PM Hot-spot Guidance

Transportation Conformity Guidance for Quantitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Nonattainment and Maintenance Areas

EPA United States Environmental Protection Agency

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Transportation and Climate Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

EPA United States Environmental Protection Agency

EPA-420-B-21-037
October 2021

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Section 1: Introduction

1.1 Purpose of this Guidance

This guidance describes how to complete quantitative hot-spot analyses for certain highway and transit projects in $PM_{2.5}$ and PM_{10} (PM) nonattainment and maintenance areas.[1] This guidance describes transportation conformity requirements for hot-spot analyses, and provides technical guidance on estimating project emissions with the Environmental Protection Agency's (EPA's) MOVES model, California's EMFAC model, and other methods.[2] It also outlines how to apply EPA's AERMOD dispersion model for PM hot-spot analyses and includes additional references and examples. However, the guidance does not change the specific transportation conformity rule requirements for quantitative PM hot-spot analyses, such as what projects require these analyses. EPA has coordinated with the Department of Transportation (DOT) during the development of this guidance.

Transportation conformity is required under Clean Air Act (CAA) section 176(c) (42 U.S.C. 7506(c)) to ensure that federally supported highway and transit project activities are consistent with (conform to) the purpose of a state air quality implementation plan (SIP). Conformity to the purpose of the SIP means that transportation activities will not cause or contribute to new air quality violations, worsen existing violations, or delay timely attainment of the relevant national ambient air quality standards (NAAQS) or required interim milestones. EPA's transportation conformity rule (40 CFR 51.390 and Part 93) establishes the criteria and procedures for determining whether transportation activities conform to the SIP. Conformity applies to transportation activities in nonattainment and maintenance areas for transportation-related pollutants, including $PM_{2.5}$ and PM_{10}. This guidance is consistent with existing regulations and guidance for the PM NAAQS, SIP development, and other regulatory programs as applicable. This guidance does not address carbon monoxide (CO) hot-spot requirements or modeling procedures.[3]

1.2 Requirement for Quantitative PM Hot-Spot Analyses

All PM hot-spot analyses necessary for meeting the requirements of transportation conformity must be quantitative. The requirement that these analyses be quantitative has been in effect since 2012. For additional information, see EPA's December 20, 2010

[1] PM, or particulate matter, includes PM_{10}, which are particles with diameters that are generally 10 microns and smaller, and $PM_{2.5}$, which are particles with diameters generally 2.5 microns and smaller. For more information, see https://www.epa.gov/pm-pollution.

[2] This guidance is applicable to MOVES3 and future versions of the MOVES model unless EPA notes otherwise when approving the model for conformity purposes.

[3] EPA has issued a separate guidance document on how to use MOVES for CO project-level analyses (including CO hot-spot analyses for conformity purposes). This guidance is available online at: https://www.epa.gov/state-and-local-transportation/project-level-conformity-and-hot-spot-analyses#coguidance.

Federal Register announcement that models and guidance for PM hot-spot analyses were available (75 FR 79370, December 20, 2010).

Quantitative hot-spot analyses must be based on the latest emissions model, according to 40 CFR 93.111. EPA publishes a *Federal Register* notice of availability for MOVES (and EMFAC in California) when a new model can be used for conformity and establishes a grace period before its use is required as the latest emissions model for PM hot-spot analyses. The effective date of the *Federal Register* notice constitutes the start of the conformity grace period for the use of that version of the model.[4] EPA has issued policy guidance on when these models are used for PM hot-spot analyses and other purposes, which provides more details on model transition.[5]

1.3 Definition of a Hot-Spot Analysis

A hot-spot analysis is defined in 40 CFR 93.101 as an estimation of likely future localized pollutant concentrations and a comparison of those concentrations to the relevant NAAQS. A hot-spot analysis assesses the air quality impacts on a scale smaller than an entire nonattainment or maintenance area, including, for example, congested highways or transit terminals. Such an analysis of the area substantially affected by the project demonstrates that CAA conformity requirements are met for the relevant NAAQS in the "project area." When a hot-spot analysis is required, it is included within a project-level conformity determination.

1.4 Projects Requiring a PM Hot-Spot Analysis

PM hot-spot analyses are required for projects of local air quality concern, which include certain highway and transit projects that involve significant levels of diesel vehicle traffic and any other project identified in the PM SIP as a localized air quality concern (40 CFR 93.116(a) and 93.123(b)). See Section 2.2 of the guidance for further information on the specific types of projects where a PM hot-spot analysis is required. A PM hot-spot analysis is not required for projects that are not of local air quality concern (40 CFR 93.116(a)). This guidance does not alter the types of projects that require a PM hot-spot analysis.

Note that additional projects may need hot-spot analyses in PM_{10} nonattainment and maintenance areas with approved conformity SIPs that are based on the federal PM_{10} hot-

[4] EPA posts all *Federal Register* notices for new emissions models on its web site: https://www.epa.gov/state-and-local-transportation/policy-and-technical-guidance-state-and-local-transportation#emission.

[5] The latest version of the policy guidance on the use of MOVES for state implementation plan development and transportation conformity is available online at: https://www.epa.gov/state-and-local-transportation/policy-and-technical-guidance-state-and-local-transportation#emission.

spot requirements that existed before the March 2006 final rule.[6] EPA strongly encourages states to revise these outdated conformity SIPs to take advantage of the streamlining flexibilities provided by the current CAA.[7] See Appendix C of this guidance for further details on how these types of approved conformity SIPs can affect what projects are required to have PM hot-spot analyses.

1.5 Other Purposes for this Guidance

This guidance addresses how to complete a quantitative PM hot-spot analysis for transportation conformity purposes and is the only EPA guidance that covers how to conduct a PM hot-spot analysis for a transportation project. Certain sections of this technical guidance may also apply when completing analyses of transportation projects for other purposes, such as general conformity determinations, National Environmental Policy Act (NEPA) analyses, or assessing near-source air quality in communities with environmental justice concerns.[8] For example, the approach described in Section 4 may be used to estimate transportation project emissions using MOVES, and Sections 7 and 8 may be used to conduct PM air quality analyses of transportation projects.

1.6 Organization of this Guidance

The remainder of this guidance is organized as follows:

- Section 2 provides an overview of transportation conformity requirements for PM hot-spot analyses.
- Section 3 describes the general process for conducting PM hot-spot analyses.
- Section 4 describes how to estimate vehicle emissions from a project using the latest emissions model MOVES (for all states other than California).
- Section 5 provides information to consider for modeling projects in California with EMFAC and is in addition to California Air Resources Board (CARB) handbook for using EMFAC to estimate emissions from projects.[9]
- Section 6 discusses how to estimate emissions from road dust, construction dust, and additional sources, if necessary.
- Section 7 describes how to determine the appropriate air quality dispersion model and select model inputs.

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[6] A "conformity SIP" includes a state's specific criteria and procedures for certain aspects of the transportation conformity process (40 CFR 51.390).

[7] For more information about conformity SIPs, see EPA's *Guidance for Developing Transportation Conformity State Implementation Plans (SIPs)*, EPA-420-B-09-001, January 2009; available online at: https://www.epa.gov/state-and-local-transportation/policy-and-technical-guidance-state-and-local-transportation#state.

[8] For more information about environmental justice, see https://www.epa.gov/environmentaljustice.

[9] CARB's EMFAC welcome website is found at: https://arb.ca.gov/emfac/. This link as well as the CARB EMFAC training website, https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/msei-training-materials, include training videos. EMFAC documentation, including documentation for project-level modeling (titled, *PL Handbook*), is found at: https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/msei-modeling-tools-emfac-software-and.

- Section 8 covers how to determine background concentrations, including nearby source emissions in the project area.
- Section 9 describes how to calculate the appropriate design concentrations and determine whether or not the project conforms. The term "design concentration" refers to the combination of the appropriate background concentration with the estimated modeled impact of the project. See Section 2.4.1 for additional discussion.
- Section 10 describes mitigation and control measures that could be considered, if necessary.

The following appendices for this guidance may also help state and local agencies conduct PM hot-spot analyses:

- Appendix A is a clearinghouse of information and resources external to this guidance that may be useful when completing PM hot-spot analyses.
- Appendix B gives examples of projects of local air quality concern.
- Appendix C discusses what projects need a PM_{10} hot-spot analysis if a state's approved conformity SIP is based on pre-2006 requirements.
- Appendix D demonstrates how to characterize links in an intersection when running MOVES.
- Appendices E, F, G, and H: reserved.[10]
- Appendix I describes how to estimate locomotive emissions in the project area.
- Appendix J includes details on how to input data and run air quality models for PM hot-spot analyses, as well as prepare outputs for design concentration calculations.
- Appendix K has examples of how to calculate design concentrations and determine transportation conformity.
- Appendix L provides information on how to calculate 24-hour $PM_{2.5}$ design concentrations using a "second tier" approach.

Except where indicated, this guidance applies for the annual $PM_{2.5}$ NAAQS, the 24-hour $PM_{2.5}$ NAAQS, and the 24-hour PM_{10} NAAQS. This guidance is written for current and future $PM_{2.5}$ and PM_{10} NAAQS. EPA will re-evaluate the applicability of this guidance, as needed, if different PM NAAQS are promulgated in the future.

1.7 Additional Information

For specific questions concerning a particular nonattainment or maintenance area, please contact the transportation conformity staff person responsible for your state at the appropriate EPA Regional Office. Contact information for EPA Regional Offices can be found at: https://www.epa.gov/state-and-local-transportation/epa-regional-contacts-regarding-state-and-local-transportation.

[10] Appendices E through H have been retained for the purpose of maintaining references throughout the document only. Their content has been removed.

General questions about this guidance and technical questions about conformity hot-spot analyses can be directed to Laura Berry at EPA's Office of Transportation and Air Quality, berry.laura@epa.gov.

Specific questions related to using MOVES at the project scale can be directed to the MOVES email in-box, mobile@epa.gov.

1.8 Guidance and Existing Requirements

This guidance does not create any new requirements. The CAA and the regulations described in this document contain legally binding requirements. This guidance is not a substitute for those provisions or regulations, nor is it a regulation in itself. Thus, it does not impose legally binding requirements on EPA, DOT, states, or the regulated community, and may not apply to a particular situation based upon the circumstances. EPA retains the discretion to adopt approaches on a case-by-case basis that may differ from this guidance but still comply with the statute and applicable regulations. This guidance may be revised periodically without public notice.

Section 2: Transportation Conformity Requirements

2.1 Introduction

This section outlines the transportation conformity requirements for quantitative PM hot-spot analyses, including the general statutory and regulatory requirements, specific analytical requirements, and the different types of agencies involved in developing hot-spot analyses.

2.2 Overview of Statutory and Regulatory Requirements

CAA section 176(c)(1) is the statutory requirement that must be met by all projects in nonattainment and maintenance areas that are subject to transportation conformity. Section 176(c)(1)(B) states that federally-supported transportation projects must not "cause or contribute to any new violation of any standard [NAAQS] in any area; increase the frequency or severity of any existing violation of any standard in any area; or delay timely attainment of any standard or any required interim emission reductions or other milestones in any area."[11]

Section 93.109(b) of the conformity rule outlines the requirements for project-level conformity determinations. For example, PM hot-spot analyses must be based on the latest planning assumptions available at the time the analysis begins (40 CFR 93.110). Also, the design concept and scope of the project must be consistent with that included in the conforming transportation plan and transportation improvement program (TIP) or regional emissions analysis (40 CFR 93.114).

Section 93.123(b)(1) of the conformity rule defines the projects that require a $PM_{2.5}$ or PM_{10} hot-spot analysis as:

> "(i) New highway projects that have a significant number of diesel vehicles, and expanded highway projects that have a significant increase in the number of diesel vehicles;
>
> (ii) Projects affecting intersections that are at Level-of-Service D, E, or F with a significant number of diesel vehicles, or those that will change to Level-of-Service D, E, or F because of increased traffic volumes from a significant number of diesel vehicles related to the project;

[11] See EPA's March 2006 final rule (71 FR 12469-12490) and March 24, 2010 final rule (75 FR 14274-14285). Both of these final rules address the statutory conformity requirements and explain how the hot-spot analyses required by EPA's regulations satisfy those requirements. Issues relating to the statutory conformity requirements are therefore not addressed in this guidance document. See also Environmental Defense v. EPA 467 F.3d 1329 (D.C. Cir. 2006) and Environmental Defense vs. EPA, 509 F.3d 553 (D.C. Cir. 2007).

(iii) New bus and rail terminals and transfer points that have a significant number of diesel vehicles congregating at a single location;

(iv) Expanded bus and rail terminals and transfer points that significantly increase the number of diesel vehicles congregating at a single location; and

(v) Projects in or affecting locations, areas, or categories of sites which are identified in the $PM_{2.5}$ or PM_{10} applicable implementation plan or implementation plan submission, as appropriate, as sites of violation or possible violation."

For all other non-exempt federal projects, state and local project sponsors should document in their project-level conformity determinations that the requirements of the CAA and 40 CFR 93.116 are met without a hot-spot analysis, since such projects have been found not to be of local air quality concern under 40 CFR 93.123(b)(1). Note that all other project-level conformity requirements must continue to be met. See Appendix B for examples of projects that are most likely to be of local air quality concern, as well as examples of projects that are not.[12] Appendix B includes the additional examples found in EPA's PM Hot-Spot Analysis FAQs.[13]

Section 93.123(c) of the conformity rule includes the general requirements for all PM hot-spot analyses. A PM hot-spot analysis must:

- Estimate the total emissions burden of direct PM emissions that may result from the implementation of the project(s), summed together with future background concentrations;
- Include the entire transportation project, after identifying the major design features that will significantly impact local concentrations;
- Use assumptions that are consistent with those used in regional emissions analyses for inputs that are needed for both analyses (e.g., temperature, humidity);
- Assume the implementation of mitigation or control measures only where written commitments for such measures have been obtained; and
- Consider emissions increases from construction-related activities only if they occur during the construction phase and last more than five years at any individual site.

Finally, the interagency consultation process must be used to develop project-level conformity determinations to meet all applicable conformity requirements for a given project. In general, when a hot-spot analysis is required, it is done when a project-level conformity determination is completed. Conformity determinations are typically developed during the National Environmental Policy Act (NEPA) process, although conformity requirements are separate from NEPA-related requirements. There can also

[12] See the preamble of the March 2006 final rule for further information regarding how and why EPA defined projects of local air quality concern (71 FR 12491-12493). EPA also clarified Section 93.123(b)(1)(i) in the January 24, 2008 final rule (73 FR 4435-4436).
[13] EPA, *PM Hot-spot Analyses: Frequently Asked Questions*, EPA-420-F-18-011, June 2018, found on EPA's website at: https://www.epa.gov/state-and-local-transportation/project-level-conformity-and-hot-spot-analyses#faq.

be limited cases when conformity requirements apply after the initial NEPA process has been completed.[14]

2.3 Interagency Consultation and Public Participation Requirements

The interagency consultation process is an important tool for completing project-level conformity determinations and hot-spot analyses. Interagency consultation must be used to develop a process to evaluate and choose models and associated methods and assumptions to be used in PM hot-spot analyses (40 CFR 93.105(c)(1)(i)). For example, each area's interagency consultation procedures must be used to determine the models and associated methods and assumptions for:

- The geographic area covered by the analysis (see Section 3.3);
- The emissions models used in the analysis (see Section 4 for MOVES and Section 5 for EMFAC);
- Whether and how to estimate road and construction dust emissions (see Section 6);
- The nearby sources considered, background data used, and air quality model chosen, including the background monitors/concentrations selected and any interpolation methods used (see Sections 7 and 8); and
- The appropriateness of receptors to be compared to the annual $PM_{2.5}$ NAAQS (see Section 9.4).

State and local agencies have flexibility to decide whether the process outlined in the interagency consultation procedures should be used for aspects of PM hot-spot analyses where consultation is not required. The roles and responsibilities of various agencies for meeting the transportation conformity requirements are addressed in 40 CFR 93.105 or in a state's approved conformity SIP. See Section 2.9 for further information on the agencies involved in interagency consultation.

This guidance describes when consultation on specific decisions is necessary, but for many aspects of PM hot-spot analyses, the general requirement for interagency consultation can be satisfied without consulting separately on each and every specific decision that arises. In general, as long as the consultation requirements are met, agencies have discretion as to how they consult on hot-spot analyses. For example, the interagency consultation process could be used to make decisions on a case-by-case basis for individual transportation projects for which a PM hot-spot analysis is required. Or, agencies involved in the consultation process could develop procedures that will apply for any PM hot-spot analysis and agree that any departures from procedures would be discussed by involved agencies.

The conformity rule also requires agencies completing project-level conformity determinations to establish a proactive public involvement process that provides

[14] Such an example may occur when NEPA is completed prior to an area being designated nonattainment, but additional federal project approvals are required after conformity requirements apply.

opportunity for public review and comment (40 CFR 93.105(e)). The NEPA public involvement process is typically used to satisfy this public participation requirement.[15] If a project-level conformity determination that includes a PM hot-spot analysis is performed after NEPA is completed, a public comment period must still be provided to support that determination. In these cases, agencies have flexibility to decide what specific public participation procedures are appropriate, as long as the procedures provide a meaningful opportunity for public review and comment.

See Section 3.10 for information about documenting the decisions made in an analysis.

2.4 Hot-Spot Analyses Are Build/No-Build Analyses

2.4.1 General

As noted above, the conformity rule requires that the emissions from the proposed project, when considered with background concentrations, will not cause or contribute to any new violation, worsen existing violations, or delay timely attainment of the relevant NAAQS or required interim milestones. As described in Section 1.3, the hot-spot analysis examines the area substantially affected by the project (i.e., the "project area").

In general, a hot-spot analysis compares the air quality concentrations with the proposed project (the build scenario) to the air quality concentrations without the project (the no-build scenario).[16] These air quality concentrations are determined by calculating a "design concentration," a statistic that describes a future air quality concentration in the project area that includes both the background and the impact from the project that can be compared to a particular NAAQS. The concept of design concentration is similar to the concept of a design value:

- A design value is a statistic that describes the air quality status of a given location relative to the level of the NAAQS.[17] Design values are based on data from air quality monitors and can be used to determine the air quality status of a given nonattainment or maintenance area (40 CFR Part 50).
- A "design concentration" also describes air quality relative to the NAAQS and is the combination of the appropriate background concentration with the estimated modeled impact of the proposed transportation project. This term is adapted from Section 9.2.2 of Appendix W of 40 CFR Part 51 (hereafter, "Appendix W").[18]

[15] Section 93.105(e) of the conformity rule requires agencies to "provide opportunity for public involvement in conformity determinations for projects where otherwise required by law."
[16] See 40 CFR 93.116(a). See also November 24, 1993 conformity rule (58 FR 62212-62213). Please note that a build/no-build analysis for project-level conformity determinations is different than the build/no-build interim emissions test for regional emissions analyses in 40 CFR 93.119.
[17] This definition is found on EPA's website at: https://www.epa.gov/air-trends/air-quality-design-values.
[18] Appendix W of 40 CFR Part 51 is the regulation known as *The Guideline on Air Quality Models*. The most recent update to this regulation is the final rule published January 17, 2017, (82 FR 5182), found on EPA's website at: https://www.epa.gov/sites/default/files/2020-09/documents/appw_17.pdf.

It is always necessary to complete emissions and air quality modeling on the build scenario and compare the resulting design concentrations to the relevant PM NAAQS. However, it will not always be necessary to conduct emissions and air quality modeling for the no-build scenario, as described further below.

2.4.2 Suggested Approach for PM Hot-Spot Analyses

To avoid unnecessary work, EPA suggests the following approach when completing a PM hot-spot analysis. As always, the approach should be discussed and agreed to within the area's interagency consultation process:

- First, model the build scenario and account for background concentrations in accordance with this guidance.
  - If the design concentrations for the build scenario are less than or equal to the relevant NAAQS, the project meets the conformity rule's hot-spot requirements and no further modeling is needed (i.e., there is no need to model the no-build scenario).
  - If this is not the case, the project sponsor could choose mitigation or control measures, perform additional modeling that includes these measures, and then determine if the build scenario is less than or equal to the relevant NAAQS.

