS Automated Surface Observing Stations (ASOS) in the early 1990's should not preclude the use of NWS ASOS data if such a station is determined to be representative of the modeled area.[99]

d. Model input data are normally obtained either from the NWS or as part of a site-specific measurement program. State climatology offices, local universities, FAA, military stations, industry, and pollution control agencies may also be sources of such data. In specific cases, prognostic meteorological data may be appropriate for use and obtained from similar sources. Some recommendations and requirements for the use of each type of data are included in this subsection.

8.4.2   Recommendations and Requirements

a. AERMET[100] shall be used to preprocess all meteorological data, be it observed or prognostic, for use with AERMOD in regulatory applications. The AERMINUTE[101] processor, in most cases, should be used to process 1-minute ASOS wind data for input to AERMET when processing NWS ASOS sites in AERMET. When processing prognostic meteorological data for AERMOD, the Mesoscale Model Interface Program (MMIF)[109] should be used to process data for input to AERMET, both for land-based applications and overwater applications. Other methods of processing prognostic meteorological data for input to AERMET should be approved by the appropriate reviewing authority. Additionally, the following meteorological preprocessors are recommended by the EPA: PCRAMMET,[102] MPRM,[103] and METPRO.[104] PCRAMMET is the recommended meteorological data preprocessor for use in applications of OCD employing hourly NWS data. MPRM is the recommended meteorological data preprocessor for applications of OCD employing site-specific meteorological data. METPRO is the recommended meteorological data preprocessor for use with CTDMPLUS.[105]

b. Regulatory application of AERMOD necessitates careful consideration of the meteorological data for input to AERMET. Data representativeness, in the case of AERMOD, means utilizing data of an appropriate type for constructing realistic boundary layer profiles. Of particular importance is the requirement that all meteorological data used as input to AERMOD should be adequately representative of the transport and dispersion within the analysis domain. Where surface conditions vary significantly over the analysis domain, the emphasis in assessing representativeness should be given to adequate characterization of transport and dispersion between the source(s) of concern and areas where maximum design concentrations are anticipated to occur. The EPA recommends that the surface characteristics input to AERMET should be representative of the land cover in the vicinity of the meteorological data, *i.e.*, the location of the meteorological tower for measured data or the representative grid cell for prognostic data. Therefore, the model user should apply the latest version AERSURFACE,[106, 107] where applicable, for determining surface characteristics when processing measured land-based meteorological data through AERMET. In areas where it is not possible to use AERSURFACE output, surface characteristics can be determined using techniques that apply the same analysis as AERSURFACE. In the case of measured meteorological data for overwater applications, AERMET calculates the surface characteristics and AERSURFACE outputs are not needed. In the case of prognostic meteorological data, the surface characteristics associated with the prognostic meteorological model output for the representative grid cell should be used.[108, 109] Furthermore, since the spatial scope of each variable could be different, representativeness should be judged for each variable separately. For example, for a variable such as wind direction, the data should ideally be collected near plume height to be adequately representative, especially for sources located in complex terrain. Whereas, for a variable such as temperature, data from a

station several kilometers away from the source may be considered to be adequately

representative. More information about meteorological data, representativeness, and surface

characteristics can be found in the AERMOD Implementation Guide.[81]

    c. Regulatory application of CTDMPLUS requires the input of multi-level measurements of

wind speed, direction, temperature, and turbulence from an appropriately sited meteorological

tower. The measurements should be obtained up to the representative plume height(s) of interest.

Plume heights of interest can be determined by use of screening procedures such as CTSCREEN.

    d. Regulatory application of OCD requires meteorological data over land and over water. The

over land or surface data, processed through PCRAMMET[102] or MPRM,[103] that provides hourly

stability class, wind direction and speed, ambient temperature, and mixing height, are required.

Data over water requires hourly mixing height, relative humidity, air temperature, and water

surface temperature. Missing winds are substituted with the surface winds. Vertical wind

direction shear, vertical temperature gradient, and turbulence intensities are optional.

    e. The model user should acquire enough meteorological data to ensure that worst-case

meteorological conditions are adequately represented in the model results. The use of 5 years of

adequately representative NWS or comparable meteorological data, at least 1 year of site-

specific (either land-based or overwater based) , or at least 3 years of prognostic meteorological

data, are required. If 1 year or more, up to 5 years, of site-specific data are available, these data

are preferred for use in air quality analyses. Depending on completeness of the data record,

consecutive years of NWS, site-specific, or prognostic data are preferred. Such data must be

subjected to quality assurance procedures as described in section 8.4.4.2.

    f. Objective analysis in meteorological modeling is to improve meteorological analyses (the

"*first guess field*") used as initial conditions for prognostic meteorological models by

incorporating information from meteorological observations. Direct and indirect (using remote

sensing techniques) observations of temperature, humidity, and wind from surface and

radiosonde reports are commonly employed to improve these analysis fields. For long-range

transport applications, it is recommended that objective analysis procedures, using direct and

indirect meteorological observations, be employed in preparing input fields to produce

prognostic meteorological datasets. The length of record of observations should conform to

recommendations outlined in paragraph 8.4.2(e) for prognostic meteorological model datasets.

8.4.3   National Weather Service Data

8.4.3.1   Discussion

a. The NWS meteorological data are routinely available and familiar to most model users.

Although the NWS does not provide direct measurements of all the needed dispersion model

input variables, methods have been developed and successfully used to translate the basic NWS

data to the needed model input. Site-specific measurements of model input parameters have been

made for many modeling studies, and those methods and techniques are becoming more widely

applied, especially in situations such as complex terrain applications, where available NWS data

are not adequately representative. However, there are many modeling applications where NWS

data are adequately representative and the applications still rely heavily on the NWS data.

b. Many models use the standard hourly weather observations available from the National

Centers for Environmental Information (NCEI).[b] These observations are then preprocessed

before they can be used in the models. Prior to the advent of ASOS in the early 1990's, the

standard "hourly" weather observation was a human-based observation reflecting a single 2-

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[b] Formerly the National Climatic Data Center (NCDC).

minute average generally taken about 10 minutes before the hour. However, beginning in January 2000 for first-order stations and in March 2005 for all stations, the NCEI has archived the 1-minute ASOS wind data (*i.e.*, the rolling 2-minute average winds) for the NWS ASOS sites. The AERMINUTE processor[101] was developed to reduce the number of calm and missing hours in AERMET processing by substituting standard hourly observations with full hourly average winds calculated from 1-minute ASOS wind data.