- If the build scenario results in design concentrations greater than the NAAQS (e.g., even with the addition of mitigation or control measures), then the no-build scenario will also need to be modeled. The no-build scenario will model the air quality impacts of sources without the proposed project. The modeling results of the build and no-build scenarios should be combined with background concentrations as appropriate.
  - If the design concentrations for the build scenario are less than or equal to the design concentrations for the no-build scenario, then the project meets the conformity rule's hot-spot requirements.
  - If not, then the project does not meet conformity requirements without further mitigation or control measures. If such measures are considered, additional modeling will need to be completed and new design concentrations calculated to ensure that the build scenario is less than or equal to the no-build scenario.

The project sponsor can decide to use the suggested approach above or a different approach (e.g., conduct the no-build analysis first, calculate design concentrations at all build and no-build scenario receptors). The project sponsor can choose to apply mitigation or control measures at any point in the process.[19] This guidance applies to any of the above approaches for a given PM hot-spot analysis.

In general, assumptions should be consistent between the build and no-build scenarios for a given analysis year, except for traffic volumes and other project activity changes or

[19] If mitigation or control measures are used to demonstrate conformity during the hot-spot analysis, the conformity determination for the project must include written commitments to implement such measures (40 CFR 93.125).

changes in nearby sources that are expected to occur due to the project (e.g., increased activity at a nearby marine port or intermodal terminal due to a new freight corridor highway). Project sponsors should document the build/no-build analysis in the project-level conformity determination, including the assumptions, methods, and models used for each analysis year(s).

The conformity rule defines how to determine if new NAAQS violations or increases in the frequency or severity of existing violations are predicted to occur based on the hot-spot analysis. Section 93.101 states:

> "*Cause or contribute to a new violation* for a project means:
> (1) To cause or contribute to a new violation of a standard in the area substantially affected by the project or over a region which would otherwise not be in violation of the standard during the future period in question, if the project were not implemented; or
> (2) To contribute to a new violation in a manner that would increase the frequency or severity of a new violation of a standard in such area."
>
> "*Increase the frequency or severity* means to cause a location or region to exceed a standard more often or to cause a violation at a greater concentration than previously existed and/or would otherwise exist during the future period in question, if the project were not implemented."

A build/no-build analysis is typically based on design concentration comparisons done on a receptor-by-receptor basis. However, there may be certain cases where a "new" violation at one receptor (in the build scenario) is relocated from a different receptor (in the no-build scenario). As discussed in the preamble to the November 24, 1993 transportation conformity rule, EPA believes that "a seemingly new violation may be considered to be a relocation and reduction of an existing violation only if it were in the area substantially affected by the project and if the predicted [future] design value [design concentration] for the "new" site would be less than the design value [design concentration] at the "old" site without the project – that is, if there would be a net air quality benefit" (58 FR 62213).[20] Since 1993, EPA has made this interpretation only in limited cases with CO hot-spot analyses where there is a clear relationship between a proposed project and a possible relocated violation (e.g., a reduced CO NAAQS violation is relocated from one corner of an intersection to another due to traffic-related changes from an expanded intersection). Any potential relocated violations in PM hot-spot analyses should be determined through an area's interagency consultation procedures.

2.4.3 Guidance Focuses on Refined PM Hot-Spot Analyses

Finally, the build/no-build analysis described in this guidance represents a refined PM hot-spot analysis, rather than a screening analysis. Refined analyses rely on detailed

[20] Note that this sentence is from the 1993 conformity rule, which predates the distinction made between "design value" and "design concentration" in the Appendix W regulation; the sentence is referring to design concentration. For more information, see Section 2.4.1 of this guidance.

local information and simulate detailed atmospheric processes to provide more specialized and accurate estimates, and can be done for both the build and no-build scenarios. In contrast, screening analyses estimate the maximum likely air quality impacts from a given source under worst case conditions for the build scenario only.[21]

EPA believes that, because of the complex nature of PM emissions, the statistical form of each NAAQS, the need to consider temperature effects throughout the time period covered by the analysis, and the variability of background concentrations over the course of a year, quantitative PM hot-spot analyses need to be completed using the refined analysis procedures described in this guidance.

However, there may be cases where using a screening analysis or components of a screening analysis could be supported in PM hot-spot analyses, such as:

- Where a project can be characterized as a single source (e.g., a transit terminal that could be characterized as a single area source). Such a case may be a candidate for a screening analysis using worst case travel activity and meteorological data and an appropriate screening model.[22]
- Where emissions modeling for a project is completed using worst case travel activity and a recommended air quality model (see Section 7.3).

Both of these options would be appropriate only for the build scenario and may be most feasible in areas where monitored PM air quality concentrations are significantly below the applicable NAAQS. In addition, other flexibilities that can simplify the hot-spot analysis process are included in later parts of this guidance (e.g., calculating design concentrations in the build scenario first for the receptor with highest modeled concentrations only).

EPA notes, however, that this guidance assumes that emissions modeling, air quality modeling, and representative background concentrations are all necessary as part of a quantitative PM hot-spot analysis in order to demonstrate conformity requirements. For example, an approach that would involve comparing only emissions between the build and no-build scenarios, without completing air quality modeling or considering representative background concentrations, would not be technically supported.[23]

Furthermore, EPA believes that the value of using a screening option decreases for a PM hot-spot analysis if a refined analysis will ultimately be necessary to meet conformity requirements.

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[21] Screening analyses for the 1-hour and 8-hour CO NAAQS have been completed based on peak emissions and worst-case meteorology. The shorter time period covered by these NAAQS, the types of projects modeled, and other factors make screening analyses appropriate for the CO NAAQS.

[22] Such as AERSCREEN or AERMOD using meteorological conditions suitable for screening analyses.

[23] Since Section 93.123(b)(1) of the conformity rule requires PM hot-spot analyses for projects with significant new levels of PM emissions, it is unlikely that every portion of the project area in the build scenario would involve the same or fewer emissions than that same portion in the no-build scenario. Such an approach would not consider the variation of emissions and potential NAAQS impacts at different locations throughout the project area, which is necessary to meet conformity requirements.

Evaluating and choosing models and associated methods and assumptions used in screening options must be completed through the process established by each area's interagency consultation procedures (40 CFR 93.105(c)(1)(i)). Please consult with your EPA Regional Office, which will coordinate with EPA's Office of Transportation and Air Quality (OTAQ) and Office of Air Quality Planning and Standards (OAQPS), if a screening analysis option is being considered for a PM hot-spot analysis.

2.5 Emissions Considered in PM Hot-Spot Analyses

2.5.1 General Requirements

PM hot-spot analyses include only directly emitted $PM_{2.5}$ or PM_{10} emissions. $PM_{2.5}$ and PM_{10} precursors are not considered in PM hot-spot analyses, since precursors take time at the regional level to form into secondary PM.[24]

2.5.2 PM Emissions from Motor Vehicle Exhaust, Brake Wear, and Tire Wear

Exhaust, brake wear, and tire wear emissions from on-road vehicles are always included in a project's $PM_{2.5}$ or PM_{10} hot-spot analysis. See Section 4 for how to quantify these emissions using MOVES (outside California). See Section 5 and the latest EMFAC model documentation from CARB for how to quantify these emissions using EMFAC (within California).[25]

2.5.3 $PM_{2.5}$ Emissions from Re-entrained Road Dust

Re-entrained road dust must be considered in $PM_{2.5}$ hot-spot analyses only if EPA or the state air agency has made a finding that such emissions are a significant contributor to the $PM_{2.5}$ air quality problem in a given nonattainment or maintenance area (40 CFR 93.102(b)(3).[26]

- If a $PM_{2.5}$ area has no adequate or approved SIP budgets for the $PM_{2.5}$ NAAQS, re-entrained road dust is not included in a hot-spot analysis unless the EPA Regional Administrator or state air quality agency determines that re-entrained road dust is a significant contributor to the $PM_{2.5}$ nonattainment problem and has so notified the metropolitan planning organization (MPO) and DOT.

- If a $PM_{2.5}$ area has adequate or approved SIP budgets, re-entrained road dust would have to be included in a hot-spot analysis only if such budgets include re-entrained road dust.

[24] See 40 CFR 93.102(b) for the general requirements for applicable pollutants and precursors in conformity determinations. Section 93.123(c) provides additional information regarding certain PM emissions for hot-spot analyses. See also EPA's March 2006 final rule preamble (71 FR 12496-8).
[25] See footnote 9 (Section 1.6) for CARB reference information.
[26] See the July 1, 2004 final conformity rule (69 FR 40004).

See Section 6 for further information regarding how to estimate re-entrained road dust for $PM_{2.5}$ hot-spot analyses, if necessary.

2.5.4 PM_{10} Emissions from Re-entrained Road Dust

Re-entrained road dust must be included in all PM_{10} hot-spot analyses. Because road dust is a significant component of PM_{10} inventories, EPA has historically required road dust emissions to be included in all conformity analyses of direct PM_{10} emissions – including hot-spot analyses.[27] See Section 6 for further information regarding how to estimate re-entrained road dust for PM_{10} hot-spot analyses.

2.5.5 PM Emissions from Construction-Related Activities

Emissions from construction-related activities are not required to be included in PM hot-spot analyses if such emissions are considered temporary as defined in 40 CFR 93.123(c)(5) (i.e., emissions which occur only during the construction phase and last five years or less at any individual site). Construction emissions would include any direct PM emissions from construction-related dust and exhaust emissions from construction vehicles and equipment.

For most projects, construction emissions would not be included in $PM_{2.5}$ or PM_{10} hot-spot analyses (because, in most cases, the construction phase is less than five years at any one site; see 40 CFR 93.123(c)(5)).[28] However, there may be limited cases where a large project is constructed over a longer time period (five years or greater) at any individual site, and non-temporary construction emissions must be included when an analysis year is chosen during project construction. See Section 6 for further information regarding how to estimate transportation-related construction emissions for PM hot-spot analyses, if necessary.

2.6 NAAQS Considered in PM Hot-Spot Analyses

The CAA and transportation conformity regulations require that conformity be met for all transportation-related NAAQS for which an area is designated nonattainment or maintenance ("relevant NAAQS"). Therefore, a project-level conformity determination must address all applicable NAAQS for a given pollutant.[29]

Accordingly, results from a quantitative hot-spot analysis will need to be compared to all relevant $PM_{2.5}$ and PM_{10} NAAQS in effect for the area undertaking the analysis. For example, in an area designated nonattainment or maintenance for only an annual $PM_{2.5}$ NAAQS or only a 24-hour $PM_{2.5}$ NAAQS, the hot-spot analysis would have to address only that relevant $PM_{2.5}$ NAAQS. If an area is designated nonattainment or maintenance

[27] See the March 2006 final rule (71 FR 12496-98).
[28] EPA's rationale for limiting the consideration of construction emissions to five years can be found in its January 11, 1993 proposed rule (58 FR 3780).
[29] See EPA's March 2006 final rule (71 FR 12468-12511).

for both an annual and 24-hour $PM_{2.5}$ NAAQS, the hot-spot analysis would have to address both NAAQS for conformity purposes. Note that conformity applies for both primary and secondary NAAQS; in most cases they are the same.

Refer to EPA's web site at https://www.epa.gov/state-and-local-transportation/baseline-year-baseline-year-test-40-cfr-93119 for a list of the PM NAAQS in effect. EPA's "Green Book" web site at https://www.epa.gov/green-book also has information about the PM NAAQS in effect, areas designated, and implementation regulations. Additional guidance about implementing the latest PM NAAQS for conformity is found on EPA's web site at: https://www.epa.gov/state-and-local-transportation/policy-and-technical-guidance-state-and-local-transportation#requirements.

2.7 Background Concentrations

As required by 40 CFR 93.123(c)(1) and discussed in Section 2.2, a PM hot-spot analysis "must be based on the total emissions burden which may result from the implementation of the project, summed together with future background concentrations…". By definition, background concentrations do not include emissions from the project itself. Background concentrations include the emission impacts of all sources that affect concentrations in the project area other than the project. Section 8: provides further information on how background concentrations can be determined.

2.8 Appropriate Time Frame and Analysis Years

Section 93.116(a) of the conformity rule requires that PM hot-spot analyses consider either the full time frame of an area's transportation plan or, in an isolated rural nonattainment or maintenance area, the 20-year regional emissions analysis.[30] Conformity requirements are met if the analysis demonstrates that no new or worsened violations occur in the year(s) of highest expected emissions – which includes the project's emissions in addition to background concentrations.[31] Analysis years must be within the timeframe of the transportation plan, per 40 CFR 93.116(a). In isolated rural areas, analysis years must be within the timeframe of regional emissions analysis, based on 40 CFR 93.116(a) and 40 CFR 93.109(g)(2)(i). Areas should analyze the year(s) within the transportation plan or regional emissions analysis, as appropriate, during which:

- Peak emissions from the project are expected; and

[30] Although CAA section 176(c)(7) and 40 CFR 93.106(d) allow the election of changes to the time horizons for transportation plan and TIP conformity determinations, these changes to do not affect the time frame and analysis requirements for hot-spot analyses.

[31] If such a demonstration can be made, then EPA believes it is reasonable to assume that no adverse impacts would occur in any other years within the time frame of the transportation plan or regional emissions analysis.

- A new NAAQS violation or worsening of an existing violation would most likely occur due to the cumulative impacts of the project and background concentrations in the project area.

If such a demonstration occurs, then no adverse impacts would be expected to occur in any other years within the time frame of the transportation plan or regional emissions analysis.[32]

The following factors (among others) should be considered when selecting the year(s) of peak emissions:

- Changes in vehicle fleets;
- Changes in traffic volumes, speeds, and vehicle miles traveled (VMT); and
- Expected trends in background concentrations, including any nearby sources that are affected by the project.

In some cases, selecting only one analysis year, such as the last year of the transportation plan or the year of project completion, may not be sufficient to satisfy conformity requirements. For example, if a project is being developed in two stages and the entire two-stage project is being approved, two analysis years should be modeled: one to examine the impacts of the first stage of the project and another to examine the impacts of the completed project.[33] As another example, it may be useful to select a near-term year when emissions rates will be highest as well as a future year when vehicle volumes and/or vehicle miles traveled is highest. Selecting appropriate analysis year(s) should be considered through the process established by each area's interagency consultation procedures (40 CFR 93.105(c)(1)(i)).

2.9 Agency Roles and Responsibilities

The typical roles and responsibilities of agencies implementing the PM hot-spot analysis requirements are described below. Further details are provided throughout later sections of this guidance.

2.9.1 Project Sponsor

The project sponsor is typically the agency responsible for implementing the project (e.g., a state department of transportation, regional or local transit operator, or local government). The project sponsor is the lead agency for developing the PM hot-spot analysis, meeting interagency consultation and public participation requirements, and documenting the final hot-spot analysis in the project-level conformity determination.

[32] See EPA's July 1, 2004 final conformity rule (69 FR 40056-40058).
[33] See EPA's July 1, 2004 final rule (69 FR 40057).

2.9.2 DOT

DOT is responsible for making project-level conformity determinations for FHWA/FTA projects (see 40 CFR 93.101 for the definition). PM hot-spot analyses and conformity determinations would generally be included in documents prepared to meet NEPA requirements. It is possible for DOT to make a project-level conformity determination outside of the NEPA process (for example, if conformity requirements apply after NEPA has been completed, but additional federal action on the project is required). DOT is also an active member of the interagency consultation process for conformity determinations.

2.9.3 EPA

EPA is responsible for promulgating transportation conformity regulations and provides policy and technical assistance to federal, state, and local conformity implementers. EPA is an active member of the interagency consultation process for conformity determinations. In addition, EPA reviews submitted SIPs, and provides policy and technical support for emissions modeling, air quality modeling, monitoring, and other issues. EPA provides tools for emissions modeling, including the MOVES emission model and associated tools, documentation, and scripts. EPA also provides tools for air quality modeling, including the AERMOD dispersion model, its associated pre-processors, and documentation. As the agency that develops and promulgates these tools, EPA would make decisions about the use of alternative dispersion models in a PM hot-spot analysis according to Appendix W.[34] EPA would also make decisions about whether monitoring data can be excluded from the background concentrations based on exceptional events in consultation with the relevant state or local air agency.[35]

2.9.4 State and Local Transportation and Air Agencies

State and local transportation and air quality agencies are part of the interagency consultation process and assist in modeling of transportation activities, emissions, and air quality. These agencies are likely to provide data required to perform a PM hot-spot analysis. For example, the state or local air quality agency operates the air quality monitoring network, processes meteorological data, and uses air quality models for air quality planning purposes (such as SIP development and modeling applications for other purposes). MPOs often conduct emissions modeling, maintain regional population forecasts, and estimate future traffic conditions relevant for project planning. The interagency consultation process can be used to discuss the role of the state or local air agency, the MPO, and other agencies in project-level conformity determinations, if such roles are not already defined in an area's conformity SIP.

[34] See footnote 18 (Section 2.4.1) for Appendix W reference information.
[35] See *Additional Methods, Determinations, and Analyses to Modify Air Quality Data Beyond Exceptional Events*, EPA-457/B-19-002, April 2019, available on EPA's website at: https://www.epa.gov/state-and-local-transportation/project-level-conformity-and-hot-spot-analyses#modify-methods.

Section 3: Overview of a Quantitative PM Hot-Spot Analysis

3.1 Introduction

This section provides a general overview of the process for conducting a quantitative PM hot-spot analysis. All individual elements or steps presented here are covered in more depth and with more technical information throughout the remainder of the guidance. The general steps required to complete a quantitative PM hot-spot analysis are depicted in Exhibit 3-1 (following page) and summarized in this section.

As previously noted in Section 2.3, the interagency consultation process is an essential part of developing PM hot-spot analyses. As a number of fundamental aspects of the analysis need to be determined through consultation, it is recommended that these discussions take place as early and as often as necessary for the analysis to be completed on schedule. In addition, early consultation allows potential data sources for the analysis to be more easily identified.

3.2 Determine Need for a PM Hot-Spot Analysis (Step 1)

The conformity rule requires a PM hot-spot analysis only for projects of local air quality concern. See Section 2.2 regarding how to determine if a project is of local air quality concern according to the conformity rule.

3.3 Determine Approach, Models, and Data (Step 2)

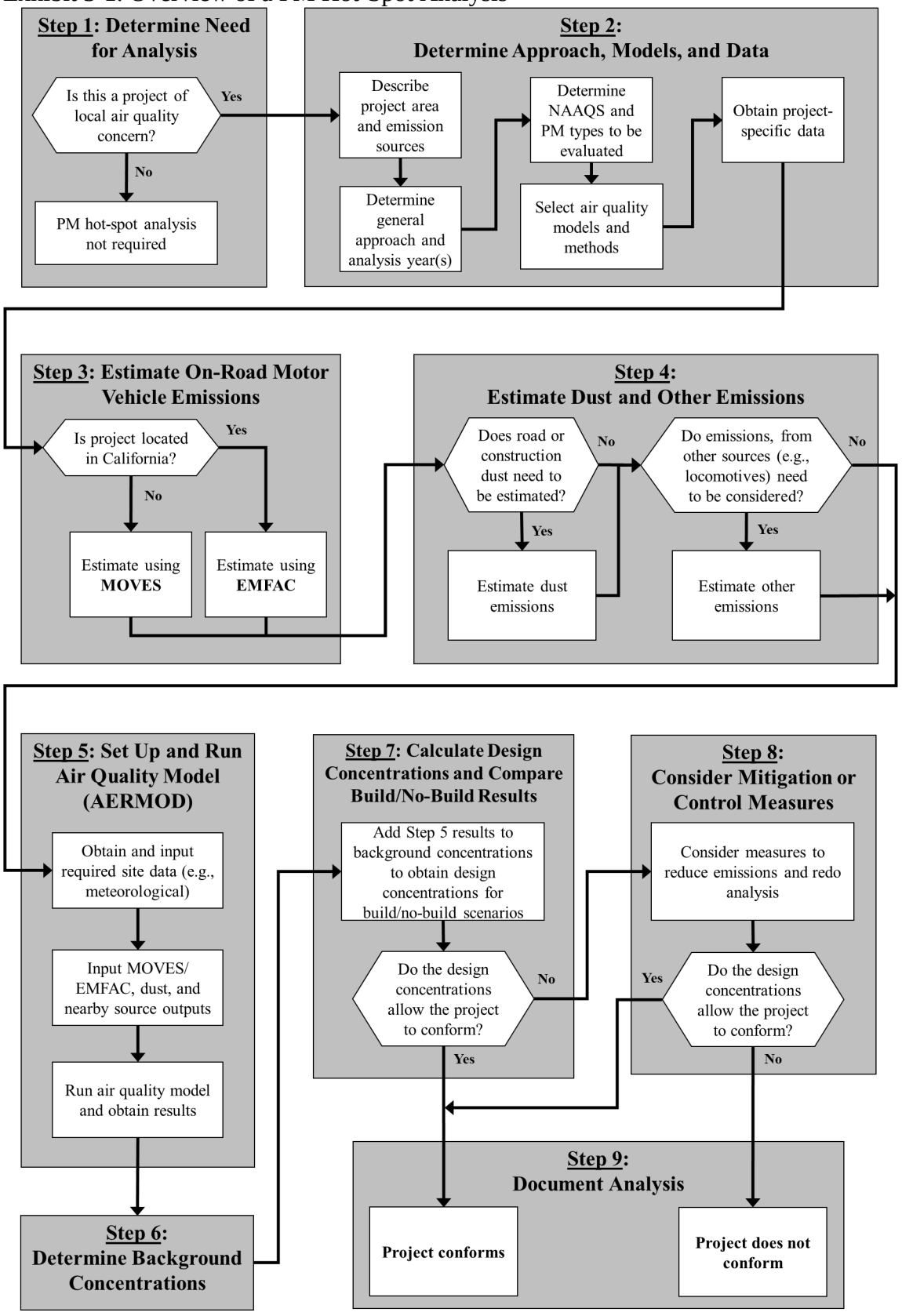
3.3.1 General

There are several decisions that need to be made before beginning a PM hot-spot analysis, including determining the:

- Geographic area to be covered by the analysis (the "project area") and emission sources to be modeled;
- General approach and analysis year(s) for emissions and air quality modeling;
- Applicable PM NAAQS to be evaluated;
- Type of PM emissions to be modeled for different sources;
- Emissions and air quality models and methods to be used, including proposed receptor locations;
- Project-specific data to be used; and
- Schedule for conducting the analysis and points of consultation.

Further details on these decisions are provided below. Evaluating and choosing models and associated methods and assumptions must be completed through the process established by each area's interagency consultation procedures (40 CFR 93.105(c)(1)(i)).

Exhibit 3-1. Overview of a PM Hot-Spot Analysis



3.3.2 Determining the Geographic Area and Emission Sources to Be Covered by the Analysis

The geographic area to be covered by a PM hot-spot analysis (the "project area") is to be determined on a case-by-case basis.[36] PM hot-spot analyses must examine the air quality impacts for the relevant PM NAAQS in the area substantially affected by the project (40 CFR 93.123(c)(1)). To meet this and other conformity requirements, it is necessary to define the project, determine where it is to be located, and ascertain what other emission sources are located in the project area.[37] In addition to emissions from the proposed highway or transit project,[38] there may be nearby sources of emissions that need to be estimated and included in air quality modeling (e.g., a freight rail terminal that is affected by the project). There also may be other sources in the project area that are determined to be insignificant to project emissions (e.g., a service drive or small employee parking lot). See Sections 4 through 6 for how to estimate emissions from the proposed project, and Sections 6 through 8 for when and how to include nearby source emissions and other background concentrations.

Hot-spot analyses must include the entire project (40 CFR 93.123(c)(2)). However, it may be appropriate in some cases to focus the PM hot-spot analysis only on the locations of highest air quality concentrations. For large projects, it may be necessary to analyze multiple locations that are expected to have the highest air quality concentrations and, consequently, the most likely new or worsened PM NAAQS violations. If conformity is demonstrated at such locations, then it can be assumed that conformity is met in the entire project area. For example, if a highway project involves several lane miles with similar travel activity (and no nearby sources that need to be modeled), the scope of the PM hot-spot analysis could involve only the point(s) of highest expected PM concentrations. If conformity requirements are met at such locations, then it can be assumed that conformity is met throughout the project area. Such an approach would be preferable to modeling the entire length of the highway project, which would involve additional time and resources.

Note that interagency consultation should be used to help identify the appropriate receptor locations in the area substantially affected by the project. For example, the area substantially affected by a highway widening project may include an interchange or parts of an intersecting arterial. These types of effects should be considered when determining which areas are to be modeled.

Questions regarding the scope of a given PM hot-spot analysis should be determined through the interagency consultation process.

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[36] Given the variety of potential projects that may require a PM hot-spot analysis, it is not possible to provide one definition or set of parameters that can be used in all cases to determine the area covered by the PM hot-spot analysis.

[37] See more in the March 24, 2010 final conformity rule entitled, *Transportation Conformity Rule $PM_{2.5}$ and PM_{10} Amendments*, 75 FR 14281; found online at: https://www.epa.gov/state-and-local-transportation/transportation-conformity-chronological-list-rulemakings.

[38] 40 CFR 93.101 defines "highway project" and "transit project" for transportation conformity purposes.

3.3.3 Deciding the General Analysis Approach and Analysis Year(s)

As stated in Section 2.4, there are several approaches for completing a build/no-build analysis for a given project. For example, a project sponsor may want to start by completing the build scenario first to see if a new or worsened PM NAAQS violation is predicted (if not, then modeling the no-build scenario would be unnecessary). In contrast, a project sponsor could start with the no-build scenario first if a future PM NAAQS violation is anticipated in both the build and no-build scenarios (even after mitigation or control measures are considered).

It is also necessary to select one or more analysis years within the time frame of the transportation plan or regional emissions analysis when emissions from the project, any nearby sources, and background are expected to be highest. See Section 2.8 for more information on selecting analysis year(s).

3.3.4 Determining the PM NAAQS to Be Evaluated

As stated in Section 2.6, PM hot-spot analyses need to be evaluated only for the NAAQS for which an area has been designated nonattainment or maintenance. For example, if an area is nonattainment for only the 24-hour NAAQS and has always been in attainment for the annual NAAQS, then only the design concentration for the 24-hour NAAQS would need to be evaluated. A hot-spot analysis for an annual $PM_{2.5}$ NAAQS would involve data and modeling throughout a given analysis year. A hot-spot analysis for the 24-hour $PM_{2.5}$ or PM_{10} NAAQS would also involve data and modeling throughout an analysis year.

3.3.5 Deciding on the Type of PM Emissions to Be Modeled

See Section 2.5 for further information on what types of directly emitted PM must be included in hot-spot analyses and Sections 4 through 6 and Section 8 on when and how to quantify PM emissions.

3.3.6 Determining the Models and Methods to Be Used

The emissions and air quality models and methods used in PM hot-spot analyses must be evaluated and chosen through the process established by each area's interagency consultation procedures (40 CFR 93.105(c)(1)(i)). The latest emissions model must be used in PM hot-spot analyses (40 CFR 93.111). The air quality model and methods must be based on the requirements specified in Appendix W.[39] See Sections 3.4 through 3.6 and the subsequent sections of the guidance they refer to for specific information about models and methods that apply.

[39] See footnote 18 (Section 2.4.1) for Appendix W reference information.

3.3.7 Obtaining Project-Specific Data

The conformity rule requires that the latest planning assumptions available at the time that the analysis begins be used in conformity determinations (40 CFR 93.110). In addition, the regulation states that hot-spot analysis assumptions must be consistent with those assumptions used in the regional emissions analysis for any inputs that are required for both analyses (40 CFR 93.123(c)(3)).

The project sponsor should use project-specific data for both emissions and air quality modeling whenever possible, though default inputs may be appropriate in some cases. The use of project-specific versus default data is discussed further in this guidance.

The following are examples of data needed to run MOVES or EMFAC, as described in Section 4 (MOVES) and in Section 5 and CARB model documentation[40] (EMFAC):

- Traffic data sufficient to characterize each link in the project area;
- Starts per hour and number of vehicles idling during each hour for off-network links/sources;
- Vehicle types and age distribution expected in the project area; and
- Temperature and humidity data for each month and hour included in the analysis.

Data that will be needed for air quality modeling, as described in Sections 7 through 9, include:

- Surface meteorological data from monitors that measure the atmosphere near the ground;
- Upper air data describing the vertical temperature profile of the atmosphere;
- Land use data describing surface characteristics near the surface meteorological monitors;
- Nearby population data; and
- Information necessary for determining locations of air quality modeling receptors.

To complete the PM hot-spot analysis, areas will also need data on background concentrations in the project area from nearby or other emission sources, as described in Section 8.

3.4 Estimate On-Road Motor Vehicle Emissions (Step 3)

There are two approved motor vehicle emissions models available for estimating the project's exhaust, brake wear, and tire wear emissions. See Section 4 for more on estimating these PM emissions with EPA's MOVES model. See Section 5 and CARB model documentation for how to apply EMFAC for estimating these emissions for projects in California.

[40] See footnote 9 (Section 1.6) for CARB reference information.

3.5 Estimate Emissions from Road Dust, Construction, and Additional Sources (Step 4)

Section 2.5 provides more information about when re-entrained road dust and/or construction emissions are included in PM hot-spot analyses. Section 6 describes methods for estimating these emissions.

There may be other sources of emissions that also need to be estimated, and included in air quality modeling. Section 8 provides further information regarding how to account for these emissions in a PM hot-spot analysis and Appendix I describes how to estimate locomotive emissions.

3.6 Select Source Types, Data Inputs, and Receptors for AERMOD (Step 5)

Emissions that result from the project (including those from vehicles, dust, and construction from Steps 3 and 4) as well as any other nearby emission sources that are affected by the project (e.g., expanded locomotive emissions at a freight terminal) are then included in air quality modeling. EPA's air quality model AERMOD is required for use in PM hot-spot analyses; (see Appendix W to part 51, Section 4.2.3.5 "Models for $PM_{2.5}$" and Section 4.2.3.6, "Models for PM_{10}").

AERMOD predicts how emissions are dispersed based on meteorological and other input data. Emissions are described or characterized within AERMOD as sources, and there are several types with different attributes that can be used. The specific locations in the project area where AERMOD estimates PM concentrations are known as receptors. See Section 7.6 for additional information about placing receptors.

Additional information about AERMOD is found in Section 7 and Appendix J.

3.7 Determine Background Concentrations from Nearby and Other Sources (Step 6)

The PM hot-spot analysis must also account for background PM concentrations in the project area. Section 8 provides further information on selecting representative background concentrations, including when to incorporate nearby sources into air quality modeling.

3.8 Calculate Design Concentrations and Determine Conformity (Step 7)

In general, the PM concentrations estimated from air quality modeling (from Step 5) are then combined with background concentrations (from Step 6) at the receptor locations for both the build and no-build scenarios. The resulting statistic is referred to as a design concentration; how it is calculated depends on the form of the NAAQS. (Refer to Section 2.4.1 for more discussion of design concentrations.) If the design concentration in the build scenario is less than or equal to the relevant PM NAAQS at appropriate receptors, then the project meets conformity requirements. In the case where the design concentration is greater than the NAAQS in the build scenario, a project could still meet conformity requirements if the design concentrations in the build scenario were less than or equal to the design concentrations in the no-build scenario at appropriate receptors. See Sections 2.4 and 9 for further details on build/no-build approaches and implementation.

3.9 Consider Mitigation or Control Measures (Step 8)

Where a project does not meet conformity requirements, a project sponsor may consider mitigation or control measures to reduce emissions in the project area. If such measures are considered, additional modeling will need to be completed and new design concentrations calculated to ensure that conformity requirements are met. A project sponsor could decide to add mitigation or control measures at any time in the process; such measures must include written commitments for implementation (40 CFR 93.125). See Section 10 for more information on possible measures for consideration.

3.10 Document the PM Hot-Spot Analysis (Step 9)

The PM hot-spot analysis should include sufficient documentation to support the conclusion that a proposed project meets conformity rule requirements per 40 CFR 93.116 and 93.123. The transportation conformity regulation at 40 CFR 93.105(e) requires that "affected agencies making conformity determinations on transportation plans, programs, and projects shall establish a proactive public involvement process…" The regulation also states, "These agencies shall also provide opportunity for public involvement in conformity determinations for projects whether otherwise required by law." Documentation of the project-level conformity determination, including technical and policy information considered in the PM hot-spot analysis, should be made available to the public at the beginning of the comment period.

This documentation should include, at a minimum:

- A description of the proposed project, including where the project is located, the project's scope (e.g., adding an interchange, widening a highway, expanding a major bus terminal), when the project is expected to be open to traffic, travel

activity projected for the analysis year(s), and what part of 40 CFR 93.123(b)(1) applies. Maps and diagrams are useful for conveying this information;[41]

- A description of the analysis year(s) examined and the factors considered in determining the year(s) of peak emissions;
- Emissions modeling, including the emissions model used (e.g., MOVES), modeling inputs and results, and how the project was characterized in terms of links;
- Modeling inputs and results for estimating re-entrained road dust, construction emissions, and any nearby source emissions (if applicable to a particular PM hot-spot analysis);
- Explanation of naming conventions, if used, for project links so that these can be related to specific areas of the project;
- Written narrative that explains step-by-step how emissions from MOVES or EMFAC were used as inputs in air quality modeling. If MOVES emission rates were generated, explain how such rates are used in the air quality model specifically, including information about grade, speed, and vehicle mix (e.g., percentage of light- and heavy-duty vehicles) on each link of the project. Include sufficient information, such as link-by-link traffic volumes, scripts used, and intermediate tables, so that a reviewer can follow and recreate the process of how MOVES emission rates are applied to the specific sources in AERMOD;
- Air quality modeling data, including modeling inputs and results and description of the sources and receptors employed in the analysis;
- A description of the assumptions used to determine background concentrations;
- A discussion of any mitigation or control measures that will be implemented, the methods and assumptions used to quantify their expected effects, and associated written commitments;
- A description of how the interagency consultation and public participation requirements in 40 CFR 93.105 were met; and
- A conclusion for how the proposed project meets 40 CFR 93.116 and 93.123 conformity requirements for the $PM_{2.5}$ and/or PM_{10} NAAQS.

Documentation should describe the sources of data used in preparing emissions and air quality modeling inputs. This documentation should also describe any critical assumptions that have the potential to affect predicted concentrations. Documentation of PM hot-spot analyses would be included in the project-level conformity determination.

[41] This information could reference the appropriate sections of any NEPA document prepared for the project.

Section 4: Estimating Project-Level PM Emissions Using MOVES

4.1 Introduction

This section of the guidance describes how to use MOVES to estimate PM exhaust, brake wear, and tire wear emissions for PM hot-spot analyses outside of California.[42] This section presumes users already have a basic understanding of how to run the MOVES model.[43] This section focuses on determining the appropriate project-level inputs and how MOVES should be run to provide the necessary information to complete air quality modeling.[44]

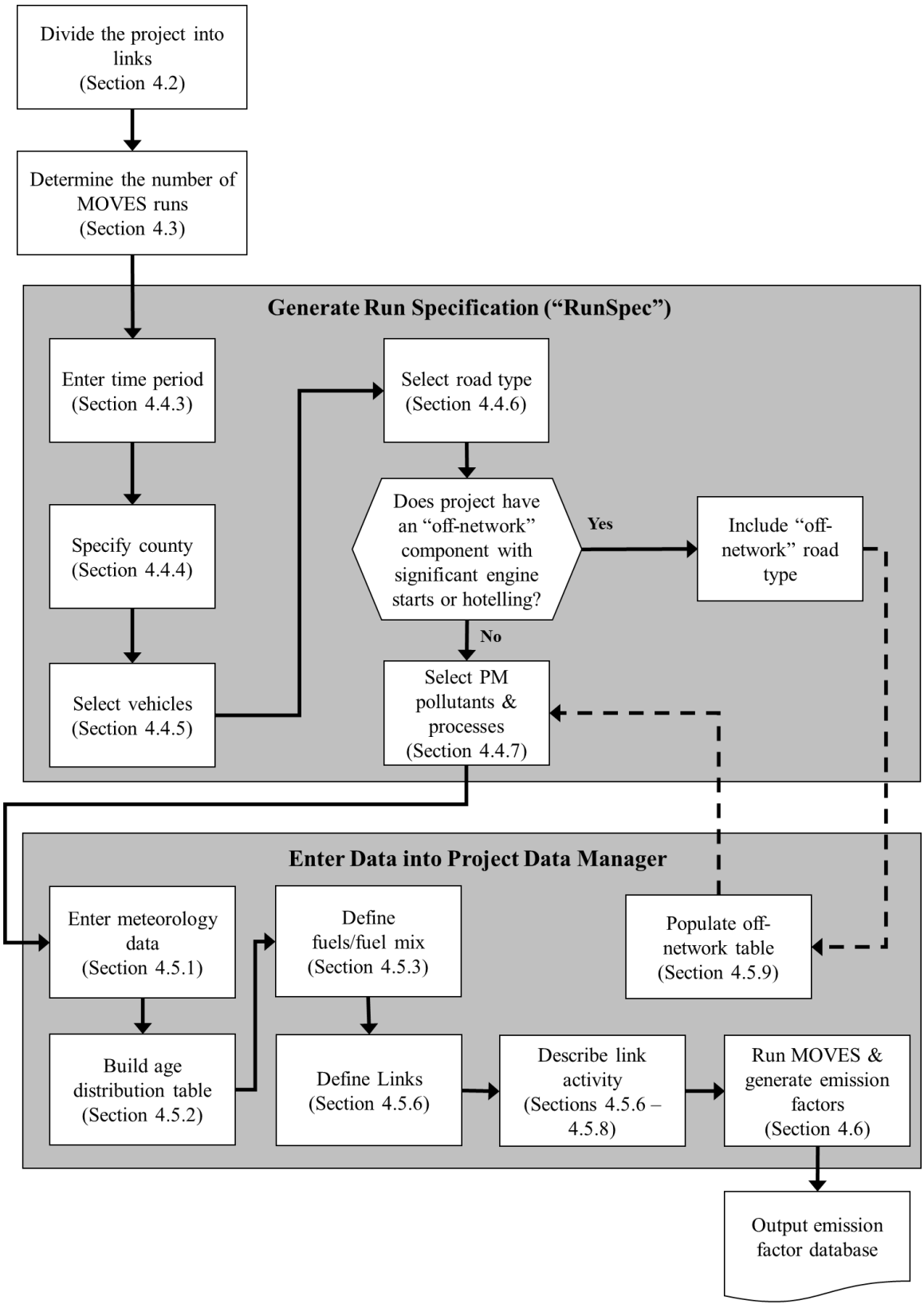
MOVES is a computer model designed by EPA to estimate emissions from cars, trucks, buses, and motorcycles, and nonroad equipment. MOVES can estimate PM emissions at high resolution, accounting for fuel characteristics, ambient temperatures, and vehicle activity patterns including speed and acceleration. As a result, MOVES allows users to incorporate a wide array of vehicle activity data for each roadway link, as well as start, idling, and hotelling activity.[45] For more information about MOVES, including the EPA rulemakings, emissions data, and new features included in the latest version of the model, please see https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves.