8.4.3.2   Recommendations

a. The preferred models listed in Addendum A all accept as input the NWS meteorological data preprocessed into model compatible form. If NWS data are judged to be adequately representative for a specific modeling application, they may be used. The NCEI makes available surface and upper air meteorological data online and in CD-ROM format. Upper air data are also available at the Earth System Research Laboratory Global Systems Divisions Web site and from NCEI. For the latest Web sites of available surface and upper air data see reference 100.

b. Although most NWS wind measurements are made at a standard height of 10 m, the actual anemometer height should be used as input to the preferred meteorological processor and model.

c. Standard hourly NWS wind directions are reported to the nearest 10 degrees. Due to the coarse resolution of these data, a specific set of randomly generated numbers has been developed by the EPA and should be used when processing standard hourly NWS data for use in the preferred EPA models to ensure a lack of bias in wind direction assignments within the models.

d. Beginning with year 2000, NCEI began archiving 2-minute winds, reported every minute to the nearest degree for NWS ASOS sites. The AERMINUTE processor was developed to read those winds and calculate hourly average winds for input to AERMET. When such data are available for the NWS ASOS site being processed, the AERMINUTE processor should be used,

in most cases, to calculate hourly average wind speed and direction when processing NWS

ASOS data for input to AERMOD.[99]

e. Data from universities, FAA, military stations, industry and pollution control agencies may

be used if such data are equivalent in accuracy and detail (*e.g.*, siting criteria, frequency of

observations, data completeness, etc.) to the NWS data, they are judged to be adequately

representative for the particular application, and have undergone quality assurance checks.

f. After valid data retrieval requirements have been met,[110] large number of hours in the

record having missing data should be treated according to an established data substitution

protocol provided that adequately representative alternative data are available. Data substitution

guidance is provided in section 5.3 of reference 110[110]. If no representative alternative data are

available for substitution, the absent data should be coded as missing using missing data codes

appropriate to the applicable meteorological pre-processor. Appropriate model options for

treating missing data, if available in the model, should be employed.

8.4.4   Site-specific data

8.4.4.1   Discussion

a. Spatial or geographical representativeness is best achieved by collection of all of the

needed model input data in close proximity to the actual site of the source(s). Site-specific

measured data are, therefore, preferred as model input, provided that appropriate instrumentation

and quality assurance procedures are followed, and that the data collected are adequately

representative (free from inappropriate local or microscale influences) and compatible with the

input requirements of the model to be used. It should be noted that, while site-specific

measurements are frequently made "on-property" (*i.e.*, on the source's premises), acquisition of

adequately representative site-specific data does not preclude collection of data from a location

off property. Conversely, collection of meteorological data on a source's property does not of itself guarantee adequate representativeness. For help in determining representativeness of site-specific measurements, technical guidance[110] is available. Site-specific data should always be reviewed for representativeness and adequacy by an experienced meteorologist, atmospheric scientist, or other qualified scientist in consultation with the appropriate reviewing authority (paragraph 3.0(b)).

8.4.4.2   Recommendations

a. The EPA guidance[110] provides recommendations on the collection and use of site-specific 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 other limited guidance on these subjects.[5, 97, 111, 112] Detailed information on quality assurance is also available.[113] As a minimum, site-specific measurements of ambient air temperature, transport wind speed and direction, and the variables necessary to estimate atmospheric dispersion should be available in meteorological datasets to be used in modeling. Care should be taken to ensure that meteorological instruments are located to provide an adequately representative characterization of pollutant transport between sources and receptors of interest. The appropriate reviewing authority (paragraph 3.0(b)) is available to help determine the appropriateness of the measurement locations.

i. *Solar radiation measurements*. Total solar radiation or net radiation should be measured with a reliable pyranometer or net radiometer sited and operated in accordance with established site-specific meteorological guidance.[110, 113]

ii. *Temperature measurements*. Temperature measurements should be made at standard

shelter height (2m) in accordance with established site-specific meteorological guidance.[110]

iii. *Temperature difference measurements.* Temperature difference (DT) measurements should be obtained using matched thermometers or a reliable thermocouple system to achieve adequate accuracy. Siting, probe placement, and operation of DT systems should be based on guidance found in Chapter 3 of reference 110 and such guidance should be followed when obtaining vertical temperature gradient data. AERMET may employ the Bulk Richardson scheme, which requires measurements of temperature difference, in lieu of cloud cover or insolation data. To ensure correct application and acceptance, AERMOD users should consult with the appropriate reviewing authority (paragraph 3.0(b)) before using the Bulk Richardson scheme for their analysis.

iv. *Wind measurements*. For simulation of plume rise and dispersion of a plume emitted from a stack, characterization of the wind profile up through the layer in which the plume disperses is desirable. This is especially important in complex terrain and/or complex wind situations where wind measurements at heights up to hundreds of meters above stack base may be required in some circumstances. For tall stacks when site-specific data are needed, these winds have been obtained traditionally using meteorological sensors mounted on tall towers. A feasible alternative to tall towers is the use of meteorological remote sensing instruments (*e.g.*, acoustic sounders or radar wind profilers) to provide winds aloft, coupled with 10-meter towers to provide the near-surface winds. Note that when site-specific wind measurements are used, AERMOD, at a minimum, requires wind observations at a height above ground between seven times the local surface roughness height and 100 m. (For additional requirements for AERMOD and CTDMPLUS, *see* Addendum A.) Specifications for wind measuring instruments and systems are contained in reference 110.

b. All processed site-specific data should be in the form of hourly averages for input to the dispersion model.

i. *Turbulence data*. There are several dispersion models that are capable of using direct measurements of turbulence (wind fluctuations) in the characterization of the vertical and lateral dispersion (*e.g.*, CTDMPLUS or AERMOD). When turbulence data are used to directly characterize the vertical and lateral dispersion, the averaging time for the turbulence measurements should be 1-hour. For technical guidance on processing of turbulence parameters for use in dispersion modeling, refer to the user's guide to the meteorological processor for each model (*see* section 8.4.2(a)).

ii. *Stability categories*. For dispersion models that employ P-G stability categories for the characterization of the vertical and lateral dispersion, the 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 height observations. The wind speed measurements are made at or near 10 m. The insolation rate is typically assessed using observations of cloud cover and ceiling height based on criteria outlined by Turner.[77] It is recommended that the P-G stability category be estimated using the Turner method with site-specific wind speed measured at or near 10 m and representative cloud cover and ceiling height. Implementation of the Turner method, as well as considerations in determining representativeness of cloud cover and ceiling height in cases for which site-specific cloud observations are unavailable, may be found in section 6 of reference 110. In the absence of requisite data to implement the Turner method, the solar radiation/delta-T (SRDT) method or wind fluctuation statistics (*i.e.*, the σ_E and σ_A methods) may be used.

iii. The SRDT method, described in section 6.4.4.2 of reference 110, is modified slightly

from that published from earlier work[114] and has been evaluated with three site-specific

databases.[115] The two methods of stability classification that use wind fluctuation statistics,

the σ_E and σ_A methods, are also described in detail in section 6.4.4 of reference 110 (note

applicable tables in section 6). For additional information on the wind fluctuation methods,

several references are available.[116, 117, 118, 119]

c. *Missing data substitution*. After valid data retrieval requirements have been met,[110] hours

in the record having missing data should be treated according to an established data substitution

protocol provided that adequately representative alternative data are available. Such protocols are

usually part of the approved monitoring program plan. Data substitution guidance is provided in

section 5.3 of reference 110. If no representative alternative data are available for substitution,

the absent data should be coded as missing, using missing data codes appropriate to the

applicable meteorological pre-processor. Appropriate model options for treating missing data, if

available in the model, should be employed.

8.4.5   Prognostic meteorological data

8.4.5.1   Discussion

a. For some modeling applications, there may not be a representative NWS or comparable

meteorological station available (*e.g.*, complex terrain), and it may be cost prohibitive or

infeasible to collect adequately representative site-specific data. For these cases, it may be

appropriate to use prognostic meteorological data, if deemed adequately representative, in a

regulatory modeling application. However, if prognostic meteorological data are not

representative of transport and dispersion conditions in the area of concern, the collection of site-

specific data is necessary.

b. The EPA has developed a processor, the MMIF,[108] to process MM5 (Mesoscale Model 5)

or WRF (Weather Research and Forecasting) model data for input to various models including AERMOD. MMIF can process data for input to AERMET or AERMOD for a single grid cell or multiple grid cells. MMIF output has been found to compare favorably against observed data (site-specific or NWS).[120] Specific guidance on processing MMIF for AERMOD can be found in reference 109109. When using MMIF to process prognostic data for regulatory applications, the data should be processed to generate AERMET inputs and the data subsequently processed through AERMET for input to AERMOD. If an alternative method of processing data for input to AERMET is used, it must be approved by the appropriate reviewing authority (paragraph 3.0(b)).

8.4.5.2   Recommendations

a. *Prognostic model evaluation.* Appropriate effort by the applicant should be devoted to the process of evaluating the prognostic meteorological data. The modeling data should be compared to NWS observational data or other comparable data in an effort to show that the data are adequately replicating the observed meteorological conditions of the time periods modeled. An operational evaluation of the modeling data for all model years (*i.e.*, statistical, graphical) should be completed.[64] The use of output from prognostic mesoscale meteorological models is contingent upon the concurrence with the appropriate reviewing authority (paragraph 3.0(b)) that the data are of acceptable quality, which can be demonstrated through statistical comparisons with meteorological observations aloft and at the surface at several appropriate locations. [64]

b. *Representativeness.* When processing MMIF data for use with AERMOD, the grid cell used for the dispersion modeling should be adequately spatially representative of the analysis domain. In most cases, this may be the grid cell containing the emission source of interest. Since the dispersion modeling may involve multiple sources and the domain may cover several grid

cells, depending on grid resolution of the prognostic model, professional judgment may be needed to select the appropriate grid cell to use. In such cases, the selected grid cells should be adequately representative of the entire domain.

c. *Grid resolution.* The grid resolution of the prognostic meteorological data should be considered and evaluated appropriately, particularly for projects involving complex terrain. The operational evaluation of the modeling data should consider whether a finer grid resolution is needed to ensure that the data are representative. The use of output from prognostic mesoscale meteorological models is contingent upon the concurrence with the appropriate reviewing authority (paragraph 3.0(b)) that the data are of acceptable quality.

8.4.6   Marine Boundary Layer Environments

8.4.6.1   Discussion

a. Calculations of boundary layer parameters for the marine boundary layer present special challenges as the marine boundary layer can be very different from the boundary layer over land. For example, convective conditions can occur in the overnight hours in the marine boundary layer while typically over land, stable conditions occur at night. Also, surface roughness in the marine environment is a function of wave height and wind speed and less static with time than surface roughness over land.

b. While the Offshore and Coastal Dispersion Model (OCD) is the preferred model for overwater applications, there are applications where the use of AERMOD is applicable. These include applications that utilize features of AERMOD not included in OCD (*e.g.*, NO_2 chemistry). Such use of AERMOD would require consultation with the Regional Office and appropriate reviewing authority to ensure that platform downwash and shoreline fumigation are adequately considered in the modeling demonstration.

c. For the reasons stated above, a standalone pre-processor to AERMOD, called AERCOARE[47] was developed to use the Coupled Ocean Atmosphere Response Experiment (COARE) bulk-flux algorithms[48] to bypass AERMET and calculate the boundary layer parameters for input to AERMOD for the marine boundary layer. AERCOARE can process either measurements from water-based sites such as buoys or prognostic data. To better facilitate the use of the COARE algorithms for AERMOD, EPA has included the COARE algorithms into AERMET thus eliminating the need for a standalone pre-processor and ensuring the algorithms are updated as part of routine AERMET updates.

8.4.6.2   Recommendations

a. *Measured data.* For applications in the marine environment that require the use of AERMOD, measured surface data, such as from a buoy or other offshore platform, should be processed in AERMET with the COARE processing option following recommendations in the AERMET User's Guide[100] and AERMOD Implementation Guide.[81] For applications in the marine environment that require the use of OCD, users should use the recommended meteorological pre-processor MPRM.

b. *Prognostic data.* For applications in the marine environment that require the use of AERMOD and prognostic data, the prognostic data should be processed via MMIF for input to AERMET following recommendations in paragraph 8.4.5.1(b) and the guidance found in reference 109.

8.4.7   Treatment of Near-Calms and Calms

8.4.7.1   Discussion

a. Treatment of calm or light and variable wind poses a special problem in modeling applications since steady-state Gaussian plume models assume that concentration is inversely

proportional to wind speed, depending on model formulations. Procedures have been developed to prevent the occurrence of overly conservative concentration estimates during periods of calms. These procedures acknowledge that a steady-state Gaussian plume model does not apply during calm conditions, and that our knowledge of wind patterns and plume behavior during these conditions does not, at present, permit the development of a better technique. Therefore, the procedures disregard hours that are identified as calm. The hour is treated as missing and a convention for handling missing hours is recommended. With the advent of the AERMINUTE processor, when processing NWS ASOS data, the inclusion of hourly averaged winds from AERMINUTE will, in some instances, dramatically reduce the number of calm and missing hours, especially when the ASOS wind are derived from a sonic anemometer. To alleviate concerns about these issues, especially those introduced with AERMINUTE, the EPA implemented a wind speed threshold in AERMET for use with ASOS derived winds.[99, 100] Winds below the threshold will be treated as calms.

b. AERMOD, while fundamentally a steady-state Gaussian plume model, contains algorithms for dealing with low wind speed (near calm) conditions. As a result, AERMOD can produce model estimates for conditions when the wind speed may be less than 1 m/s, but still greater than the instrument threshold. Required input to AERMET for site-specific data, the meteorological processor for AERMOD, includes a threshold wind speed and a reference wind speed. The threshold wind speed is the greater of the threshold of the instrument used to collect the wind speed data or wind direction sensor.[110] The reference wind speed is selected by the model as the lowest level of non-missing wind speed and direction data where the speed is greater than the wind speed threshold, and the height of the measurement is between seven times the local surface roughness length and 100 m. If the only valid observation of the reference wind

speed between these heights is less than the threshold, the hour is considered calm, and no concentration is calculated. None of the observed wind speeds in a measured wind profile that are less than the threshold speed are used in construction of the modeled wind speed profile in AERMOD.