Exhibit 4-1 (on the following page) shows the necessary steps for applying the MOVES model for project-level PM hot-spot analyses.

MOVES includes a default database of meteorology, fleet, activity, fuel, and control program data for the entire United States. The data included in this database come from a variety of sources and are not necessarily the most accurate or up-to-date information available at the local level for a particular project. This section describes when the use of that default database is appropriate for PM hot-spot analysis, as well as when available local data must be used (40 CFR 93.110 and 93.123(c)).

[42] This guidance applies to MOVES3 and future versions of the MOVES model, unless EPA notes otherwise when approving the model for conformity purposes.
[43] The MOVES model and supporting documentation are available online at: www.epa.gov/moves.
[44] The most recent technical guidance on using MOVES for regional emissions inventories can be found online at: www.epa.gov/state-and-local-transportation/policy-and-technical-guidance-state-and-local-transportation#emission.
[45] "Hotelling" refers to any long period of time that drivers spend in their long-haul combination trucks (source type 62) during mandated rest times. When hotelling, one or more accessories such as a heater, air conditioner, television, or computer could be running. More information is included in Sections 4.2 and 4.5.

Exhibit 4-1. Steps for Using MOVES in a Quantitative PM Hot-Spot Analysis



Note: The steps in this exhibit and in the accompanying text describe how to use MOVES at the project-level for a PM hot-spot analysis.

As discussed in Section 2.4, it is suggested that project sponsors conduct emissions and air quality modeling for the project build scenario first. If the resulting design concentration does not exceed the NAAQS, then the project meets the hot-spot analysis requirements of project-level conformity, and it is not necessary to model the no-build scenario. Following this approach will allow users to avoid unnecessary emissions and air quality modeling.

Finally, Section 4 describes how to use MOVES to estimate emissions from a highway or transit project that requires a PM hot-spot analysis ("the project"); this section could also be used to estimate emissions for any other highway and transit facilities in the project area, when necessary.

4.2 Characterizing a Project in Terms of Links

Prior to entering data into MOVES, the first step is to identify the project type, described further below, and the associated emission processes (e.g., running, start, brake wear, tire wear, hotelling, and crankcase) to be modeled. This guidance distinguishes between two types of transportation projects: (1) highway and intersection projects, and (2) transit or other terminal projects:

- For highway and intersection projects, running exhaust, crankcase, brake wear, and tire wear emissions are the main focus.
- For transit and other terminal projects, start, crankcase, idling, and hotelling emissions are typically needed; in some cases, these projects will also need to address running exhaust, brake wear and tire wear from cruise, approach and departure on affected links.

Within MOVES, a link represents a segment of road or an "off-network" location where a certain type of vehicle activity occurs.[46] The goal of defining a project's links is to accurately estimate emissions from a specific type of activity where that activity occurs. In modeling highway and intersection projects, the user will primarily be defining links representing road segments, and for transit and other terminal projects, the user will be defining activity at an off-network location. However, in modeling either of the two types of projects described above, the user may need a combination of links representing road segments and off-network areas.

Generally, the links specified for a project should include segments with similar traffic/activity conditions and characteristics (e.g., decelerating vehicles approaching an intersection should be treated as one link). From the link-specific activity and other inputs, MOVES calculates emissions from every link of a project for a specific hour chosen by the modeler for the MOVES run. In MOVES, running emissions, including

[46] "Off-network" in the context of MOVES refers to an area of activity not occurring on a roadway. Examples of off-network links include parking lots and freight or bus terminals.

periods of idling,[47] can be defined in the Links Importer (see Section 4.5.6); there are also other alternatives when the user has additional information (see Section 4.5.8). Starts and hotelling of combination long-haul trucks are defined in the Off-Network Importer (see Section 4.5.9). There are no limits to the number of links representing road segments that can be defined in a MOVES run, but only one off-network link can be defined per run.

4.2.1 Highway and Intersection Projects

General

A PM hot-spot analysis fundamentally depends on the availability of accurate data on roadway link speed and traffic volumes for build and no-build scenarios.[48] Thus, local traffic data should be used to characterize each link sufficiently. It is recommended that the user divide a project into separate links to allow sufficient resolution at different vehicle traffic and activity patterns; characterizing this variability in emissions within the project area will assist in air quality modeling (see Section 7).

In MOVES, activity on free-flow highway links can be defined by an average speed, link drive schedule, or operating mode ("Op-Mode") distribution (discussed in Section 4.5.8). For analyses with MOVES, average speed and traffic volume, at a minimum, is needed for each link. If no other information is available, MOVES uses default assumptions of vehicle activity patterns (called drive cycles) for average speed and type of roadway to estimate emissions. Default drive cycles use different combinations of vehicle activity (acceleration, deceleration, cruise, and/or idle) depending on the speed and road type. For example, if the link average speed is 30 mph and it is an urban arterial (urban unrestricted road type), MOVES uses a default drive cycle that includes a high proportion of acceleration, deceleration, and idle activity as would be expected on an urban arterial with frequent stops. If the average speed is 60 mph and it is a rural freeway (rural restricted road type), MOVES uses a default drive cycle that assumes a higher proportion of cruise activity, smaller proportions of acceleration and deceleration activity, and little or no idle activity.

Project sponsors should determine average congested speeds by using appropriate methods based on best practices used for highway analysis. Some resources are available

[47] All kinds of idling that are not specifically long-haul combination truck hotelling are modeled as running emissions on running links at Project Scale in MOVES. This includes idling at traffic signals, idling during pick up and drop off of passengers, idling during deliveries, etc. For users that are familiar with the County Scale features of MOVES, note that Project Scale does not implicitly model "Off-Network Idling" (ONI). The kinds of idle that would be accounted for as ONI in County Scale (such as idling during pick up and drop off of passengers) are instead accounted for in Project Scale using running links. See Section 4.5.8 for more information.

[48] Project sponsors should document available traffic data sets, their sources, key assumptions, and the methods used to develop build and no-build scenario inputs for MOVES. Documentation should include differences between how build and no-build traffic projections are obtained. For projects of local air quality concern, differences in traffic volumes and other activity changes between the build and no-build scenarios must be accounted for in the data that is used in the PM hot-spot analysis.

through FHWA's Travel Model Improvement Program (TMIP).[49] Methodologies for computing intersection control delay are provided in the *Highway Capacity Manual*.[50]

As described further in Section 4.5.8, users should take advantage of the full capabilities of MOVES for estimating emissions on different highway and intersection project links. Although average speeds and travel volumes are typically available for most transportation projects and may need to be relied upon during the transition to using MOVES, users can develop and use more precise data through the MOVES Operating Mode Distribution Importer or Link Drive Schedules Importer, as described further below. When more detailed data are available to describe the pattern of changes in vehicle activity (proportion of time in acceleration, deceleration, cruise, or idle activity) over a length of road, MOVES is capable of calculating these specific emission impacts. EPA encourages users to consider these options for highway and intersection projects, especially as MOVES is implemented further into the future, or for more advanced MOVES applications.

Free-flow Highway Links

The links defined in MOVES should capture the expected physical layout of a project and representative variations in vehicle activity. For example, a single, one directional, four-lane highway could be simply characterized as one link. More sophisticated analyses for a facility may use multiple links to vary operating modes or drive cycles depending on the relative acceleration, cruise, or deceleration activity occurring on each segment of that link. Another possibility is to define multiple links for the same road segment, for various vehicle types. For example, one link could be for light-duty vehicles and a second link for heavy-duty vehicles if these two categories of vehicles are expected to have different vehicle activity on that road segment. In general, the definition of a link will depend on the traffic volume present, how vehicle activity (acceleration, deceleration, cruise or idle) changes over a length of roadway, the level of detail of available data, and the modeling approach used with MOVES. For a highway lane where vehicle behavior is fairly constant, the length of the link could be longer and the use of detailed activity data will have a smaller impact on results.

Intersection Links

If the project analysis involves intersections, the intersections need to be treated separately from the free-flow links that connect to those intersections. Although road segments between intersections may experience free-flow traffic operations, the approaches and departures from the intersections will likely involve acceleration, deceleration, and idling activity not present on the free-flow link. For intersection modeling, the definition of link length will depend on the geometry of the intersection,

[49] See FHWA's TMIP website: http://tmip.fhwa.dot.gov/.
[50] Users should consult the most recent version of the *Highway Capacity Manual*. As of the release of this guidance, the latest version is the *Highway Capacity Manual, Sixth Edition: A Guide for Multimodal Mobility Analysis*, released September 2016 by the Transportation Research Board (see www.trb.org/Main/Blurbs/175169.aspx for details).

how that geometry affects vehicle activity, and the level of detail of available activity information. Guidance for defining intersection links is given in Appendix D, but the definition of links used for a particular project will depend on the specific details of that project and the amount of available activity information. Idling at an intersection should be represented in combination with decelerating, accelerating, and free-flow traffic on an approach segment of an intersection.

Note: For both free-flow highway and intersection links, users may directly enter output from traffic simulation models in the form of second-by-second individual vehicle trajectories. These vehicle trajectories for each road segment can be input into MOVES using the Link Drive Schedule Importer and defined as unique LinkIDs. There are no limits in MOVES as to how many links can be defined; however, model run times increase as the user defines more links. More information on using vehicle trajectories from traffic micro-simulation models is found in Appendix D.

Off-network Links

If the analysis involves an area that is not part of the road network, such as a terminal or a parking area, such an area can be modeled using an off-network link defined in the Off-Network Importer and one or more links defined in the Links Importer:

- Start and hotelling activity would be defined in the Off-Network Importer. Section 4.5 describes the inputs needed.
- Running and idling activity at this area would be defined the way other road links are defined (e.g., in the Links Importer, using on-network road types).

4.2.2 Transit and Other Terminal Projects

Projects such as a bus terminal or intermodal freight terminal can also be defined in terms of links. On these types of projects, a variety of activity – start, hotelling, idling, or running – may be occurring, and can be defined in MOVES in terms of links. (Note that while included in this list for completeness, hotelling would not likely be occurring at a terminal.)

The user should have information on the activity occuring in this area: starts per hour, number of long-haul trucks hotelling, and number of vehicles idling during each hour.[51] This activity will likely vary from hour to hour.

Start Activity: If there are vehicles starting, it is necessary to provide an estimate of the duration that vehicles are parked before starting (soak-time distribution). If there are multiple areas of start activity within a project with roughly the same soak time distributions, these areas can be modeled with one off-network link using an appropriately weighted distribution of soak times.[52]

[51] Idling here is non-hotelling idling.

[52] In the event that a project has multiple areas of start activity in different locations that have different soak time distributions, please consult with EPA before modeling.

Hotelling: Hotelling activity, including extended idling, auxiliary power unit (APU) use, and electrification, applies only to long-haul combination trucks. This type of activity is defined on an off-network link and would not likely be occurring at transit or other terminals. (Shorter periods of idling for long-haul combination trucks should be modeled as a running link via the Links Importer.)

Idling Activity: Areas within the project with different amounts of idling can be specified as separate running links. See Section 4.5.8 for more information on how to model idling with running links.

Running Activity: Some transit and other terminal projects may have significant running emissions similar to free-flow highway projects (such as buses and trucks coming to and from an intermodal terminal). These emissions can be calculated by defining one or more unique running links as described in Section 4.2.1 and Appendix D (that is, in addition to any other roadway links associated with the project). These running link emissions can then be aggregated with the emissions from the other activities happening on the off-network link (e.g., start activity, hotelling, idling activity) outside of the MOVES model to generate the necessary air quality model inputs.

> *Note: The user may choose to exclude sources such as a separate service drive, separate small employee parking lot, or other minor sources that are determined to be insignificant to project emissions.*

4.3 Determining the Number of MOVES Runs

4.3.1 General

When MOVES is run at the project scale, it estimates emissions for only the hour specified by the user. Before running MOVES to calculate emission factors, users should first determine the number of unique scenarios that can sufficiently describe activity variation in a project. In most projects, traffic volume, average speed, idling, fleet mix, and the corresponding emission factors will likely vary from hour to hour, day to day, and month to month. However, it is unlikely that data are readily available that capture such finite changes. Project sponsors may have activity data collected at a range of possible temporal resolutions. The conformity rule requires the use of the latest planning assumptions or data available at the time the conformity analysis begins (40 CFR 93.110).[53] Depending on the sophistication of the activity data analysis for a given project, these data may range from a daily average-hour and peak-hour value to hourly estimates for all days of the year. EPA encourages the development of sufficient travel activity data to capture the expected ranges of traffic conditions for the build and no-build scenarios.

[53] See *EPA and DOT Joint Guidance for the Use of Latest Planning Assumptions in Transportation Conformity Determinations*, EPA-420-B-08-901, December 2008, for a more detailed discussion of the latest planning assumptions requirements, available on EPA's website at: https://www.epa.gov/state-and-local-transportation/policy-and-technical-guidance-state-and-local-transportation#requirements.

The number of MOVES runs should be based on the best available activity data and the PM NAAQS involved. MOVES models the PM impact of activity, fuel and temperature conditions that may change over a day and across a year.

However, the PM temperature adjustment has changed in MOVES3, as described in EPA's report, *Emission Adjustments for Temperature, Humidity, Air Conditioning, and Inspection and Maintenance for Onroad Vehicles in MOVES3*.[54] To summarize, while there is a temperature effect on PM start emissions from gasoline vehicles, there is no temperature effect for PM running emissions from gasoline vehicles, and there is no temperature effect for any PM emissions from diesel or CNG vehicles.

Therefore, EPA is recommending the minimum number of MOVES runs that is necessary for PM hot-spot analysis to capture changes in emission rates due to changes in ambient conditions, and these recommendations depend on whether or not the project includes start activity from gasoline vehicles. Exhibit 4-2 includes EPA's general recommendations for PM hot-spot analyses:

Exhibit 4-2. Typical Minimum Number of MOVES Runs for an Analysis Year

Type of Project	**Applicable NAAQS**	**Build Scenario**	**No-build Scenario[55]**
Projects without gasoline start activity	All $PM_{2.5}$ and PM_{10} NAAQS	4	4
Projects with start activity from gasoline vehicles	All $PM_{2.5}$ and PM_{10} NAAQS	16	16

Many types of projects do not include gasoline start activity, including new highways, expanded highways, projects that affect intersections, and those terminal projects that predominantly involve diesel rather than gasoline vehicles. For projects that do not include gasoline start activity, hot-spot analyses for any of the PM NAAQS could be done using four unique MOVES runs, to represent four different time periods of the day: morning peak, midday, evening peak, and overnight. In this case, the month selected in MOVES should be a month with the seasonal fuel that results in the highest PM emissions,[56] and modelers should input the VMT from the month where VMT is the greatest.[57] Note that the month with the highest VMT may be different than the month with the seasonal fuel with the highest PM emissions. For a typical build/no-build

[54] See EPA's report, *Emission Adjustments for Temperature, Humidity, Air Conditioning, and Inspection and Maintenance for Onroad Vehicles in MOVES3*, EPA-420-R-20-013, November 2020, available on EPA's website at: https://www.epa.gov/moves/moves-onroad-technical-reports#moves3.

[55] There are some cases where the no-build scenario and associated emissions and air quality modeling is not necessary. See Section 2.4 for further information.

[56] If this is not known, a modeler can do a simple run to determine which seasonal fuel produces the highest emissions.

[57] If only annual VMT or daily VMT is available, modelers can export the default MOVES table that apportions VMT across the months of the year.

analysis, a total of eight runs would be needed (four for the build scenario and four for the no-build scenario).

Using four runs as described here instead of 16 may be more conservative. Modelers have the choice to run MOVES more times, e.g., for four different seasons, or for additional time periods of the day, to better represent variation in VMT across seasons and across the day if they choose.

In contrast, where projects include start activity from gasoline vehicles, such as projects that include a parking area or parking garage, hot-spot analyses should include 16 unique MOVES runs (i.e., four runs for different time periods for each of four calendar quarters). For a typical build/no-build analysis, a total of 32 runs would be needed (16 for the build scenario and 16 for the no-build scenario).

The product of the MOVES analysis is a year's worth of hour-specific emission factors for each project link that will be applied in AERMOD (discussed in Section 7) and compared to the relevant PM NAAQS (discussed in Section 9).

The following subsections provide further information for determining MOVES runs for all PM NAAQS, based on the level of available travel activity data.

4.3.2 Projects with Typical Travel Activity Data

Traffic forecasts for highway and intersection projects are often completed for annual average daily traffic volumes, with an allocation factor for a daily peak-hour volume. This data can be used to conduct an analysis with MOVES that is representative for all hours of the year. The most reasonable methods in accordance with good practice should be used to obtain the peak hour allocation factors and diurnal distribution of traffic; these methods must be determined in accordance with interagency consultation procedures (40 CFR 93.105(c)(1)(i)). It is important to capture variation in emission rates as activity and in some cases ambient temperature change (as noted above) over the period being analyzed.

For projects that do not include start activity from gasoline vehicles, four runs would be done for the month with the seasonal fuel that results in the highest PM emissions using the highest monthly VMT.

For projects that include start activity from gasoline vehicles, to complete 16 MOVES runs as outlined above, the user should run MOVES for four months: January, April, July, and October; and four weekday time periods: morning peak (AM), midday (MD), evening peak (PM), and overnight (ON).[58] The emission factors for each month's runs should be used for the other months within the season. Each of the four months suggested for the minimum number of MOVES runs represent emissions in that month as

[58]Weekdays usually have higher activity than weekend days. In the case of a project where that is not true, weekend days should be chosen instead. Note the rationale for choosing weekend days over weekdays should be discussed within the interagency consultation process and documented in the analysis.

well as the months immediately before and after that month. For instance, January emissions represent emissions in the months of December, January, and February; April emissions represent emissions in March, April and May; and so forth.[59]

The AM and PM peak periods should be run with peak-hour traffic activity; MD and ON periods should be run with average-hour activity. The results for each of the four hours can then be extrapolated to cover the entire day. For example, the peak-hour volume can be used to represent activity conditions over a three-hour morning (AM) and three-hour evening (PM) period. The remaining 18 hours of the day can be represented by the average-hour volume (AADT minus the total volume assigned to the peak period, divided by the number of off-peak hours). These 18 hours would be divided into a midday (MD) and overnight (ON) scenario.

The following is one suggested approach for an analysis employing the average-hour/peak-hour traffic scenario:

- Morning peak (AM) emissions based on traffic data and meteorology occurring between 6 a.m. and 9 a.m.
- Midday (MD) emissions based on data from 9 a.m. to 4 p.m.
- Evening peak (PM) emissions based on data from 4 p.m. to 7 p.m.
- Overnight (ON) emissions based on data from 7 p.m. to 6 a.m.

If there are local or project-specific data to suggest that the AM or PM peak traffic periods will occur in different hours than the default values suggested here, or over a longer or shorter period of time, that information should be documented and the hours representing each time period adjusted accordingly. Additionally, users should determine peak periods for the build and no-build scenarios independently and not assume that each scenario is identical.

4.3.3 Projects with Additional Travel Activity Data

Some project sponsors may have developed traffic or other activity data to show variations in volume and speed across hours, days, or months. Additionally, if users are modeling a transit or other terminal project, traffic volumes, starts, soak times, and idling estimates are likely to be readily available for each hour of the day. Under either of these circumstances, users have the option of applying the methodology described above (using average-hour and peak-hour as representative for all hours of the year) if it is determined through the interagency consultation process that using the additional data would not significantly impact the emissions modeling results. For example, if the start and idling temporal patterns are likely to differ significantly from the temporal patterns in VMT, and start and idling emissions make a notable contribution to the total PM emissions, then additional modeling may be useful. Alternatively, additional MOVES runs could be generated to produce unique emission factors using these additional activity data and emission factors for each period of time for which specific activity data are available.

[59] For example, January 2030 emissions represent emissions in January, February, and December of 2030 (rather than December 2029).

4.4 Developing Run Specification Inputs

Once the user has defined the project conceptually in terms of links and determined the number of MOVES runs, the next step in using MOVES for project-level analyses is to develop a run specification ("RunSpec"). The RunSpec is a computer file in XML format that can be edited and executed directly or with the MOVES Graphical User Interface (GUI). MOVES needs the user to set up a RunSpec to define the place and time of the analysis as well as the vehicle types, road types, and the emission-producing processes and pollutants that will be included in the analysis. Once selections are made for the RunSpec, the user has to create an input database for that RunSpec using the MOVES Project Data Manager, described in Section 4.5.

The headings in this subsection describe each set of input options needed to create the RunSpec as defined in the Navigation Panel of the MOVES GUI. In order to create a project-level RunSpec, the user would go down the Navigation Panel filling in the appropriate data for each of the items listed. A new panel will open for each item:

- Description
- Scale
- Time Spans
- Geographic Bounds
- Onroad Vehicles
- Road Type
- Pollutants and Processes
- General Output
- Output Emissions Detail
- Create Input Database
- Advanced Features

Additional information on each panel can be found in the resources for MOVES training available on EPA's website (https://www.epa.gov/moves/moves-training-sessions).

4.4.1 Description

The Description Panel allows the user to enter a description of the RunSpec using up to 5,000 characters of text. Entering a complete description of the RunSpec is important for users to keep track of their MOVES runs as well as to provide supporting documentation for the regulatory submission. Users may want to identify the project, the time period being analyzed, and the purpose of the analysis in this field.

4.4.2 Scale

The Scale Panel in MOVES allows the user to select different scales or domains for the MOVES analysis. In this panel, MOVES allows users to choose the "Onroad" or "Nonroad" module; "Onroad" is the appropriate choice for project-level analyses. All MOVES runs for project-level analysis must be done using the "Project" domain in the

Scale Panel. Selecting the "Project" domain is necessary to allow MOVES to accept detailed activity input at the link level.[60]

The Scale Panel also requires that the user select a calculation type of either Inventory or Emission Rates:

- If Inventory is selected, MOVES provides emission estimates as mass for each link, using the link activity entered by the user. Inventory emission estimates at Project Scale are equivalent to link-specific grams per hour emission factors.
- If Emission Rates is selected, MOVES provides emission rates as mass per unit of activity. The Emission Rates mode produces link-specific grams per vehicle-mile emission factors.

The selection of calculation type is required early in the RunSpec construction process because this choice affects the available options in later panels. The Emission Rates mode is more complex than the Inventory mode. Successful application of this mode requires careful planning and a clear understanding of the rates calculations in MOVES. Large differences in results between the Inventory and Emission Rates modes usually indicate a mistake in post-processing of the emission rates using the Emission Rates mode. The most common mistakes when using the Emission Rates mode are:

- not including all pollutant processes, and
- multiplying emission rates by the wrong activity.

Even when done correctly, minor differences in post-processing methods can create small differences in results. EPA recommends that the same mode be used in any analysis that compares two or more cases, e.g., the same mode should be used for build and no-build scenarios of an analysis, and for multiple years in the same analysis. The interagency consultation process should be used to agree upon a common approach and to share detailed results during reviews of draft PM hot-spot analyses that support project-level conformity determinations.

This guidance explains the steps of post-processing both "Inventory" and "Emission Rates" results to produce the desired emission inputs for AERMOD in Section 4.6.

4.4.3 Time Spans

At the Project scale, each MOVES run represents one specific hour. The Time Spans Panel is used to define the specific time period covered in the MOVES run. The Time Spans Panel allows the user to select the year, month, day, and hour that the run will represent. As Project Scale models only one hour at a time, only the start hour needs to be selected on this panel.

The user should enter the desired time period (i.e., the specific year, month, type of day, and hour) in the MOVES Time Spans Panel for estimating $PM_{2.5}$ and/or PM_{10} emissions

[60] Running MOVES using the "County" or "Default" domains would not allow for detailed link-level input or output that is needed for PM hot-spot analyses.

for the relevant NAAQS in a given nonattainment or maintenance area. The "day" selection should be set to "weekdays" or "weekend," but not both. Most users will be defining activity for a typical weekday. For instance, one run for the hot-spot analysis might be for the specific hour of: 2030, January, Weekdays, 8:00 to 8:59 a.m. The user may choose to build a batch file to automate the process of running multiple scenarios.[61]

4.4.4 Geographic Bounds

The Geographic Bounds Panel allows the user to define the specific county that will be modeled. The MOVES database includes county codes and descriptive information for the 3,000-plus counties in the United States. Specifying a county in MOVES determines certain default information for the analysis. Users should select the specific county where the project is located. Only a single county can be included in a MOVES run at the Project Scale. If a project spans multiple counties, users have two options:

1. If the county-specific local data (e.g., fuel information, age distribution of vehicles in the fleet) are the same for all of the counties, select the county in which the majority of the project area is located;
2. If not, separate the project into multiple parts (each of which is in a separate county) and do a separate MOVES run for each part.

4.4.5 Onroad Vehicles

The Onroad Vehicles Panel is used to specify the vehicle types that are included in the MOVES run. MOVES allows the user to select from among 13 "source use types" (the terminology that MOVES uses to describe vehicle types). Users should generally select all 13 vehicle types. The exception may be when modeling projects that contain a captive fleet where only certain types of vehicles are present (e.g., a transit bus terminal).

Selecting a vehicle type will include the relevant fuel types for that vehicle. To change the percentages of vehicles using the different fuel types in the project, use the Fuel Importer of the Project Data Manager (discussed in Section 4.5.3).

4.4.6 Road Type

The Road Type Panel is used to define the types of roads that are included in the project. MOVES defines five different road types:

- Off-Network – any location where the predominant activity is vehicle starts and hotelling (parking lots, truck stops, rest areas, freight or bus terminals);
- Rural Restricted Access – a rural highway that can be accessed only by an on-ramp;
- Rural Unrestricted Access – all other rural roads (arterials, connectors, and local streets);

[61] For more information about using batch commands, see Running MOVES from the Windows command line.

- Urban Restricted Access – an urban highway that can be accessed only by an on-ramp; and
- Urban Unrestricted Access – all other urban roads (arterials, connectors, and local streets).

MOVES uses these road types to determine the default drive cycle on a particular link. For example, MOVES uses drive cycles for unrestricted access road types that assume stop-and-go driving, including multiple accelerations, decelerations, and short periods of idling. For restricted access road types, MOVES uses drive cycles that include a higher fraction of cruise activity with much less time spent accelerating or idling.

For project-level analyses, the extent to which MOVES uses these default drive cycles will depend on how much additional information the user can supply for the link. The process of choosing default or local drive cycles is described in Sections 4.2 and 4.5.7. However, even if the user will be supplying detailed, link-specific drive cycle information or an Op-Mode distribution, road type is a necessary input in the RunSpec and users should select one or more of the five road types that correspond to the road types of the links that will be included in the project area. The determination of rural or urban road types should be based on the Highway Performance Monitoring System (HPMS) functional classification of the road type.

Additionally, any project that includes a significant number of engine starts or significant amounts of hotelling for long-haul combination trucks needs to include the "Off-Network" road type to account for emissions from those activities properly. More details on describing inputs for engine start and hotelling activity are given in Section 4.5.9.

4.4.7 Pollutants and Processes

The Pollutants and Processes Panel is used to select both the types of pollutants and the emission processes that produce them. For $PM_{2.5}$ or PM_{10} emissions, MOVES calculates emissions for several pollutant species:

- Total running exhaust PM, calculated from the pollutant species of elemental carbon (EC), non-elemental carbon (Non-ECPM) and sulfate particulate
- Brakewear Particulate
- Tirewear Particulate

In addition, MOVES divides emissions by pollutant process. For a PM hot-spot analysis, the relevant processes are:

- Running Exhaust
- Crankcase Running Exhaust
- Brakewear
- Tirewear
- Start Exhaust
- Crankcase Start Exhaust
- Extended Idle Exhaust (associated with hotelling)

- Crankcase Extended Idle Exhaust (associated with hotelling), and
- Auxiliary Power Exhaust

For a $PM_{2.5}$ hot-spot analysis, the user should select "Primary Exhaust $PM_{2.5}$ - Total" (or "Primary Exhaust PM_{10} - Total" if it is a PM_{10} hot-spot analysis), which is an aggregate of each of the pollutant species (Composite Non-ECPM, EC, and sulfate) for each process. For MOVES to run, users must select "Primary Exhaust $PM_{2.5}$ – Total" and click the button "Select Prerequisites" to ensure all necessary species are selected. (These can be viewed by clicking the [+] next to "Primary Exhaust PM2.5 (or PM10) – Species.) In addition, if the analysis has road links with running emissions, users would also select "Primary $PM_{2.5}$ - Brakewear Particulate" and "Primary $PM_{2.5}$ - Tirewear Particulate" (or their PM_{10} equivalents) as brake wear and tire wear are not included in the exhaust totals.

MOVES does not automatically sum the appropriate processes to create an aggregate emission factor, although EPA has created several MOVES scripts that automate the summing of aggregate emissions when completing project-level analyses. These scripts are available in the Post-Processing Menu item of the MOVES graphical user interface (GUI) and are described further in Section 4.6.

If the scripts are not used, the user should calculate total PM from the MOVES output table results for each link using the formulas described below:

For highway links (roads, intersections, ramps, etc.) where output is specified as a grams/vehicle-mile emission factor ("Emission Rates" output), the aggregate total PM emission factor (i.e., the sum of all PM emission factors for a link) is calculated as follows:

$$PM_{\text{aggregate total}} = (PM_{\text{total running}}) + (PM_{\text{total crankcase running}}) + (\text{brakewear}) + (\text{tirewear})$$

The same equation above is also used for highway links where output is specified as grams/hour ("Inventory output") and "Emissions Process" is selected on the Output Emissions Detail Panel.[62]

For off-network links (links with start and hotelling activity), where output is selected as grams/hour ("Inventory" output) and "Emissions Process" is selected on the Output Emissions Detail Panel, the aggregate total PM emission factor (i.e., the sum of all PM emission factors for a link) is calculated as follows:

[62] If "Emissions Process" is not selected on the Output Emissions Detail Panel, MOVES will combine PM total running and total crankcase running emissions; brake wear and tire wear will still need to be added for the aggregate PM total.

$$PM_{aggregate\ total} = (PM_{total\ starts}) + (PM_{total\ crankcase\ starts}) + (PM_{total\ ext.\ idle}) + (PM_{auxiliary\ power\ exhaust}) + (PM_{total\ crankcase\ ext.\ idle})$$[63]

However, EPA recommends the use of the existing scripts to eliminate the possibility of error in post-processing.

4.4.8 General Output

In the General Output Panel, users create or identify an output database where MOVES will put the results of the run. It is helpful for the output database name to be related to the name of the project to help both the modeler and future reviewers keep track. EPA also recommends that an output database name end with "_out" to indicate it is an output database and distinguish it from an input database. Only letters, numbers, and underscores can be used for database names.

An output database can hold the results of multiple MOVES runs. EPA recommends that modelers use the same output database for all of the runs associated with a project. More discussion of good data management practices is found in Section 4.4.10.

Units for output of "grams", "joules, and "miles" are already chosen and the user can change them as needed. Also, "Distance Traveled" and "Population" should be selected under the "Activity" heading to obtain vehicle volume information for each link in the output.

4.4.9 Output Emissions Detail

Output Emissions Detail is used to specify the level of detail desired in the output data. Emissions by hour and link are the default selections and cannot be changed. Road type and "Emission Process" will also be checked if Emission Rates was selected on the Scale Panel. For an Inventory mode run, if start and hotelling emissions need to be quantified separately (e.g., vehicle starts and hotelling activity are geographically separated), the "Emissions Process" box should be checked; otherwise, it can be left unchecked. In addition, if the modeler wants to distinguish between light and heavy-duty emissions, "Source Use Type" should be selected; otherwise, it can be left unchecked.[64] No other boxes should be selected in order to produce fleet aggregate emission factors for each link. Emission rates for each process can be appropriately summed using a MOVES

[63] If "Emissions Process" is not selected on the Output Emissions Detail Panel, MOVES will combine PM total starts, crankcase starts, extended idle, auxiliary power exhaust, and total crankcase extended idle together; they would not need to be summed. If there is a need to geographically separate start emissions from hotelling emissions, then "Emissions Process" should be selected on the Output Emissions Detail Panel so that MOVES reports these emissions separately.

[64] Users would select output by Source Use Type when modeling light- and heavy-duty emissions as separate sources in AERMOD, or when characterizing a source's initial vertical dimension and source release height using the emission-weighted average of light-duty and heavy-duty vehicles rather than the volume-weighted average. See Section J.3.3 of the Appendix for more information on characterizing sources.

post-processing script to calculate aggregate PM emission factors for each link (as described in Section 4.6).

4.4.10 Create Input Database

The Create Input Database Panel becomes available after all the other Navigation Panel items have been completed and have green checks. The user can create the input database by entering a name. (However, it is not necessary to create the database before opening the Project Data Manager (PDM), which can be done by clicking the "Enter/Edit Data" button.)

Since modeling a project involves multiple MOVES runs, good data management practices are essential to prevent confusion and errors. As described in Section 4.3, a PM hot-spot analysis will involve multiple MOVES runs, each needing its own input database. It is helpful for the input database name to be related to the name of the project and the hour selected for the run, to help both the modeler and future reviewers keep track. For example, EPA recommends the following conventions:

- Use a naming protocol for each of the input databases that reflects the purpose of that run, e.g., "SpringAMPeak_in". EPA recommends that input database names end with "_in" to indicate it is a user input database. Only letters, numbers, and underscores can be used for database names.
- When the RunSpec is complete, save each RunSpec with a name that relates to the input database name, e.g., "SpringAMPeak.mrs". EPA recommends saving RunSpecs with the extension ".mrs", short for "MOVES RunSpec", so that these files can be easily identified.

Section 4.5 describes how to populate an input database using the PDM. Once a database has been completely populated and the PDM has been closed, users should ensure that the correct database is selected on the Create Input Database Panel. If it is not auto-populated, users may have to hit the Refresh button to make sure the database they created appears in the dropdown list.

4.4.11 Advanced Features

The Advanced Features Panel is used to invoke features that are used for model diagnostics and other special purposes. In general, the features on this panel are not appropriate for SIP and transportation conformity use, except for states that have adopted California Low Emission Vehicle (LEV) criteria pollutant standards (and such California standards have received a Clean Air Act waiver from EPA) and states in the Ozone Transport Commission (OTC) that received early implementation of National Low Emitting Vehicle (NLEV) standards. In these cases, the "Input Data Sets" feature on this panel should be used in conjunction with the LEV/NLEV tools accessed through the Tools drop-down menu in the MOVES GUI. Specifically:

- OTC states that did not adopt California LEV standards but were subject to the early implementation of NLEV should use the "Build NLEV Input Database" tool.

- OTC states that adopted California LEV standards prior to the 2001 model year should use the "Build LEV Input Database" tool.
- OTC states that were subject to the early implementation of NLEV and adopted California LEV standards beginning with model year 2001 or later should use both the "Build LEV Input Database" and the "Build NLEV Input Database" tools.
- All other states that adopted California LEV standards in any year should use the "Build LEV Input Database" tool.

Detailed instructions on how to use both tools are available in the MOVES GUI: after opening the tool via the Tools drop-down menu, click the "Open Instructions" button.

After creating the input database(s) with the appropriate tool, users should include these databases in the RunSpec through the "Input Data Sets" section of the Advanced Features Panel. Select the appropriate input database in the database drop-down menu (users may need to click the Refresh button if the database does not appear in the list), and then click the Add button.

4.5 Entering Project Details Using the Project Data Manager

After completion of all the necessary panels to create the RunSpec, the user would then populate an input database to describe the project in detail for the period of time selected in the RunSpec. An input database is a set of tables that describe project-specific data to be used for the run, and the Project Data Manager assists the user in creating and populating this set of tables. The Project Data Manager can be accessed from the Create Input Database Panel of the RunSpec with the Enter/Edit Data button.

As described in Section 4.3, a typical PM hot-spot analysis will involve multiple MOVES runs, and therefore, a typical analysis will involve 4 or 16 unique RunSpecs and the same number of unique input databases for each build or no-build scenario for each analysis year, one for each RunSpec. See Section 4.4.10 above for EPA's recommendations for good data management practices.

Also, each tab of the Project Data Manager includes a box for entering a "Description of Imported Data." Modelers should make liberal use of these descriptions to (1) indicate whether default or local data were used, and (2) indicate the source and date of any local data, along with the filename of imported spreadsheets. These descriptions are preserved with the input database so reviewers (or future users of the same runs) will have the documentation of inputs readily at hand.

If an input database was not created (by defining a name for it) in the Create Input Database Panel of the RunSpec, a database must be created on the Database Tab. When the database is created, MOVES records the selections in the RunSpec at that moment and uses this information to populate and evaluate database entries. Users should avoid

making changes to the RunSpec after the input database has been created, because this can create inconsistencies between the input database and the rest of the RunSpec.

The Project Data Manager includes multiple tabs to open importers used to enter project-specific data. These importers are:

- Meteorology Data
- Age Distribution
- Fuel
- I/M Programs
- Retrofit Data
- Links
- Link Source Types
- Link Drive Schedules
- Operating Mode Distribution
- Off-Network
- Hotelling
- Generic

Each of the importers allows the user to create a template file with the necessary data field names and some key fields populated. The user then edits this template to add project-specific local data with a spreadsheet application or other tool and imports the data files into MOVES. In some importers, there is also the option to export default data from the MOVES database in order to review and then use it. Once the user determines that the default data are accurate and applicable to the particular project, or determines that the default data need to be changed and makes those changes, the user can then import that data into MOVES. Details of the mechanics of using the data importers are provided in MOVES training.[65] Guidance for the use of these importers in PM hot-spot analyses is described below.

To run MOVES, each of these importers or tabs must have a green check; MOVES3 will not run if any of them have red Xs. The initial status of the tabs depends on the selections made in the RunSpec. For instance, when a project has no off-network links, the off-network road type would not be selected in the RunSpec. In this case, the Off-Network and Hotelling Importers would not be used and therefore those tabs will display green checks. However, if any hotelling processes are selected in the RunSpec, the Hotelling Importer will begin with a red X to indicate data is needed.

In addition, the status of some tabs depends on data loaded on other tabs. For example, when a project has an off-network link, the Operating Mode Distribution tab will start with a green check when the database is first created. When the Links tab is used to import an off-network link, the Operating Mode Distribution tab will change to show a red X, indicating that data is needed. Once the Operating Mode Distribution tab is used to import the vehicle soak activity, the tab will update to show a green check.

[65] See the latest version of "Hands-On Training" at: https://www.epa.gov/moves/moves-training-sessions.

Most analyses will not use all of the importers. Some tabs, such as Link Drive Schedules, Retrofit Data, and Generic are optional and always have green checks unless there is an issue with any of the imported data.

4.5.1 Meteorology Data

The Meteorology Data Importer is used to import temperature and humidity data for the month and hour that are defined in the MOVES RunSpec. Although temperature and humidity data can be entered for all hours, only the one hour selected in the run specification will be used for PM hot-spot analyses. Meteorology inputs for MOVES should be the same for build and no-build scenarios.

Temperatures must be consistent with those used for the project's county in the regional emissions analysis (40 CFR 93.123(c)(3)) as well as the air quality modeling inputs used in the hot-spot analysis (covered in Section 7.5). In most cases, users should simply use the MOVES meteorology file for the county in which the project is located that was used in the latest SIP or transportation conformity regional emissions analysis.

When modeling projects using four runs (e.g., projects without gasoline start activity), use temperature inputs that are consistent with those used in the regional emissions analyses for the month chosen in the RunSpec.