8.4.7.2   Recommendations

a. Hourly concentrations calculated with steady-state Gaussian plume models using calms should not be considered valid; the wind and concentration estimates for these hours should be disregarded and considered to be missing. Model predicted concentrations for 3-, 8-, and 24-hour averages should be calculated by dividing the sum of the hourly concentrations for the period by the number of valid or non-missing hours. If the total number of valid hours is less than 18 for 24-hour averages, less than 6 for 8-hour averages, or less than 3 for 3-hour averages, the total concentration should be divided by 18 for the 24-hour average, 6 for the 8-hour average, and 3 for the 3-hour average. For annual averages, the sum of all valid hourly concentrations is divided by the number of non-calm hours during the year. AERMOD has been coded to implement these instructions. For hours that are calm or missing, the AERMOD hourly concentrations will be zero. For other models listed in Addendum A, a post-processor computer program, CALMPRO[121] has been prepared, is available on the EPA's SCRAM Web site (section 2.3), and should be used.

b. Stagnant conditions that include extended periods of calms often produce high concentrations over wide areas for relatively long averaging periods. The standard steady-state Gaussian plume models are often not applicable to such situations. When stagnation conditions are of concern, other modeling techniques should be considered on a case-by-case basis (*see* also section 7.2.1.2).

c. When used in steady-state Gaussian plume models other than AERMOD, measured site-specific wind speeds of less than 1 m/s but higher than the response threshold of the instrument should be input as 1 m/s; the corresponding wind direction should also be input. Wind observations below the response threshold of the instrument should be set to zero, with the input file in ASCII format. For input to AERMOD, no such adjustment should be made to the site-specific wind data, as AERMOD has algorithms to account for light or variable winds as discussed in section 8.4.6.1(a). For NWS ASOS data, see the AERMET User's Guide[100] for guidance on wind speed thresholds. For prognostic data, see the latest guidance[109] for thresholds. Observations with wind speeds less than the threshold are considered calm, and no concentration is calculated. In all cases involving steady-state Gaussian plume models, calm hours should be treated as missing, and concentrations should be calculated as in paragraph (a) of this subsection.

9.0   Regulatory Application of Models

9.1   Discussion

a. Standardized procedures are valuable in the review of air quality modeling and data analyses conducted to support SIP submittals and revisions, NSR, or other EPA requirements to ensure consistency in their regulatory application. This section recommends procedures specific to NSR that facilitate some degree of standardization while at the same time allowing the flexibility needed to assure the technically best analysis for each regulatory application. For SIP attainment demonstrations, refer to the appropriate EPA guidance[53, 64] for the recommended procedures.

b. Air quality model estimates, especially with the support of measured air quality data, are the preferred basis for air quality demonstrations. A number of actions have been taken to ensure that the best air quality model is used correctly for each regulatory application and that it is not

arbitrarily imposed.

- First, the *Guideline* clearly recommends that the most appropriate model be used in each case. Preferred models are identified, based on a number of factors, for many uses.

- Second, the preferred models have been subjected to a systematic performance evaluation and a scientific peer review. 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 described in section 2.1.1, were generally followed.

- Third, more specific information has been provided for considering the incorporation of new models into the *Guideline* (section 3.1), and the *Guideline* contains procedures for justifying the case-by-case use of alternative models and obtaining EPA approval (section 3.2).

c. Air quality modeling is the preferred basis for air quality demonstrations. Nevertheless, there are rare circumstances where the performance of the preferred air quality model may be shown to be less than reasonably acceptable or where no preferred air quality model, screening model or technique, or alternative model are suitable for the situation. In these unique instances, there is the possibility of assuring compliance and establishing emissions limits for an existing source solely on the basis of observed air quality data in lieu of an air quality modeling analysis. Comprehensive air quality monitoring in the vicinity of the existing source with proposed modifications will be necessary in these cases. The same attention should be given to the detailed analyses of the air quality data as would be applied to a model performance evaluation.

d. The current levels and forms of the NAAQS for the six criteria pollutants can be found on the EPA's NAAQS Web site at *https://www.epa.gov/criteria-air-pollutants*. As required by the

CAA, the NAAQS are subjected to extensive review every 5 years and the standards, including

the level and the form, may be revised as part of that review. The criteria pollutants have either

long-term (annual or quarterly) and/or short-term (24-hour or less) forms that are not to be

exceeded more than a certain frequency over a period of time (*e.g.*, no exceedance on a rolling 3-

month average, no more than once per year, or no more than once per year averaged over 3

years), are averaged over a period of time (*e.g.*, an annual mean or an annual mean averaged over

3 years), or are some percentile that is averaged over a period of time (*e.g.*, annual 99th or 98th

percentile averaged over 3 years). The 3-year period for ambient monitoring design values does

not dictate the length of the data periods recommended for modeling (*i.e.*, 5 years of NWS

meteorological data, at least 1 year of site-specific, or at least 3 years of prognostic

meteorological data).

e. This section discusses general recommendations on the regulatory application of models

for the purposes of NSR, including PSD permitting, and particularly for estimating design

concentration(s), appropriately comparing these estimates to NAAQS and PSD increments, and

developing emissions limits. This section also provides the criteria necessary for considering use

of an analysis based on measured ambient data in lieu of modeling as the sole basis for

demonstrating compliance with NAAQS and PSD increments.

9.2   Recommendations

9.2.1   Modeling Protocol

a. Every effort should be made by the appropriate reviewing authority (paragraph 3.0(b)) to

meet with all parties involved in either a SIP submission or 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 to be performed. An example of the content for such an effort is contained in the Air Quality Analysis Checklist posted on the EPA's SCRAM Web site (section 2.3). This checklist suggests the appropriate level of detail 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 the pre-application meeting. The protocol should be written and agreed upon by the parties concerned, although it is not intended that this protocol be a binding, formal legal document. Changes in such a protocol or deviations from the protocol are often necessary as the data collection and analysis progresses. However, the protocol establishes a common understanding of how the demonstration required to meet regulatory requirements will be made.

9.2.2   Design Concentration and Receptor Sites

a. Under the PSD permitting program, an air quality analysis for criteria pollutants is required to demonstrate that emissions from the construction or operation of a proposed new source or modification will not cause or contribute to a violation of the NAAQS or PSD increments.

i. For a NAAQS assessment, the design concentration is the combination of the appropriate background concentration (section 8.3) with the estimated modeled impact of the proposed source. The NAAQS design concentration is then compared to the applicable NAAQS.

ii. For a PSD increment assessment, the design concentration includes impacts occurring after the appropriate baseline date from all increment-consuming and increment-expanding sources. The PSD increment design concentration is then compared to the applicable PSD increment.

b. The specific form of the NAAQS for the pollutant(s) of concern will also influence how the background and modeled data should be combined for appropriate comparison with the

respective NAAQS in such a modeling demonstration. Given the potential for revision of the form of the NAAQS and the complexities of combining background and modeled data, specific details on this process can be found in the applicable modeling guidance available on the EPA's SCRAM Web site (section 2.3). Modeled concentrations should not be rounded before comparing the resulting design concentration to the NAAQS or PSD increments. Ambient monitoring and dispersion modeling address different issues and needs relative to each aspect of the overall air quality assessment.

c. The PSD increments for criteria pollutants are listed in 40 CFR 52.21(c) and 40 CFR 51.166(c). For short-term increments, these maximum allowable increases in pollutant concentrations may be exceeded once per year at each site, while the annual increment may not be exceeded. The highest, second-highest increase in estimated concentrations for the short-term averages, as determined by a model, must be less than or equal to the permitted increment. The modeled annual averages must not exceed the increment.

d. Receptor sites for refined dispersion modeling should be located within the modeling domain (section 8.1). In designing a receptor network, the emphasis should be placed on receptor density and location, not total number of receptors. Typically, the density of receptor sites should be progressively more resolved near the new or modifying source, areas of interest, and areas with the highest concentrations with sufficient detail to determine where possible violations of a NAAQS or PSD increments are most likely to occur. The placement of receptor sites should be determined on a case-by-case basis, taking into consideration the source characteristics, topography, climatology, and monitor sites. Locations of particular importance 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. Depending on the

complexities of the source and the environment to which the source is located, a dense array of receptors may be required in some cases. In order to avoid unreasonably large computer runs due to an excessively large array of receptors, it is often desirable to model the area twice. The first model run would use a moderate number of receptors more resolved near the new or modifying source and over areas of interest. The second model run would modify the receptor network from the first model run with a denser array of receptors in areas showing potential for high concentrations and possible violations, as indicated by the results of the first model run. Accordingly, the EPA neither anticipates nor encourages that numerous iterations of modeling runs be made to continually refine the receptor network.

9.2.3   NAAQS and PSD Increments Compliance Demonstrations for New or Modifying Sources

a. As described in this subsection, the recommended procedure for conducting either a NAAQS or PSD increments assessment under PSD permitting is a multi-stage approach that includes the following two stages:

i. The EPA describes the first stage as a single-source impact analysis, since this stage involves considering only the impact of the new or modifying source. There are two possible levels of detail in conducting a single-source impact analysis with the model user beginning with use of a screening model and proceeding to use of a refined model as necessary.

ii. The EPA describes the second stage as a cumulative impact analysis, since it takes into account all sources affecting the air quality in an area. In addition to the project source impact, this stage includes consideration of background, which includes contributions from nearby sources and other sources (*e.g*., natural, minor, distant major, and unidentified sources).

b. Each stage should involve increasing complexity and details, as required, to fully

demonstrate that a new or modifying source will not cause or contribute to a violation of any NAAQS or PSD increment. As such, starting with a single-source impact analysis is recommended because, where the analysis at this stage is sufficient to demonstrate that a source will not cause or contribute to any potential violation, this may alleviate the need for a more time-consuming and comprehensive cumulative modeling analysis.

c. The single-source impact analysis, or first stage of an air quality analysis, should begin by determining the potential of a proposed new or modifying source to cause or contribute to a NAAQS or PSD increment violation. In certain circumstances, a screening model or technique may be used instead of the preferred model because it will provide estimated worst-case ambient impacts from the proposed new or modifying source. If these worst case ambient concentration estimates indicate that the source will not cause or contribute to any potential violation of a NAAQS or PSD increment, then the screening analysis should generally be sufficient for the required demonstration under PSD. If the ambient concentration estimates indicate that the source's emissions have the potential to cause or contribute to a violation, then the use of a refined model to estimate the source's impact should be pursued. The refined modeling analysis should use a model or technique consistent with the *Guideline* (either a preferred model or technique or an alternative model or technique) and follow the requirements and recommendations for model inputs outlined in section 8. If the ambient concentration increase predicted with refined modeling indicates that the source will not cause or contribute to any potential violation of a NAAQS or PSD increment, then the refined analysis should generally be sufficient for the required demonstration under PSD. However, if the ambient concentration estimates from the refined modeling analysis indicate that the source's emissions have the potential to cause or contribute to a violation, then a cumulative impact analysis should be

undertaken. The receptors that indicate the location of significant ambient impacts should be used to define the modeling domain for use in the cumulative impact analysis (section 8.2.2).

d. The cumulative impact analysis, or the second stage of an air quality analysis, should be conducted with the same refined model or technique to characterize the project source and then include the appropriate background concentrations (section 8.3). The resulting design concentrations should be used to determine whether the source will cause or contribute to a NAAQS or PSD increment violation. This determination should be based on: (1) The appropriate design concentration for each applicable NAAQS (and averaging period); and (2) whether the source's emissions cause or contribute to a violation at the time and location of any modeled violation (*i.e.*, when and where the predicted design concentration is greater than the NAAQS). For PSD increments, the cumulative impact analysis should also consider the amount of the air quality increment that has already been consumed by other sources, or, conversely, whether increment has expanded relative to the baseline concentration. Therefore, the applicant should model the existing or permitted nearby increment-consuming and increment-expanding sources, rather than using past modeling analyses of those sources as part of background concentration. This would permit the use of newly acquired data or improved modeling techniques if such data and/or techniques have become available since the last source was permitted.

9.2.3.1   Considerations in Developing Emissions Limits

a. Emissions limits and resulting control requirements should be established to provide for compliance with each applicable NAAQS (and averaging period) and PSD increment. It is possible that multiple emissions limits will be required for a source to demonstrate compliance with several criteria pollutants (and averaging periods) and PSD increments. Case-by-case determinations must be made as to the appropriate form of the limits, *i.e.*, whether the emissions

limits restrict the emission factor (*e.g.*, limiting lb/MMBTU), the emission rate (*e.g.*, lb/hr), or both. The appropriate reviewing authority (paragraph 3.0(b)) and appropriate EPA guidance should be consulted to determine the appropriate emissions limits on a case-by-case basis.

9.2.4   Use of Measured Data in Lieu of Model Estimates

a. As described throughout the *Guideline*, modeling is the preferred method for demonstrating compliance with the NAAQS and PSD increments and for determining the most appropriate emissions limits for new and existing sources. When a preferred model or adequately justified and approved alternative model is available, model results, including the appropriate background, are sufficient for air quality demonstrations and establishing emissions limits, if necessary. In instances when the modeling technique available is only a screening technique, the addition of air quality monitoring data to the analysis may lend credence to the model results. However, air quality monitoring data alone will normally not be acceptable as the sole basis for demonstrating compliance with the NAAQS and PSD increments or for determining emissions limits.

b. There may be rare circumstances where the performance of the preferred air quality model will be shown to be less than reasonably acceptable when compared with air quality monitoring data measured in the vicinity of an existing source. Additionally, there may not be an applicable preferred air quality model, screening technique, or justifiable alternative model suitable for the situation. In these unique instances, there may be the possibility of establishing emissions limits and demonstrating compliance with the NAAQS and PSD increments solely on the basis of analysis of observed air quality data in lieu of an air quality modeling analysis. However, only in the case of a modification to an existing source should air quality monitoring data alone be a basis for determining adequate emissions limits or for demonstration that the modification will

not cause or contribute to a violation of any NAAQS or PSD increment.