For projects that include gasoline vehicle start activity, users should enter data specific to the project's location and time period modeled, as gasoline vehicle PM start emissions vary with temperature. The accuracy of emission estimates for these projects improves when meteorological data specific to the modeled location is included. In this case, within each period of day in each season, temperatures should be used that represent the average temperature within that time period. For example, for January AM peak periods corresponding to 6 a.m. to 9 a.m., the average January temperature based on the meteorological record for those hours should be used in the January AM peak MOVES run. Humidity estimates should be based on the same hours and data source as the temperature estimates.

See Section 4.3 for further information on the number of MOVES runs recommended for different project analyses.

4.5.2 Age Distribution

The Age Distribution Importer is used to enter data that provides the distribution of vehicle fractions by age for each calendar year (yearID) and vehicle type (sourceTypeID). These data are needed for running MOVES at the project level. The distribution of ageID (the variable for age) fractions must sum to one for each vehicle type and calendar year. These inputs should generally be the same for build and no-build scenarios, unless something about the project would change them (e.g., a bus terminal project that includes the purchase of new buses in the build scenario).

To build a MOVES-compatible age distribution table, there are three possible options.

1. If available, users should use the latest state or local age distribution assumptions from their SIP or transportation conformity regional emissions analysis. The MOVES3 Technical Guidance covers how this would be created.[66]

2. If the project is designed to serve a fleet that operates only locally, such as a drayage yard or bus terminal, the user should provide project-specific fleet age distribution data. For most captive fleets, an exact age distribution should be readily available or obtainable.

3. If no state or local age distribution is available, the MOVES default age distribution should be used by exporting it from the Age Distribution Importer. These fractions are national defaults and could be significantly different than the local project age distribution. Age distribution can have a considerable impact on emission estimates, so the default data for local fleets should be used only if an alternative state or local dataset cannot be obtained. For single unit long-haul and combination long-haul trucks, it is generally more appropriate to use MOVES national default age distributions.

4.5.3 Fuel

The user needs to define in MOVES what fuel(s) and fuel mix will be used in the project area. The four required tables in the Fuel Importer: FuelSupply, FuelFormulation, FuelUsageFraction, and AVFT (Alternative Vehicle and Fuel Technology) are used to enter the necessary information describing fuel mix and fuel type for each MOVES run, including the appropriate fractions of gasoline, diesel, CNG and electric vehicles. These inputs should generally be the same for build and no-build scenarios, unless something about the project would change them (e.g., a project that includes alternate fuel vehicles and infrastructure in the build scenario).

Users should review the default fuel formulation and fuel supply data in MOVES by exporting it from the Fuel Importer, and make changes only if local volumetric fuel property information is available. Otherwise, EPA strongly recommends that the MOVES default fuel supply and formulation information be used unless a full local fuel property study exists. The one exception to this guidance is in the case of Reid Vapor Pressure (RVP), where a user should change the value to reflect any specific local regulatory requirements and differences between ethanol and non-ethanol blended gasoline not reflected in the default database. Any changes to RVP (or to any other gasoline formulation parameters) should be made using the "Fuel Wizard" tool accessible in the Fuel Importer.

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[66] See EPA's *MOVES3 Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity*, EPA-420-B-20-052 November 2020, available on EPA's web site at: https://www.epa.gov/state-and-local-transportation/policy-and-technical-guidance-state-and-local-transportation#emission.

For additional guidance on defining fuel supply and formulation information, consult EPA's MOVES Technical Guidance.[67]

4.5.4 I/M Programs

MOVES does not provide a PM emission benefit from Inspection and Maintenance (I/M) programs. Therefore, if the modeler includes an I/M program, the selection will have no impact on PM emissions. However, this importer needs a green check for the MOVES run to execute. For a PM hot-spot analysis, a modeler can get a green check for this importer by checking the box labeled "No I/M Program" on this tab.

4.5.5 Retrofit Data

The Retrofit Data Tab in MOVES allows users to enter heavy-duty diesel retrofit and/or replacement program data that apply adjustments to vehicle emission rates. There are no default retrofit or replacement data in MOVES. However, users are not required to input such data into MOVES; they would only do so if they have a retrofit or replacement program that they want to model. For example, a bus terminal project might include plans to mitigate emissions by retrofitting or replacing the bus fleet that will operate at that terminal with control equipment that reduces PM emissions. In that case, the user would specify the details of the retrofit or replacement project using the Retrofit Data Importer. Please refer to EPA's latest guidance on quantifying emission reductions from retrofit and replacement programs for conformity purposes.[68] Strategies that affect vehicle activity, such as implementing a truck idle reduction plan, should be handled in the Off-Network Importer and Links Importer.

See Section 10 for further information regarding the inclusion of mitigation and/or control measures in PM hot-spot analyses.

4.5.6 Links

The Links Importer is used to define the individual roadway links. All links being modeled should have unique IDs. The Links Importer requires information on each link's length (in miles), traffic volume (units of vehicles per hour), average speed (miles per hour), and road grade (percent; 100 percent equals a 45-degree slope). Users should follow guidance given above in Section 4.2 when determining the number of links and the length of specific links. Consult Section 7 for information on how these links should be formatted for use in air quality modeling.

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[67] The MOVES3 Technical Guidance can be found at: https://www.epa.gov/state-and-local-transportation/policy-and-technical-guidance-state-and-local-transportation#emission.

[68] *Diesel Retrofit and Replacement Projects: Quantifying and Using Their Emission Benefits in SIPs and Conformity - Guidance for State and Local Air and Transportation Agencies*, EPA-420-B-18-017, March 2018. This guidance can be found on EPA's web site at: https://www.epa.gov/state-and-local-transportation/policy-and-technical-guidance-state-and-local-transportation#quantifying.

This importer also includes a column to add a link description. Descriptions are helpful to both modelers and reviewers to keep track of what is included in the modeling run.

Note that if the run includes the off-network road type, the Operating Mode Distribution Importer will not display a green check until the vehicle soak distribution for the off-network link is entered using the Operating Mode Distribution Importer.

4.5.7 Link Source Types

The Link Source Types Importer allows the user to enter the fraction of the link traffic volume that is represented by each vehicle type (source type). For each LinkID, the "SourceTypeHourFractions" must sum to one across all source types. If there is an off-network link, that LinkID should not be included; instead, information for an off-network link will need to be included in the Off-Network and Operating Mode Distribution Importers.[69]

Additionally, the user needs to ensure that the source types selected in the MOVES Onroad Vehicles Panel match the source types defined through the Link Source Type Importer.

There are no defaults that can be exported from the Link Source Type Importer. For any analysis at the project level, the user needs to provide source type fractions for all links being modeled and for each MOVES run, as vehicle mixes may vary by link and may change from hour to hour and month to month. There are two options available to populate the Link Source Type input:

1. For projects that will have an entirely different source type distribution than that of the regional fleet, the preferred option is for the user to collect project-specific data. For example, for projects such as bus or freight terminals or maintenance facilities that contain links that are primarily used by a specific subset of the regional fleet, users need to develop the fractions of link traffic volume by vehicle type data specific to the project. This could be based on analysis of similar existing projects through the interagency consultation process.

2. If the project traffic data suggests that the source type distribution for the project can be represented by the distribution of the regional fleet for a given road type, the user can provide a source type distribution consistent with the road type used in the latest regional emissions analysis. For example, interstates tend to have a higher fraction of truck traffic than minor arterial roads. Therefore, the interstate

[69] When using MOVES 3.0.0 or 3.0.1, and the only link in a MOVES run is an off-network link, the Link Source Types Importer will still need a green check. In this case, create a template for the linkSourceTypeHour table. This will create a file with a row for each source type in the run. Fill in linkID as 0 for each row, and provide a sourceTypeHourFraction that sums to 1. This distribution will not be used since there is no linkID 0 defined in the Links importer, but it will provide a green check for this importer. This workaround is not needed for MOVES3.0.2 or later versions.

source type distribution used in the regional emissions analysis may be appropriate to use for an interstate project.

4.5.8 Options for Describing Running Activity (Running and Idling)

This section describes the options for describing running activity: running and idling, and covers two optional importers, the Link Drive Schedules Importer and Operating Mode Distribution Importer.

MOVES determines vehicle emissions based on operating modes, which represent different types of vehicle activity such as acceleration (at different rates), deceleration, idle, and cruise that have distinct emission rates. MOVES handles these data in the form of a distribution of the time vehicles spend in different operating modes.

There are several methods that users may employ to generate an operating mode distribution based on the project design and available traffic information. MOVES currently offers three options that the user can employ to add link activity data, depending on data availability. These are:

1. Provide average speed and road type through the Links Importer:
   Using this approach, MOVES will calculate emissions based on a default drive cycle for a given speed and road type. Input of link drive schedules or operating mode distributions is not needed under this option. For users modeling a free-flow link with only basic information on average speed, volume, and grade on a link, this option may be appropriate. This approach accounts for some differences in emissions due to changes in operating modes associated with different average speeds on a specific road type. However, this approach provides the least resolution when analyzing the emission impact of a project because the default drive cycles used by the model may not accurately reflect the specific project. For instance, due to the range of operating modes associated with intersection projects, a single average speed would not spatially capture localized idling and acceleration emissions. Additionally, the default drive schedules may be more appropriate for links on flat terrain.

   Average speed is an appropriate input when running MOVES in Inventory mode to model an idle-only link, using a running link with an average speed of 0. The result for such a link would be the emissions from the volume vehicles on that link idling for the entire hour. If vehicles idle for only part of the hour, the link volume needs to be multiplied by the fraction of idling time, i.e., (minutes of idling/60 minutes) before being input. For example, if 30 transit buses idle on a link for 20 minutes of the hour, the volume of this link should be the number of transit buses (30) multiplied by (20/60), which is a volume of 10.

   When running in Emission Rates mode, an idle-only link must be modeled using an operating mode distribution (see below).

2. Provide a link drive schedule using the Link Drive Schedules Importer:
   The Link Drive Schedules Importer allows the user to define the precise speed and grade as a function of time (seconds) on each roadway link. The time domain is entered in units of seconds, the speed variable is miles-per-hour and the grade variable in percent grade (vertical distance/lateral distance, 100% grade equals a 45-degree slope).[70] If this optional importer is used, MOVES will build an operating mode distribution from the information in the Link Drive Schedules table combined with default assumptions regarding vehicle weights and road load coefficients. This MOVES-calculated operating mode distribution will be used to calculate link running emissions instead of using the average speed in the Links table.

   Link Drive Schedules are applied to all source types operating on the link. The Link Drive Schedule therefore represents the "tracer" path of an average vehicle on each link. Link drive schedules could be based on observations using methods such as chase (floating) cars on similar types of links, or on expected vehicle activity based on an analysis of link geometry. Link drive schedules will only represent average vehicle activity, not the full range of activity that will occur on the link. As described in Section 4.2 and Appendix D, users can overcome this limitation by defining multiple links for the same portion of the project (links that "overlap") with separate source distributions and drive schedules to model individual vehicle types.

3. Provide a detailed operating mode distribution for the link:
   The Operating Mode Distribution Importer allows the user to directly import operating mode fraction data for source types, hour/day combinations, roadway links, and pollutant/process combinations that are included in the run specification. Operating mode distributions may be obtained from:
   - Op-Mode distribution data from other locations with similar geometric and operational (traffic) characteristics;[71] or
   - Output from traffic microsimulation models.[72]

   If this optional importer is used, MOVES will use these operating mode fractions for calculating link running emissions instead of creating an operating mode distribution from the average speed included in the Links table.

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[70] Note that MOVES does not determine if the vehicle speed trajectory is realistic for assumed vehicle characteristics and the grade input. Users should ensure that vehicle speeds are realistic and appropriate for all characteristics of a link, including grade.

[71] For example, chase (or floating) cars, traffic cameras, and radar guns have been used previously to collect some traffic data for use in intelligent transportation systems and other applications. EPA encourages the development of validated methods for collecting verifiable vehicle operating mode distribution data at specific locations representative of different projects covered by this guidance.

[72] A traffic microsimulation model can be used to construct link drive schedules or operating mode distributions if prior validation of the model's predictions of speed and acceleration patterns for roadway links similar to those in the project was conducted. If a user has a microsimulation model that has been previously demonstrated to adequately predict speed/acceleration patterns for relevant vehicle classes (e.g., heavy-duty), and has a procedure for importing data into MOVES, it may be appropriate to use the microsimulation model, subject to interagency consultation.

When running MOVES in Emission Rates mode, the operating mode distribution input can be used to model an idle-only link:

- With the Links Importer, specify a running link with an average speed of 1 mph.[73]
- With the Operating Mode Distribution Importer:
  - For all running polProcessIDs (i.e., polProcessIDs with the last two digits of "01"), input a fraction of:
    - 1.0 for opModeID 1
    - 0.0 for opModeIDs 0 and 11 through 40
  - To account for brakewear, input the following fractions for polProcessID 11609 ($PM_{2.5}$) and 10609 (PM_{10}):
    - 1.0 for opModeID 501
    - 0.0 for opModeIDs 0 through 40
  - To account for tirewear, input the following fractions for polProcessID 11610 ($PM_{2.5}$) and 10610 (PM_{10}):
    - 1.0 for opModeID 400
    - 0.0 for opModeIDs 401 through 416

Users should consider the discussion in Section 4.2 when deciding on the appropriate activity input. The MOVES model is capable of using complex activity datasets with high levels of resolution to calculate link-level emissions. EPA encourages the development of validated methods for collecting verifiable vehicle Op-Mode distribution data at locations and in traffic conditions representative of different projects covered by this guidance. However, the user should determine the most robust activity dataset that can be reasonably collected while still achieving the goal of determining an accurate assessment of the PM air quality impacts from a given project. The choice of whether to rely on average speed information in the Links Importer, or add more detailed information through the Link Drive Schedules or Op-Mode Distribution Importers should be based on the data available to the user. Regardless of which option is used, the inputs should reflect the latest available vehicle activity and behavior information on each link.

4.5.9 Describing Off-Network Activity (Starting and Hotelling)

Where a project analysis includes areas where vehicles are not driving on the project links, but are part of the area substantially affected by the project, the user will define this "off-network" activity in MOVES as well. For example, an off-network link would be used if the area substantially affected by the project includes a parking area, a bus terminal, or a freight terminal. [74] Interagency consultation should be used to help identify appropriate receptor locations in the area substantially affected by the project. (See Section 7.6 for additional discussion of placing receptors in air quality modeling.)

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[73] The units for the running emissions process in Rates mode is "mass per distance," and no distance is traveled while idling. Therefore, an average speed of 1 mph is used to transform the units for an idling link to "mass per hour."

[74] Smaller off-network areas within the project area that are determined to be insignificant through interagency consultation can be omitted. An example might be an employee parking area.

Activity at these areas may include:

- vehicles starting, which would be defined through the Off-Network and Operating Mode Distribution Importers,
- hotelling by long-haul combination trucks, which would be defined through the Off-Network and Hotelling Importers, and
- vehicles running and idling. Even though the activity is occurring in the same area as off-network activity, running and idling activity in these areas would be defined using one or more running links. See Section 4.5.8 above for more information on how to specify activity on running links.

The methods and assumptions used to derive off-network inputs (including starts, hotelling activity, and soak-time distributions) should be documented as part of the analysis, including any adjustments based on data from similar projects.

Off-Network Importer. The Off-Network Importer should be used if the project includes an area where highway vehicles are parked, starting their engines, or in hotelling mode (such as at a truck stop, parking lot, or passenger or freight intermodal terminal). The Off-Network Importer allows only one off-network link to be described per run. If more than one off-network link is associated with the project, another set of MOVES runs may be needed to characterize each additional off-network location for each build or no-build scenario.[75]

There are no default values available for any of the off-network inputs, so users will need to populate the Off-Network table with information describing vehicle activity in the off-network area being modeled. The necessary fields are vehicle population, start fraction, and "extended idle fraction" (which refers to all hotelling activity rather than only extended idling):

- The "vehiclePopulation" column reflects the total number of vehicles of each source type parked on the off-network area over the course of the hour covered by the MOVES run.[76]
- The "startFraction" column is the fraction of that total vehicle population that starts during the hour.
- The "extendedIdleFraction" specifies the fraction of time that the vehicle population spends in hotelling operation in the hour. This column should be zero for all vehicles other than long-haul combination trucks, because hotelling is an activity that applies only to long-haul combination trucks. For combination long-haul trucks (SourceTypeID 62), if a non-zero number is entered, the user would also complete the Hotelling Importer.

[75] Alternatively, if the off-network links are identical in terms of fleet mix and soak times, one off-network link can be used and the results post-processed so that they can be used to represent parking areas with different numbers of starts per hour. See the MOVES module of EPA's PM hot-spot training for more information, available on the web site at: https://www.epa.gov/state-and-local-transportation/project-level-training-quantitative-pm-hot-spot-analyses. Please consult with EPA if your project includes more than one off-network area.

[76] Note that while link volume for the off-network link is required on the Links input, the vehicle population column of the Off-Network table is what MOVES uses to calculate emissions on this link.

- The "parkedVehicleFraction" is not required as an input and can be left blank as it is used for evaporative emissions and does not apply to PM modeling.

Operating Mode Distribution Importer. If an off-network link is defined, users need to also define an Op-Mode distribution that describes the soak-time distribution of vehicles on the link; this will affect the start emissions. The soak time is the time a vehicle is stationary with the engine turned off, following the last time it was operated. There are no default soak-time distributions available. Soak times and soak-time distributions should be specific to the type of project being modeled. This information could either be directly collected or obtained from information collected for a similar project. For instance, a park-and-ride lot may have vehicles parked for eight or nine hours prior to starting, while an intermodal freight terminal may have vehicles parked for only one hour before starting. This information should be defined through the appropriate distribution of soak-time Op-Modes (OpModes 101-108) in the Op-Mode Distribution table. [77]

When a template is created for this importer, operating modes for the running and braking processes (i.e., opModeIDs 0 through 40 and 501) will be present if these processes are selected in the RunSpec. These operating modes should be deleted unless the user is supplying detailed operating mode distributions to describe running activity, as discussed in Section 4.5.8.

Hotelling Importer. Hotelling applies only to long-haul combination trucks (source type 62) and is defined as the operation of the truck in "hotelling" mode, typically at overnight rest areas. In order to heat and cool the cab, as well as to run appliances, an added energy load is necessary. This energy is provided from four possible modes, defined in the Hotelling Importer for each model year:

- Extended idling (OpModeID 200), where the truck engine is operating at a higher RPM than during normal idling to accommodate the extra load from the accessories;
- Diesel auxiliary power unit (OpModeID 201), or APU, where a small, separate diesel engine is used to power accessories;
- Battery power (OpModeID 203), where the engine is off and the accessories are being run from battery power; and
- Engine-off (OpModeID 204), where accessories are powered by an external source of electricity available at the truck stop.[78]

Note that battery power and engine-off both yield zero emissions. Local hotelling activity for a given project will likely be different than the national defaults. Default

[77] When a template is created for this importer, if operating modes other than soak time are present, they should be deleted. For example, the template may include operating modes for hotelling, but hotelling operating modes are input through the Hotelling importer. Note that soak time op-mode definitions are listed in a tab of the spreadsheet. In addition, these definitions can be found on the MOVES Onroad Cheat Sheet available at: https://github.com/USEPA/EPA_MOVES_Model/blob/master/docs/MOVES3CheatsheetOnroad.pdf.

[78] More information is available in the *Population and Activity of Onroad Vehicles in MOVES3*, EPA-420-R021-012, April 2021, available on EPA's website at: https://www.epa.gov/moves/moves-onroad-technical-reports#moves3.

information is available but should be used only in the absence of local information. Users should look at the default information and decide whether it is consistent with the expected operating modes in the project's location.