c. The following items should be considered prior to the acceptance of an analysis of measured air quality data as the sole basis for an air quality demonstration or determining an emissions limit:

i. Does a monitoring network exist for the pollutants and averaging times of concern in the vicinity of the existing source?

ii. Has the monitoring network been designed to locate points of maximum concentration?

iii. Do the monitoring network and the data reduction and storage procedures meet EPA monitoring and quality assurance requirements?

iv. Do the dataset and the analysis allow impact of the most important individual sources to be identified if more than one source or emission point is involved?

v. Is at least one full year of valid ambient data available?

vi. Can it be demonstrated through the comparison of monitored data with model results that available air quality models and techniques are not applicable?

d. Comprehensive air quality monitoring in the area affected by the existing source with proposed modifications will be necessary in these cases. Additional meteorological monitoring may also be necessary. The appropriate number of air quality and meteorological monitors from a scientific and technical standpoint is a function of the situation being considered. The source configuration, terrain configuration, and meteorological variations all have an impact on number and optimal placement of monitors. Decisions on the monitoring network appropriate for this type of analysis can only be made on a case-by-case basis.

e. Sources should obtain approval from the appropriate reviewing authority (paragraph

3.0(b)) and the EPA Regional Office for the monitoring network prior to the start of monitoring.

A monitoring protocol agreed to by all parties involved is necessary to assure that ambient data

are collected in a consistent and appropriate manner. The design of the network, the number,

type, and location of the monitors, the sampling period, averaging time, as well as the need for

meteorological monitoring or the use of mobile sampling or plume tracking techniques, should

all be specified in the protocol and agreed upon prior to start-up of the network.

f. Given the uniqueness and complexities of these rare circumstances, the procedures can

only be established on a case-by-case basis for analyzing the source's emissions data and the

measured air quality monitoring data, and for projecting with a reasoned basis the air quality

impact of a proposed modification to an existing source in order to demonstrate that emissions

from the construction or operation of the modification will not cause or contribute to a violation

of the applicable NAAQS and PSD increment, and to determine adequate emissions limits. The

same attention should be given to the detailed analyses of the air quality data as would be applied

to a comprehensive model performance evaluation. In some cases, the monitoring data collected

for use in the performance evaluation of preferred air quality models, screening technique, or

existing alternative models may help inform the development of a suitable new alternative

model. Early coordination with the appropriate reviewing authority (paragraph 3.0(b)) and the

EPA Regional Office is fundamental with respect to any potential use of measured data in lieu of

model estimates.

10.0   References

1. *Code of Federal Regulations*; Title 40 (Protection of Environment); part 51; §§ 51.112, 51.117, 51.150, 51.160.

2. U.S. Environmental Protection Agency, 1990. New Source Review Workshop Manual: Prevention of Significant Deterioration and Nonattainment Area Permitting (Draft). Office of Air Quality Planning and Standards, Research Triangle Park, NC.

3. *Code of Federal Regulations*; Title 40 (Protection of Environment); part 51; §§ 51.166 and 52.21.

4. *Code of Federal Regulations*; Title 40 (Protection of Environment); part 93; §§ 93.116, 93.123, and 93.150.

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ADDENDUM A TO APPENDIX W OF PART 51—SUMMARIES OF PREFERRED AIR QUALITY MODELS

Table of Contents

A.0   Introduction and Availability

(1) 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 (where applicable), 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.

(2) These models have been subjected to a performance evaluation using comparisons with observed air quality data. Where possible, 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.

(3) Codes and documentation for all models listed in this appendix are available from the EPA's Support Center for Regulatory Air Models (SCRAM) Web site at *https://www.epa.gov/scram*. Codes and documentation may also be available from the National Technical Information Service (NTIS), *https://www.ntis.gov*, and, when available, are referenced with the appropriate NTIS accession number.

A.1   AERMOD (AMS/EPA Regulatory Model)

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Schulman, L. L., D.G. Strimaitis and J.S. Scire, 2000. Development and evaluation of the PRIME plume rise and building downwash model. *Journal of the Air & Waste Management Association,* 50: 378-390.

Schulman, L. L., and Joseph S. Scire, 1980. Buoyant Line and Point Source (BLP) Dispersion Model User's Guide. Document P-7304B. Environmental Research and Technology, Inc., Concord, MA. (NTIS No. PB 81–164642).

Availability

The model codes and associated documentation are available on EPA's SCRAM Web site (paragraph A.0(3)).

Abstract

AERMOD is a steady-state plume dispersion model for assessment of pollutant concentrations from a variety of sources. AERMOD simulates transport and dispersion from multiple point, area, volume, and line sources based on an up-to-date characterization of the atmospheric boundary layer. Sources may be located in rural or urban areas, and receptors may be located in simple or complex terrain. AERMOD accounts for building wake effects (*i.e.*, plume downwash) based on the PRIME building downwash algorithms. The model employs

hourly sequential preprocessed meteorological data to estimate concentrations for averaging times from 1-hour to 1-year (also multiple years). AERMOD can be used to estimate the concentrations of nonreactive pollutants from highway traffic. AERMOD also handles unique modeling problems associated with aluminum reduction plants, and other industrial sources where plume rise and downwash effects from stationary buoyant line sources are important. AERMOD is designed to operate in concert with two pre-processor codes: AERMET processes meteorological data for input to AERMOD, and AERMAP processes terrain elevation data and generates receptor and hill height information for input to AERMOD.

a. *Regulatory Use*

(1) AERMOD is appropriate for the following applications:

- Point, volume, and area sources;

- Buoyant, elevated line sources (*e.g.*, aluminum reduction plants);

- Mobile sources;

- Surface, near-surface, and elevated releases;

- Rural or urban areas;

- Simple and complex terrain;

- Transport distances over which steady- state assumptions are appropriate, up to 50 km;

- 1-hour to annual averaging times,

- Continuous toxic air emissions; and,

- Applications in the marine boundary layer environment where the effects of shoreline fumigation and/or platform downwash are adequately assessed or are not applicable.

(2) For regulatory applications of AERMOD, the regulatory default option should be set, *i.e.*, the parameter DFAULT should be employed in the MODELOPT record in the COntrol Pathway.

The DFAULT option requires the use of meteorological data processed with the regulatory options in AERMET, the use of terrain elevation data processed through the AERMAP terrain processor, stack-tip downwash, sequential date checking, and does not permit the use of the model in the SCREEN mode. In the regulatory default mode, pollutant half-life or decay options are not employed, except in the case of an urban source of sulfur dioxide where a 4-hour half-life is applied. Terrain elevation data from the U.S. Geological Survey (USGS) 7.5-Minute Digital Elevation Model (DEM), or equivalent (approx. 30-meter resolution and finer), (processed through AERMAP) should be used in all applications. Starting in 2011, data from the 3D Elevation Program (3DEP, *https://apps.nationalmap.gov/downloader*), formerly the National Elevation Dataset (NED), can also be used in AERMOD, which includes a range of resolutions, from 1-m to 2 arc seconds and such high resolution would always be preferred. In some cases, exceptions from the terrain data requirement may be made in consultation with the appropriate reviewing authority (paragraph 3.0(b)).

b. *Input Requirements*

(1) Source data: Required inputs include source type, location, emission rate, stack height, stack inside diameter, stack gas exit velocity, stack gas exit temperature, area and volume source dimensions, and source base elevation. For point sources subject to the influence of building downwash, direction-specific building dimensions (processed through the BPIPPRM building processor) should be input. Variable emission rates are optional. Buoyant line sources require coordinates of the end points of the line, release height, emission rate, average line source width, average building width, average spacing between buildings, and average line source buoyancy parameter. For mobile sources, traffic volume; emission factor, source height, and mixing zone width are needed to determine appropriate model inputs.

(2) Meteorological data: The AERMET meteorological preprocessor requires input of surface characteristics, including surface roughness (zo), Bowen ratio, and albedo, as well as, hourly observations of wind speed between 7zo and 100 m (reference wind speed measurement from which a vertical profile can be developed), wind direction, cloud cover, and temperature between zo and 100 m (reference temperature measurement from which a vertical profile can be developed). Meteorological data can be in the form of observed data or prognostic modeled data as discussed in paragraph 8.4.1(d). Surface characteristics may be varied by wind sector and by season or month. When using observed meteorological data, a morning sounding (in National Weather Service format) from a representative upper air station is required. Latitude, longitude, and time zone of the surface, site-specific or prognostic data (if applicable) and upper air meteorological stations are required. The wind speed starting threshold is also required in AERMET for applications involving site-specific data. When using prognostic data, modeled profiles of temperature and winds are input to AERMET. These can be hourly or a time that represents a morning sounding. Additionally, measured profiles of wind, temperature, vertical and lateral turbulence may be required in certain applications (*e.g.*, in complex terrain) to adequately represent the meteorology affecting plume transport and dispersion. Optionally, measurements of solar and/or net radiation may be input to AERMET. Two files are produced by the AERMET meteorological preprocessor for input to the AERMOD dispersion model. When using observed data, the surface file contains observed and calculated surface variables, one record per hour. For applications with multi-level site-specific meteorological data, the profile contains the observations made at each level of the meteorological tower (or remote sensor). When using prognostic data, the surface file contains surface variables calculated by the prognostic model and AERMET. The profile file contains the observations made at each level of

a meteorological tower (or remote sensor), the one-level observations taken from other representative data (*e.g.*, National Weather Service surface observations), one record per level per hour, or in the case of prognostic data, the prognostic modeled values of temperature and winds at user-specified levels.

(i) Data used as input to AERMET should possess an adequate degree of representativeness to ensure that the wind, temperature and turbulence profiles derived by AERMOD are both laterally and vertically representative of the source impact area. The adequacy of input data should be judged independently for each variable. The values for surface roughness, Bowen ratio, and albedo should reflect the surface characteristics in the vicinity of the meteorological tower or representative grid cell when using prognostic data, and should be adequately representative of the modeling domain. Finally, the primary atmospheric input variables, including wind speed and direction, ambient temperature, cloud cover, and a morning upper air sounding, should also be adequately representative of the source area when using observed data.

(ii) For applications involving the use of site-specific meteorological data that includes turbulences parameters (*i.e.*, sigma-theta and/or sigma-w), the application of the ADJ_U* option in AERMET would require approval as an alternative model application under section 3.2.

(iii) For recommendations regarding the length of meteorological record needed to perform a regulatory analysis with AERMOD, *see* section 8.4.2.

(3) Receptor data: Receptor coordinates, elevations, height above ground, and hill height scales are produced by the AERMAP terrain preprocessor for input to AERMOD. Discrete receptors and/or multiple receptor grids, Cartesian and/or polar, may be employed in AERMOD. AERMAP requires input of DEM or 3DEP terrain data produced by the USGS, or other equivalent data. AERMAP can be used optionally to estimate source elevations.

c. *Output*

Printed output options include input information, high concentration summary tables by receptor for user-specified averaging periods, maximum concentration summary tables, and concurrent values summarized by receptor for each day processed. Optional output files can be generated for: a listing of occurrences of exceedances of user-specified threshold value; a listing of concurrent (raw) results at each receptor for each hour modeled, suitable for post-processing; a listing of design values that can be imported into graphics software for plotting contours; a listing of results suitable for NAAQS analyses including NAAQS exceedances and culpability analyses; an unformatted listing of raw results above a threshold value with a special structure for use with the TOXX model component of TOXST; a listing of concentrations by rank (*e.g.*, for use in quantile-quantile plots); and a listing of concentrations, including arc-maximum normalized concentrations, suitable for model evaluation studies.

d. *Type of Model*

AERMOD is a steady-state plume model, using Gaussian distributions in the vertical and horizontal for stable conditions, and in the horizontal for convective conditions. The vertical concentration distribution for convective conditions results from an assumed bi-Gaussian probability density function of the vertical velocity.

e. *Pollutant Types*

AERMOD is applicable to primary pollutants and continuous releases of toxic and hazardous waste pollutants. Chemical transformation is treated by simple exponential decay.

f. *Source-Receptor Relationships*

AERMOD applies user-specified locations for sources and receptors. Actual separation between each source-receptor pair is used. Source and receptor elevations are user input or are

determined by AERMAP using USGS DEM or 3DEP terrain data. Receptors may be located at user-specified heights above ground level.

g. *Plume Behavior*

(1) In the convective boundary layer (CBL), the transport and dispersion of a plume is characterized as the superposition of three modeled plumes: 1) the direct plume (from the stack); 2) the indirect plume; and 3) the penetrated plume, where the indirect plume accounts for the lofting of a buoyant plume near the top of the boundary layer, and the penetrated plume accounts for the portion of a plume that, due to its buoyancy, penetrates above the mixed layer, but can disperse downward and re-enter the mixed layer. In the CBL, plume rise is superposed on the displacements by random convective velocities (Weil, *et al.*, 1997).

(2) In the stable boundary layer, plume rise is estimated using an iterative approach to account for height-dependent lapse rates, similar to that in the CTDMPLUS model (*see* A.2 in this appendix).

(3) Stack-tip downwash and buoyancy induced dispersion effects are modeled. Building wake effects are simulated for stacks subject to building downwash using the methods contained in the PRIME downwash algorithms (Schulman, *et al.*, 2000). For plume rise affected by the presence of a building, the PRIME downwash algorithm uses a numerical solution of the mass, energy and momentum conservation laws (Zhang and Ghoniem, 1993). Streamline deflection and the position of the stack relative to the building affect plume trajectory and dispersion. Enhanced dispersion is based on the approach of Weil (1996). Plume mass captured by the cavity is well-mixed within the cavity. The captured plume mass is re-emitted to the far wake as a volume source.