Sources of Information and Documentation. For vehicle population inputs, the user should be able to rely on existing project documentation. The user will also need to estimate the number of starts and idle operation of the facility for other inputs, which will depend on the project involved. For example, in a bus terminal project, the user could estimate the number of starts and idling based on expected passenger ridership and proposed operating schedules for the buses using the terminal. (Again, note that bus idling at a bus terminal project would be defined with a running link.) Most buses would be expected to first start early in the morning, prior to the morning peak period. The buses might operate all day, with little or no start activity during the midday hours. Idle operation is likely a function of the volume of buses accessing the terminal each hour and the duration that those buses idle prior to leaving the terminal. Conversely, an employee parking lot would have little or no idle activity and may have the opposite trend in start activity. Typically, employees arrive during the morning peak period and leave during the evening peak period. In this case, most starts would occur during the evening peak period.

Information on start and idle activity should be specific to the project being modeled. However, data from similar projects could be adapted for use in a quantitative PM hot-spot analysis, when appropriate. For instance, the ratio of starts to number of vehicles and the distribution of starts throughout the day for a project being analyzed could be determined by studying a similar parking lot.

The methods and assumptions used to derive off-network inputs (including starts, soak-time distributions, and hotelling) should be documented as part of the analysis, including any adjustments based on data from similar projects.

4.6 Generating Emission Factors for Use in Air Quality Modeling

The MOVES model provides results as either an emission total (if Inventory mode is selected) or an emission rate (if Emission Rates mode is selected). The emission results calculated for each pollutant are in the following terms (assuming grams and miles are selected on the General Output Panel, as described in Section 4.4.8):

- grams/hour for each link in Inventory mode
- grams/vehicle-mile for each link in Emission Rates mode

Regardless of which mode is used, MOVES will produce emission results at the level of detail selected on the Output Emissions Detail Panel of the RunSpec, as described in Section 4.4.9. For example, if output by "Emission Process" is selected, MOVES will produce separate grams/hour or grams/vehicle-mile results for each emission process modeled.

However, AERMOD requires a single emissions value for each time unit and link being modeled. AERMOD uses a gram/time emission factor for each source and for each hour of the day. AERMOD sources should be mapped to links modeled by MOVES and the time of day should be mapped based on the time periods analyzed, as described in Section 4.3. See Section 7 and Appendix J for instructions on running AERMOD for PM hot-spot analyses.

MOVES includes post-processing scripts that can calculate a single emissions value for each time unit and link being modeled. After running MOVES, these scripts can be run on the output database. First, make sure that the correct output database is selected on the General Output Panel. Then, in the Post Processing menu, select "Run MySQL Script on Onroad Output Database." In the pop-up window, select the desired script, and click OK. After reading the next informational dialog that pops up, click OK to run the script. Each script will produce a table in the output database, with the table name corresponding to the name of the script. The SQL screen may need to be refreshed to display the new table created by the script.

- If Inventory mode is used, the following scripts will calculate total emissions in grams/hour for each MOVES run, year, month, hour, and link in the output database:
  - PM25_Grams_Per_Hour.sql
  - PM10_Grams_Per_Hour.sql[79]

  These grams/hour emissions would need to be converted into the appropriate inputs for AERMOD, such as grams/second (volume source type), or grams/second/square meter (line/area source type).

- If Emission Rates mode is used, the following scripts will calculate total emissions in grams/vehicle-mile for each MOVES run, year, month, hour, and link in the output database:
  - PM25_Grams_Per_Veh_Mile.sql
  - PM10_Grams_Per_Veh_Mile.sql

  These grams/vehicle-mile emissions from MOVES would need to be converted into the appropriate inputs for AERMOD. Converting these emissions is more complicated than converting results from Inventory mode, because these rates must be multiplied by the correct hourly volumes and link lengths first, then converted to into the appropriate inputs such as grams/second (volume source type), or grams/second/square meter (line/area source type).

EPA also has a tool, "MOVES2AERMOD," to convert MOVES results done with Inventory mode into a format that can be included in AERMOD (with the AERMOD

[79] See EPA's PM hot-spot training for examples of running scripts – refer to the MOVES module of the training zip file on EPA's website at: https://www.epa.gov/state-and-local-transportation/project-level-training-quantitative-pm-hot-spot-analyses.

keyword EMISFACT). The MOVES2AERMOD script can be found on EPA's MOVES website.[80] The ZIP file contains instructions for using the tool.

Section 7 and Appendix J discuss AERMOD in further detail.

[80] See EPA's website at: https://www.epa.gov/moves/tools-develop-or-convert-moves-inputs#emisfact. The MOVES2AERMOD tool can be used with any number of MOVES runs. MOVES runs represent emissions at different times. In the MOVES2AERMOD tool, the modeler assigns the runs to the appropriate hours of the day in all four seasons of the year via the "Traffic_Distribution" spreadsheet, one of the three spreadsheets that modelers need to populate to use the tool.

Section 5: Estimating Project-Level PM Emissions Using the EMFAC Model in California

5.1 Introduction

This section of the guidance describes characterizing a project in terms of links and determining the number of runs necessary when using the EMFAC model. The California Air Resources Board (CARB) maintains the EMission FACtors (EMFAC) model, which is approved by EPA for developing on-road motor vehicle emission inventories and conformity analyses in California. EMFAC models on-road mobile source emissions under multiple temporal and spatial scales; it produces composite emission factors for an average day of a month (January to December), a season (summer and winter), or an annual average, for specific California geographic areas by air basin, district, and county as well as the statewide level. EMFAC can produce $PM_{2.5}$ and PM_{10} emission rates for three exhaust emission processes (running, starting, and idle), tire wear, and brake wear. CARB provides its own documentation for how to use the EMFAC model at the project scale. Please refer to CARB's web page for this documentation; note that the latest EPA-approved version of EMFAC would be used for a PM hot-spot analysis, or the previous version during the conformity grace period.[81]

EPA notes that the latest state, local, or project-specific assumptions should be used for conducting PM hot-spot analyses with EMFAC to meet conformity requirements. For example, a project sponsor should use age distribution assumptions from their SIP or transportation conformity regional emissions analysis, or other project-specific age distribution data, if available. Project-specific age distribution data and other significant data for emissions modeling purposes, such as project-specific rest/soak times for relevant projects, should be used rather than EMFAC defaults for the county in which the project is located. If a terminal project is designed to serve a fleet that operates only locally, such as a drayage yard or bus terminal, the project sponsor should provide project-specific fleet age distribution data. The interagency consultation process should be used to determine the use of the latest planning assumptions for projects on a case-by-case basis.

As discussed in Section 2.4, it is suggested that project sponsors conduct emissions and air quality modeling for the project build scenario first. If the design concentrations for the build scenario are less than or equal to the relevant NAAQS, then the project meets the hot-spot analysis requirements of project-level conformity and it is not necessary to model the no-build scenario. Following this approach will allow users to avoid additional emissions and air quality modeling. Please see Section 2.4 for additional information if the design concentrations for the build scenario are greater than the relevant NAAQS.

[81] The *Federal Register* notice for EPA's most recent approval of the EMFAC model can be found on EPA's website at: https://www.epa.gov/state-and-local-transportation/policy-and-technical-guidance-state-and-local-transportation#emission. See footnote 9 (Section 1.6) for CARB reference information.

5.2 Characterizing a Project in Terms of Links

Prior to using EMFAC, users first need to identify the project type and the associated emission processes (running, start, brake wear, tire wear, and idle exhaust) to be modeled. This guidance distinguishes between two types of transportation projects: (1) highway and intersection projects, and (2) transit or other terminal projects:

- For highway and intersection projects, running exhaust, brake wear, and tire wear emissions are the main focus.
- For transit and other terminal projects, start and idle emissions are typically needed, and in some cases these projects will also need to address cruise, approach and departure running exhaust emissions on affected links.

The goal of defining a project's links is to accurately estimate emissions from a specific type of activity where that activity occurs. A link represents a segment of a highway or transit project characterized by a certain type of vehicle activity. Generally, the links specified for a highway project should include road segments with similar traffic conditions and characteristics. Links representing transit or other terminal projects should similarly reflect variation in idle and start activity, as well as other relevant cruise, approach and departure running exhaust emissions.

Users of EMFAC should ensure that the latest information about vehicles operating on the project is used in the emissions modeling.

5.2.1 Highway and Intersection Projects

A PM hot-spot analysis fundamentally depends on the availability of accurate data on roadway link speed and traffic volumes for build and no-build scenarios.[82] Thus, local traffic data should be used to characterize each link sufficiently. It is recommended that the user divide a project into separate links to allow sufficient resolution at different vehicle traffic and activity patterns; characterizing this variability in emissions within the project area will assist in air quality modeling (see Section 7).

For analyses with EMFAC, an average speed and traffic volume is needed for each link.[83] A simple example would be a single, one directional, four-lane highway that could be characterized as one link with one average speed. If the project analysis involves intersections, the intersections need to be treated separately from the free-flow links that connect to those intersections. Although road segments between intersections may experience free-flow traffic operations, the approaches and departures from the

[82] Project sponsors should document available traffic data sets, their sources, key assumptions, and the methods used to develop build and no-build scenario inputs for EMFAC. Documentation should include differences between how build and no-build traffic projections are obtained. For projects of local air quality concern, differences in traffic volumes and other activity changes between the build and no-build scenarios must be accounted for in the data that is used in the PM hot-spot analysis.

[83] Unlike MOVES, EMFAC does not allow a user to account for more detailed data to describe the pattern of changes in vehicle activity (proportion of time in acceleration, deceleration, cruise, and idle activity) over the length of a road.

intersections will involve acceleration, deceleration, and idling activity not present on the free-flow link. For intersection modeling, the definition of link length will depend on the geometry of the intersection, how that geometry affects vehicle activity, and the level of detail of available activity information.

When using EMFAC, project sponsors can use average speeds for highway and intersection links based on travel time and distance. Travel time should account for the total delay attributable to traffic signal operation, including the portion of travel when the light is green and the portion of travel when the light is red. The effect of a red signal cycle on travel time includes deceleration delay, move-up time in a queue, stopped delay, and acceleration delay. Each approach link would be modeled as one link to reflect the higher emissions associated with vehicle idling through lower speeds affected by stopped delay; each departure link would be modeled as another link to reflect the higher emissions associated with vehicle acceleration through lower speeds affected by acceleration delay.

Project sponsors should determine average congested speeds by using appropriate methods based on best practices used for highway analysis. Some resources are available through FHWA's Travel Model Improvement Program (TMIP).[84] Methodologies for computing intersection control delay are provided in the Highway Capacity Manual.[85]

5.2.2 Transit and Other Terminal Projects

For transit and other terminal projects such as a bus terminal or intermodal freight terminal, the user should have information on starts per hour and number of vehicles idling during each hour. This activity will likely vary from hour to hour. It is recommended that the user divide such a project into separate links to characterize variability in emission density within the project area appropriately (as discussed in Section 7). In this case, each "link" describes an area with a certain number of vehicle starts per hour, or a certain number of vehicles idling during each hour.

Generally, users need to account for the number of vehicle starts and the amount of idle activity (in hours). Grams/trip rates can be calculated for start exhaust emissions. Additionally, grams/idle-hour (grams/hour) emission rates can be calculated for both regular idle and extended idle exhaust emissions. Users need to have data on the number of vehicle starts per hour and number of vehicles idling during each hour to get the total project or project area emission factor.

In addition, some transit and other terminal projects may have significant running emissions similar to free-flow highway projects (such as buses and trucks traveling to and from an intermodal terminal). These emissions can be calculated by defining one or more unique running links as described in Section 5.2.1, in addition to the other running links associated with roads of the project. These running link emissions can then be

[84] See FHWA's TMIP website: http://tmip.fhwa.dot.gov/.
[85] Users should consult the most recent version of the *Highway Capacity Manual*. See footnote 50 (Section 4.2.1) for reference information.

aggregated with emissions from starts and idling from non-running activity on the transit or other terminal link outside of the EMFAC model to generate the necessary air quality model inputs.

Note: The user may choose to exclude sources such as a separate service drive, separate small employee parking lot, or other minor sources that are determined to be insignificant to project emissions.

5.3 Determining the Number of EMFAC Runs

5.3.1 General

Before using EMFAC to calculate emission factors, users should first determine the number of unique scenarios that can sufficiently describe activity variation in a project. In most projects, traffic volume, average speed, idling, fleet mix, and the corresponding emission factors will likely vary from hour to hour, day to day, and month to month. However, it is unlikely that data are readily available to capture such finite changes. Project sponsors may have activity data collected at a range of possible temporal resolutions. The conformity rule requires the use of latest planning assumptions or data available at the time the conformity analysis begins (40 CFR 93.110).[86] Depending on the sophistication of the activity data analysis for a given project, these data may range from a daily average-hour and peak-hour value to hourly estimates for all days of the year. EPA encourages the development of sufficient travel activity data to capture the expected ranges of traffic conditions for the build and no-build scenarios.

5.3.2 Projects with Typical Travel Activity Data

Traffic forecasts for highway and intersection projects are often completed for annual average daily traffic volumes, with an allocation factor for a daily peak-hour volume. This data can be used to conduct an analysis with EMFAC that is representative for all hours of the year. The most reasonable methods in accordance with good practice should be used to obtain the peak-hour allocation factors and diurnal distribution of traffic and the methods must be determined in accordance with interagency consultation procedures (40 CFR 93.105(c)(1)(i)).

One option is to represent traffic over four time periods: morning peak (AM), midday (MD), evening peak (PM), and overnight (ON). For example, the peak-hour volume can be used to represent activity conditions over a three-hour morning (AM) and three-hour evening period (PM). The remaining 18 hours of the day can be represented by the average off-peak hourly volume (AADT minus the total volume assigned to the peak period, divided by the number of off-peak hours). These 18 hours would be divided into a midday (MD) and overnight (ON) scenario.

[86] See *EPA and DOT Joint Guidance for the Use of Latest Planning Assumptions in Transportation Conformity Determinations*, EPA-420-B-08-901, December 2008; available online at: www.epa.gov/otaq/stateresources/transconf/policy/420b08901.pdf.

The following is one suggested approach for an analysis employing the average-hour/peak-hour traffic scenario:

- Morning peak (AM) emissions based on peak hour traffic data, applied to hours between 6 a.m. and 9 a.m.;
- Midday (MD) emissions based on average off-peak hourly traffic data, applied to hours from 9 a.m. to 4 p.m.;
- Evening peak (PM) emissions based on peak hour traffic data, applied to hours from 4 p.m. to 7 p.m.; and
- Overnight (ON) emissions based on average off-peak hourly traffic data, applied to hours from 7 p.m. to 6 a.m.

If there are local or project-specific data to suggest that the AM or PM peak traffic periods will occur in different hours than the default values suggested here, or over a longer or shorter period of time, that information should be documented and the hours representing each time period adjusted accordingly. Additionally, users should determine peak periods for the build and no-build scenarios independently and not assume that each scenario is identical.

The number of EMFAC runs needed to represent changes in fleet mix depends on what modeling approach is required to complete the analysis. See CARB's model documentation for details.

Since PM emission rates do not vary with temperature and humidity in EMFAC, it is not not necessary to run multiple EMFAC scenarios to capture seasonal variation in emission rates. An exception to this concerns medium-heavy and heavy-heavy diesel truck idling rates, which do vary by season to account for load factor changes due to heating, air conditioning, and accessory use. See CARB handbook for more information about these idling rates and options for accounting for this variation in a particular analysis.

5.3.3 Projects with Additional Travel Activity Data

Some project sponsors may have developed traffic or other activity data to show variations in volume and speed across hours, days, or months. Additionally, if users are modeling a transit or other terminal project, traffic volumes, starts, and idling estimates are likely to be readily available for each hour of the day. Under either of these circumstances, users have the option of applying the methodology described above (using average-hour and peak-hour as representative for all hours of the year) if it is determined through the interagency consultation process that using the additional data would not significantly impact the emissions modeling results. Alternatively, additional EMFAC scenarios could be generated to produce a unique emission factor for each activity scenario (i.e., each period of time for which specific activity data are available).

Section 6: Estimating Emissions from Road Dust, Construction, and Additional Sources

6.1 Introduction

This section provides guidance on how to estimate re-entrained road dust and transportation-related construction dust emissions. MOVES and EMFAC do not estimate emissions of road or construction dust, so this section must be consulted if dust is required to be included in the PM hot-spot analysis. See Section 2.5 for further information regarding when dust emissions are required to be included in a PM hot-spot analysis. This section also includes information on quantifying emissions from construction vehicles and equipment and additional sources in the project area, when applicable. The models and associated methods and assumptions used in estimating these emissions must be evaluated and chosen through the process established by each area's interagency consultation procedures (40 CFR 93.105(c)(1)(i)).

6.2 Overview of Dust Methods and Requirements

In summary, road or construction dust can be quantified using EPA's AP-42 method or alternative local methods. AP-42 is EPA's compilation of data and methods for estimating average emission rates from a variety of activities and sources from various sectors. Refer to EPA's website (https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors) to access the latest version of AP-42 sections and for more information about AP-42 in general. The sections of AP-42 that address emissions of re-entrained road dust from paved and unpaved roads and emissions of construction dust are found in AP-42, Chapter 13, "Miscellaneous Sources." The key portions of the chapter include:

- Section 13.2: "Introduction to Fugitive Dust Sources,"
- Section 13.2.1: "Paved Roads"
- Section 13.2.2: "Unpaved Roads"
- Section 13.2.3: "Heavy Construction Operations" (includes road construction)

Users should consult EPA's website to ensure they are using the latest approved version of AP-42, as the methodology and procedures may change over time.[87]

In addition to the latest version of AP-42, alternative local methods can be used for estimating road or construction dust; in some areas, these methods may already exist and can be considered for use in quantitative PM hot-spot analyses.

This section presumes users already have a basic understanding of how to use AP-42 or other dust methods.

[87] This guidance is applicable to current and future versions of AP-42, unless otherwise noted by EPA in the future.

6.3 Estimating Re-entrained Road Dust

6.3.1 $PM_{2.5}$ Nonattainment and Maintenance Areas

The transportation conformity rule requires a hot-spot analysis in a $PM_{2.5}$ nonattainment and maintenance area to include emissions from re-entrained road dust only if emissions from re-entrained road dust are determined to be a significant contributor to the $PM_{2.5}$ nonattainment problem. See Section 2.5 for further information.

6.3.2 PM_{10} Nonattainment and Maintenance Areas

Re-entrained road dust must be included in all PM_{10} hot-spot analyses. EPA has historically required road dust emissions to be included in all conformity analyses of direct PM_{10} emissions – including hot-spot analyses. See Section 2.5 for further information.

6.3.3 Using AP-42 for Road Dust on Paved Roads

Section 13.2.1 of AP-42 provides a method for estimating emissions of re-entrained road dust from paved roads for situations for which silt loading, mean vehicle weight, and mean vehicle speeds on paved roads fall within ranges given in AP-42, Section 13.2.1.3 and with reasonably free-flowing traffic (if the project doesn't meet these conditions, see Section 6.3.5, below). Section 13.2.1 of AP-42 contains predictive emission factor equations that can be used to estimate an emission factor for road dust.[88]

When estimating emissions of re-entrained road dust from paved roads, site-specific silt loading data must be consistent with the data used for the project's county in the regional emissions analysis (40 CFR 93.123(c)(3)). In addition, if the project is located in an area where anti-skid abrasives for snow-ice removal are applied, information about their use should be included (e.g., the number of times such anti-skid abrasives are applied).

6.4 Adding Dust Emissions to MOVES/EMFAC Modeling Results

Emission factors for road and construction dust should be added to the emission factors generated for each link by MOVES or EMFAC (in California). Once this data is available, the user can move on to Section 7 to develop input files for the appropriate air quality model.

6.4.1 Using AP-42 for Road Dust on Unpaved Roads

Section 13.2.2 of AP-42 provides a method for estimating emissions of re-entrained road dust from unpaved roads. Different equations are provided for vehicles traveling unpaved surfaces at industrial sites and vehicles traveling on publicly accessible roads.

[88] This section can be downloaded from EPA's website. See website information in Section 6.2.