(4) For elevated terrain, AERMOD incorporates the concept of the critical dividing

streamline height, in which flow below this height remains horizontal, and flow above this height tends to rise up and over terrain (Snyder, *et al.*, 1985). Plume concentration estimates are the weighted sum of these two limiting plume states. However, consistent with the steady-state assumption of uniform horizontal wind direction over the modeling domain, straight-line plume trajectories are assumed, with adjustment in the plume/receptor geometry used to account for the terrain effects.

h. *Horizontal Winds*

Vertical profiles of wind are calculated for each hour based on measurements and surface-layer similarity (scaling) relationships. At a given height above ground, for a given hour, winds are assumed constant over the modeling domain. The effect of the vertical variation in horizontal wind speed on dispersion is accounted for through simple averaging over the plume depth.

i. *Vertical Wind Speed*

In convective conditions, the effects of random vertical updraft and downdraft velocities are simulated with a bi-Gaussian probability density function. In both convective and stable conditions, the mean vertical wind speed is assumed equal to zero.

j. *Horizontal Dispersion*

Gaussian horizontal dispersion coefficients are estimated as continuous functions of the parameterized (or measured) ambient lateral turbulence and also account for buoyancy-induced and building wake-induced turbulence. Vertical profiles of lateral turbulence are developed from measurements and similarity (scaling) relationships. Effective turbulence values are determined from the portion of the vertical profile of lateral turbulence between the plume height and the receptor height. The effective lateral turbulence is then used to estimate horizontal dispersion.

k. *Vertical Dispersion*

In the stable boundary layer, Gaussian vertical dispersion coefficients are estimated as continuous functions of parameterized vertical turbulence. In the convective boundary layer, vertical dispersion is characterized by a bi-Gaussian probability density function and is also estimated as a continuous function of parameterized vertical turbulence. Vertical turbulence profiles are developed from measurements and similarity (scaling) relationships. These turbulence profiles account for both convective and mechanical turbulence. Effective turbulence values are determined from the portion of the vertical profile of vertical turbulence between the plume height and the receptor height. The effective vertical turbulence is then used to estimate vertical dispersion.

l. *Chemical Transformation*

Chemical transformations are generally not treated by AERMOD. However, AERMOD does contain an option to treat chemical transformation using simple exponential decay, although this option is typically not used in regulatory applications except for sources of sulfur dioxide in urban areas. Either a decay coefficient or a half-life is input by the user. Note also that the Generic Reaction Set Method, Plume Volume Molar Ratio Method and the Ozone Limiting Method (section 4.2.3.4) for NO_2 analyses are available.

m. *Physical Removal*

AERMOD can be used to treat dry and wet deposition for both gases and particles. Currently, Method 1 particle deposition is available for regulatory applications. Method 2 particle deposition and gas deposition are currently alpha options and not available for regulatory applications

n. *Evaluation Studies*

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Dispersion Model, Scientific Evaluation, prepared by Woodward-Clyde Consultants, Lexington, Massachusetts, for American Petroleum Institute, Washington, D.C., 20005-4070.

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Brode, R.W., 2004. Implementation and Evaluation of Bulk Richardson Number Scheme in AERMOD. 13th Joint Conference on Applications of Air Pollution Meteorology, August 23-26, 2004; American Meteorological Society, Boston, MA.

U.S. Environmental Protection Agency, 2003. AERMOD: Latest Features and Evaluation Results. Publication No. EPA-454/R-03-003. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

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Environmental Protection Agency, 2023. Technical Support Document (TSD) for Adoption of the Generic Reaction Set Method (GRSM) as a Regulatory Non-Default Tier-3 NO2 Screening Option. Publication No. EPA-454/R-23-009. Office of Air Quality Planning & Standards, Research Triangle Park, NC.

A.2   CTDMPLUS (Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations)

References

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. U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS No. PB 89-181424).

Perry, S.G., 1992. CTDMPLUS: A Dispersion Model for Sources near Complex Topography. Part I: Technical Formulations. *Journal of Applied Meteorology,* 31(7): 633-645.

Availability

The model codes and associated documentation are available on the EPA's SCRAM Web site (paragraph A.0(3)).

Abstract

CTDMPLUS is a refined point source Gaussian air quality model for use in all stability conditions for complex terrain applications. The model 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. *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

- 1-hour to annual averaging times when used with a post-processor program such as CHAVG.

b. *Input Requirements*

(1) 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.

(2) Meteorological data: For applications of CTDMPLUS, multiple level (typically three or more) measurements of wind speed and direction, temperature and turbulence (wind fluctuation statistics) are required to create the basic meteorological data file ("PROFILE"). 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 and/or RASS if the representative plume height(s) of interest is above the levels represented by the tower measurements. 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).

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

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

c. *Output*

(1) 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, and

- Source-receptor location (line printer map).

(2) 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, and

- Plume characteristics at each receptor, *i.e.*,

  o Distance in along-flow and cross flow direction

  o Effective plume-receptor height difference

  o Effective σy & σz values, both flat terrain and hill induced (the difference shows the effect of the hill)

o Concentration components due to WRAP, LIFT and FLAT.

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

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

(i) A binary file of concentrations, one value for each receptor in the hourly sequence as run;

(ii) A text file of concentrations, one value for each receptor in the hourly sequence as run; or

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

(5) 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°, so that the linearized equation of motion for Boussinesq 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*

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

(2) 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.

(3) 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, σv, 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.*, σw (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. U.S. 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. U.S. 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.

A.3   OCD (Offshore and Coastal Dispersion) Model

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

The model codes and associated documentation are available on EPA's SCRAM Web site (paragraph A.0(3)).

Abstract

(1) 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.

(2) 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. *Regulatory Use*

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 appropriate reviewing authority (paragraph 3.0(b)).

b. *Input Requirements*

(1) 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.

(2) Meteorological data: PCRAMMET is the recommended meteorological data preprocessor for use in applications of OCD employing hourly NWS data. MPRM is the recommended meteorological data preprocessor for applications of OCD employing site-specific meteorological data

(i) Over land: Surface weather data including hourly stability class, wind direction, wind speed, ambient temperature, and mixing height are required.

(ii) Over water: Hourly values for mixing height, relative humidity, air temperature, and water surface temperature are required; if wind speed/direction are missing, values over land will be used (if available); vertical wind direction shear, vertical temperature gradient, and turbulence intensities are optional.

(3) Receptor data: Location, height above local ground-level, ground-level elevation above the water surface.

c. *Output*

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

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

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

(4) Concentration output files 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*

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

(2) Receptors and sources are allowed at any location.

(3) 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*

(1) The basic plume rise algorithms are based on Briggs' recommendations.

(2) Momentum rise includes consideration of the stack angle from the vertical.

(3) 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.

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

(5) 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*

(1) Constant, uniform wind is assumed for each hour.

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

(3) 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*

(1) 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.

(2) 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.

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

(4) 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*

(1) 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.

(2) 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.

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

(4) 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.

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