Most PM hot-spot analyses will involve only vehicles traveling on publicly accessible roads. When applying an equation that accounts for surface material moisture content, the percentage of surface material moisture must be consistent with the data used for the project's county in the regional emissions analysis (40 CFR 93.123(c)(3)).

6.4.2 Using Alternative Local Approaches for Road Dust

Some PM areas have historically used locally-developed methods for estimating re-entrained road dust emissions that may be more appropriate than the AP-42 methods given specific local conditions. Other areas may develop alternatives in the future.

Also, an alternative method could be used if the equations in AP-42 do not apply to a particular project, as they were developed using a particular range of source conditions. Section 13.2.1 of AP-42 currently states that users should use caution when applying the 13.2.1 equation outside of the range of variables and operating conditions specified. In these cases, users are encouraged to consider alternative methods that can better reflect local conditions.

6.5 Estimating Transportation-Related Construction Dust

6.5.1 Determining Whether Construction Dust Must Be Considered

Construction-related $PM_{2.5}$ or PM_{10} emissions associated with a particular project are required to be included in hot-spot analyses only if such emissions are not considered temporary as defined in 40 CFR 93.123(c)(5) (see Section 2.5.5). The following discussion includes guidance only for construction-related dust emissions; any other construction emissions (e.g., exhaust emissions from construction equipment) would need to be calculated separately, as discussed in Section 6.6.

6.5.2 Using AP-42 for Construction Dust

Section 13.2.3 of AP-42 describes how to estimate emissions of dust from construction of transportation projects.[89] Section 13.2.3 of AP-42 indicates that a substantial source of construction-related emissions could be from material that is tracked out from the site and deposited on adjacent paved streets. Therefore, AP-42 states that persons developing construction site emission estimates need to consider the potential for increased adjacent emissions from off-site paved roadways; users should refer to the discussion regarding paved roads in Section 6.3.3.

[89] This section can be downloaded from EPA's website. See website information in Section 6.2.

6.5.3 Using Alternative Approaches for Construction Dust

Some PM nonattainment or maintenance areas have historically used alternative methods for estimating construction dust that may be more appropriate than AP-42, given specific local conditions. Other areas may develop alternatives in the future.

Also, an alternative method may be more appropriate if the project's conditions – such as surface material silt and moisture content percentages, mean vehicle weight and speed – are not within the ranges of source conditions that were tested in developing the equations. In such cases, users may consider alternative methods that are more appropriate for local conditions.

6.6 Estimating Additional Sources of Emissions in the Project Area

6.6.1 Construction-Related Vehicles and Equipment

In certain cases, emissions resulting from construction vehicles and equipment, including exhaust emissions as well as dust, must be included in an analysis; refer to Section 2.5.5 for more information on when to include such emissions. State and local air agencies may have quantified these types of emissions for the development of SIP non-road mobile source inventories, and related methods should be considered for PM hot-spot analyses. Evaluating and choosing models and associated methods and assumptions for quantifying construction-related emissions must be determined through an area's interagency consultation procedures (40 CFR 93.105(c)(1)(i)).

6.6.2 Locomotives

EPA has developed guidance to quantify locomotive emissions when they are a component of a transit or freight terminal or otherwise a source in the project area being modeled. See Appendix I for further general guidance, resources, and examples.

6.6.3 Additional Emission Sources

When applicable, additional sources need to be estimated and included in air quality modeling, as described in Section 8. For example, a port could be the source of additional emissions that would need to be included in air quality modeling. EPA's *Port Emissions Inventory Guidance* provides methodologies on how to develop port-related and goods movement emissions inventories, including emissions of PM.[90] This guidance describes the latest, state-of-the-science methodologies for preparing an emissions inventory in the following mobile source sectors: ocean-going vessels, harbor craft, recreational marine, cargo handling equipment, and rail. Note that while the *Port*

[90] EPA, *Port Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions*, EPA-420-B-20-046, September 2020, available on EPA's website at: https://www.epa.gov/state-and-local-transportation/port-emissions-inventory-guidance.

Emissions Inventory Guidance also includes sections on estimating emissions from onroad vehicles and locomotives, Section 4 of the *PM Hot-Spot Guidance* (this guidance) provides the latest information on estimating PM emissions from onroad vehicles for PM hot-spot analyses, and Appendix I of the *PM Hot-Spot Guidance* provides information for estimating emissions from locomotives for PM hot-spot analyses.

Section 7: Estimating Project-Level PM Concentrations Using AERMOD

7.1 Introduction

This section describes the recommended source characterization, data inputs, and receptor considerations when using AERMOD for PM hot-spot analyses. This guidance is consistent with the conformity rule and requirements for air quality modeling in EPA's *Guideline on Air Quality Models* regulation (Appendix W to 40 CFR Part 51).[91]

The quality of a model's predictions depends on appropriate input data, proper formatting, model setup, quality assurance, and other assumptions. As noted in Section 2, air quality modeling for PM hot-spot analyses must meet the conformity rule's general requirements for such analyses (40 CFR 93.123(c)) and rely on the latest planning assumptions available when the conformity analysis begins (40 CFR 93.110).

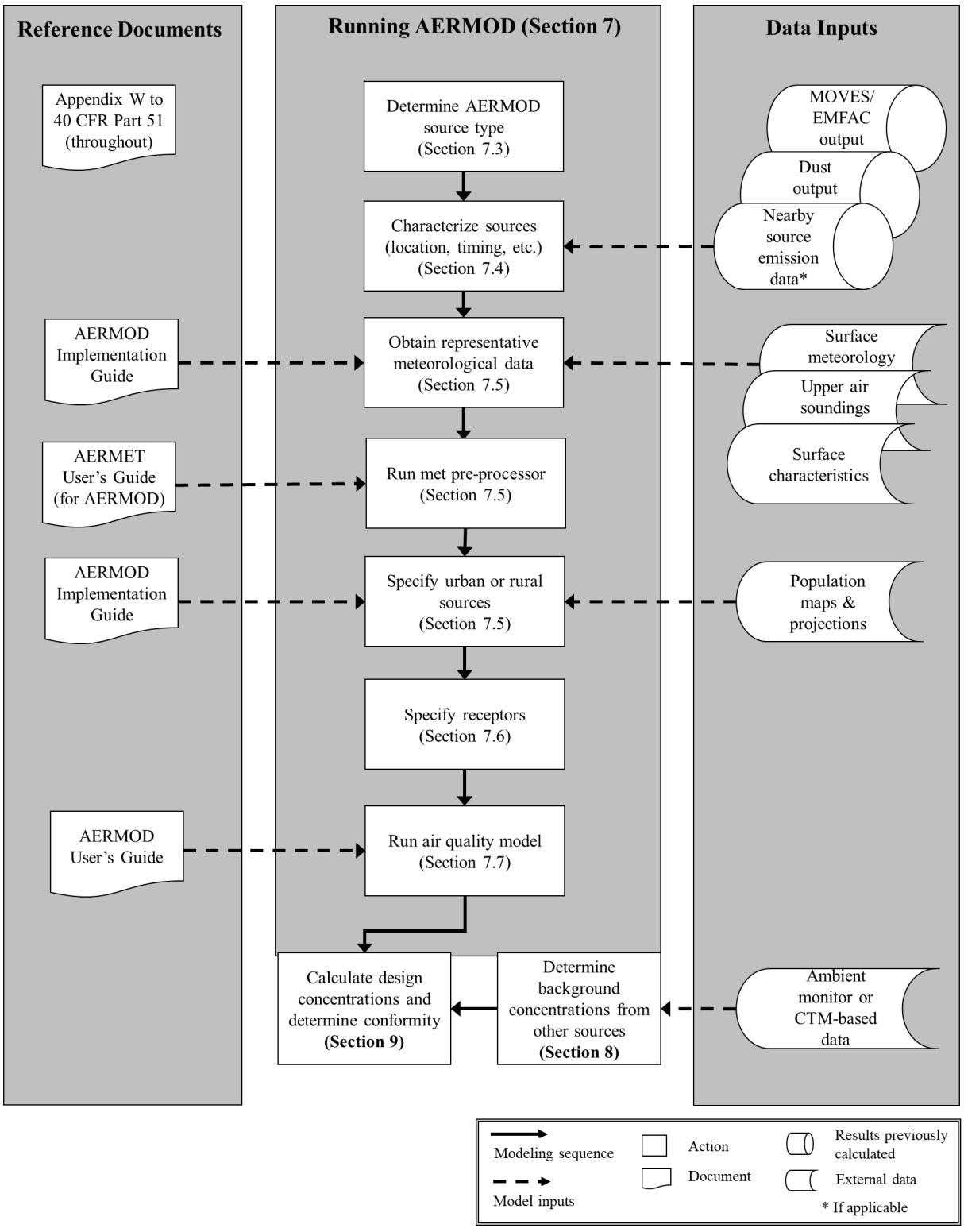
This section presumes that users already have a basic understanding of air quality modeling. EPA has also included additional details on air quality modeling in Appendix J of this guidance. The AERMOD model, AERMOD User's Guide, and other supporting documentation and materials (such as preprocessors and examples) are available through EPA's Support Center for Regulatory Air Models (SCRAM) website at: https://www.epa.gov/scram. Project sponsors conducting PM hot-spot analyses will need to refer to the latest AERMOD User's Guide and other available guidance for complete instructions.[92] EPA's Office of Air Quality Planning and Standards maintains the SCRAM website and maintains and supports AERMOD on an ongoing basis. Modelers should regularly check this website to ensure use of the latest regulatory version. In addition, there is helpful information on EPA's project-level conformity and hot-spot analysis page, including information about air quality modeling: https://www.epa.gov/state-and-local-transportation/project-level-conformity-and-hot-spot-analyses.

7.2 General Overview of Air Quality Modeling

Air quality modeling methods and assumptions need to be determined for each PM hot-spot analysis through the interagency consultation process (40 CFR 93.105(c)(1)(i)). Exhibit 7-1 (following page) outlines the basic process for conducting air quality modeling for a given project. This exhibit depicts the flow of information developed for air quality modeling (as described in this section), the development of background concentration estimates (see Section 8), and the calculation of design concentrations and comparison to the NAAQS (see Section 9).

[91] See footnote 18 (Section 2.4.1) for Appendix W reference information.
[92] For AERMOD-related documentation, see EPA's website at: https://www.epa.gov/scram/air-quality-dispersion-modeling-preferred-and-recommended-models#aermod.

Exhibit 7-1. Overview and Data Flow for Air Quality Modeling with AERMOD



7.3 Using AERMOD

7.3.1 AERMOD Is EPA's Dispersion Model for Transportation Projects

PM hot-spot analyses should be developed consistent with EPA's current recommended model under Appendix W to 40 CFR Part 51.[93]
The American Meteorological Society/EPA Regulatory Model (AERMOD) is EPA's required near-field dispersion model for many regulatory applications. EPA first recommended AERMOD in a November 9, 2005 final rule, *Guideline on Air Quality Models,* that amended EPA's Appendix W regulation after more than ten years of development and peer review that resulted in substantial improvements and enhancements.

In the 2017 update to Appendix W, EPA removed the CALINE3 model from the regulations, making AERMOD the only model for refined modeling for mobile source applications such as PM hot-spot analyses.[94] The three-year transition period set forth in that final rule for the use of CALINE3-based models has now transpired. Therefore, as of January 2020, all PM hot-spot analyses must use AERMOD for air quality modeling (see Appendix W to part 51, Section 4.2.3.5 "Models for $PM_{2.5}$" and Section 4.2.3.6, "Models for PM_{10}").

AERMOD includes options for modeling emissions from line/area, volume, and point sources and can therefore model the impacts of many different source types, including highway and transit projects. AERMOD is used to model air quality near roadways, other transportation sources, and other ground-level sources for regulatory applications by EPA and other federal and state agencies.

7.3.2 How Emissions Are Represented in AERMOD

AERMOD simulates how pollutants disperse in the atmosphere. To do so, the model classifies emission sources within a project as line, area, volume, or point sources:

- Line sources are generally linear emission sources, which can include highways, intersections, and rail lines. A highway "line source" can be modeled using a series of adjacent line/area sources (see the AERMOD User Guide and the AERMOD Implementation Guide for suggestions).[95]
- Volume sources are three-dimensional spaces from which emissions originate (e.g., areas designated for truck or bus queuing or idling that correspond to off-network links in MOVES, driveways and pass-throughs in bus terminals, and locomotive activity at commuter rail or freight rail terminals).[96] A highway "line source" can be modeled using a series of adjacent volume sources.

[93] See footnote 18 (Section 2.4.1) for Appendix W reference information.
[94] Note that while CAL3QHCR can no longer be used for PM hot-spot analyses, CAL3QHC can still be used for CO screening analyses. See 82 *FR* 5190 and 5192, January 17, 2017.
[95] The latest versions of these documents are available on EPA's website; see footnote 92 (Section 7.1).
[96] See Appendix I for information on estimating locomotive emissions.

- Point source emissions emanate from a discrete location in space, such as a bus garage or transit terminal exhaust stack.

Each of these source types may be appropriate for representing different sources in a PM hot-spot analysis. For example, highways may be modeled as a series of adjoining line/area or volume sources in AERMOD. Using another example, an exhaust vent from a bus garage might be best represented as a point source, area source, or volume source, depending on its physical characteristics. Project sponsors should consult with the most recent user guides for air quality models to determine the most appropriate way to represent a particular source within a model. Appendix J includes additional specific information for modeling highway and transit projects.

The latest version of AERMOD now also includes two additional source types to represent line sources: "RLINE" and "RLINEXT" (for RLINE-extended). RLINE is a Beta feature, meaning its use requires alternative model approval (see Section 7.3.3), and RLINEXT is an Alpha feature, meaning it is for research purposes only.[97]

When modeling highway and intersection sources using AERMOD, experience in the field has shown that area sources may be easier to characterize correctly compared to volume sources, and have a shorter run time.[98]

It is helpful for modelers to consider in advance which source type to use for a project in advance of the modeling, since source characterization inputs vary by source type. For example, a modeling protocol can be useful in this process of thinking through the project's elements and the options for how it can best be modeled. Such a protocol can also be useful to get input from other agencies involved in the interagency consultation process (required in the transportation conformity regulation, 40 CFR 93.105 and 93.112), before modeling is begun, ultimately saving time in the process. When project sponsors use a modeling protocol, it does not prohibit a change in modeling approach.

Appendix J includes important additional information about configuring AERMOD when using it to complete PM hot-spot analyses.

7.3.3 Alternate Models

In limited cases, an alternate model for use in a PM hot-spot analysis may be considered. As stated in Section 3.2 of the Appendix W regulation, "Selection of the best techniques for each individual air quality analysis is always encouraged, but the selection should be

[97] For more information, see EPA's *Guidance on New R-LINE Additions to AERMOD 19191 for Refined Transportation Project Analyses*, EPA-420-B-19-042, September 2019, available on EPA's website at https://www.epa.gov/state-and-local-transportation/project-level-conformity-and-hot-spot-analyses#dispersionmodel.

[98] For additional information on issues related to applying volume sources, see EPA's presentation, "PM Hot-spot Modeling: Lessons Learned in the Field": http://www3.epa.gov/otaq/stateresources/transconf/projectlevel-hotspot.htm#training.

done in a consistent manner."[99] This section of the Appendix W regulation sets out objective criteria by which alternate models may be considered.

Analyses of individual projects are not expected to involve the development of new air quality models. However, should a project sponsor seek to employ a new or alternate model for a particular transit or highway project, that model must address the criteria set forth in Section 3.2 of Appendix W. Determining model acceptability in a particular application is an EPA Regional Office responsibility involving consultation with EPA Headquarters, when appropriate.

7.4 Characterizing Emission Sources

Characterizing sources is the way in which the transportation project's features and emissions are represented within an air quality model. In order to determine the concentrations downwind of a particular emission source, an air quality model needs to have a description of the sources, including:

- Physical characteristics and location;
- Emission rates/emission factors; and
- Timing of emissions.

There may be several different emission sources within the project area. Sections 4 and 5 describe how a project can be characterized into different links, which will each have separate emission rates to be used in air quality modeling. Sections 6 and 8.2 outline how nearby source emissions, when present, can be characterized to account for emissions throughout the project area. Properly characterizing all of these distinct sources within the PM hot-spot analysis will help ensure that the locations with the greatest impacts on PM air quality concentrations are identified.

This section describes the major elements needed to characterize a source properly for use in an air quality model.

7.4.1 Physical Characteristics and Location

When modeling an emission source, its physical characteristics and location need to be described using the relevant model's input format, as described in the appropriate user guide. Sources with the same emission rate but with different physical characteristics may have different impacts on predicted concentrations.

Refer to Appendix J of this guidance and to the user guide for AERMOD for specific information about how physical characteristics and location of sources are included in the model.

[99] See footnote 18 (Section 2.4.1) for Appendix W reference information.

In addition, for emissions on or near rooftops, such as those from exhaust stacks on transit or other terminal projects, building downwash can result in higher concentrations on the downwind side of nearby buildings than would otherwise be present.[100] Consult Appendix J for guidance on when to include building downwash for these projects.

7.4.2 Emission Rates/Emission Factors

The magnitude of emissions within a given time period or location is a necessary component of dispersion modeling. For motor vehicles, MOVES-based emission rates are required in all areas other than the state of California, where EMFAC-based emission rates are required, as described in Sections 4 and 5, respectively. For road and construction dust, emission factors from AP-42 or a local method are required, as described in Section 6. For nearby sources, the appropriate emission rates should also be estimated, as described in Sections 6 and 8.2.

AERMOD accepts emission rates in grams/time. When employing line/area sources with AERMOD (e.g., roads or parking lots), emission rates must be specified in grams/second per unit area.

7.4.3 Timing of Emissions

The proper description of emissions across time of year, day of week, and hour of day is critical to the utility of air quality modeling.[101] Sections 4 and 5 describe how to account for different periods of the day in emissions modeling with MOVES and EMFAC. This approach is then applied to air quality modeling to estimate air quality concentrations throughout a day and year.

Section 4 and Appendix J describe how results from MOVES and EMFAC should be prepared for use as inputs in AERMOD.

7.5 Incorporating Meteorological Data

7.5.1 Finding Representative Meteorological Data

One of the key factors in producing credible results in a PM hot-spot analysis is the use of meteorological data that is as representative as possible of the project area. Meteorological data are necessary for running AERMOD because meteorology affects how pollutants will be dispersed in the lower atmosphere. The following paragraphs provide an overview of the meteorological data needed and sources of this data. More detailed information can be found in Appendix J and in the AERMOD user and implementation guides. EPA's SCRAM web site also contains additional information,

[100] Building downwash occurs when air moving over a building mixes to the ground on the downwind side of the building.
[101] The timing of emissions in AERMOD is described in Section 3.3.6 of the AERMOD User Guide.

including additional guidance, archived meteorological data (which may be suitable for some analyses), and links to data sources.

Meteorological data is used by air quality dispersion models to characterize the extent of wind-driven (mechanical) and temperature-driven (convective) mixing in the lower atmosphere throughout the day.[102] For emissions near the ground, as is common in transportation projects, dispersion is driven more by mechanical mixing, but temperature-driven mixing can still have a significant impact on air quality. As a source's plume moves further downwind, temperature-driven mixing becomes increasingly important in determining concentrations.

AERMOD can include variations in emissions (e.g., by season and hour) and multiple years of meteorological data using a single input file and run. See further information in Section 7.5.3.

The following types of information are needed to characterize mechanical and convective mixing:

- Surface meteorological data, from surface meteorological monitors that measure the atmosphere near the ground (typically at a height of 10 meters—see Section 7.5.2);
- Upper air data on the vertical temperature profile of the atmosphere (see Section 7.5.2);
- Data describing surface characteristics, including the surface roughness, albedo, and Bowen ratio (see Section 7.5.4); and
- Population data to account for the "urban heat island effect" (see Section 7.5.5).

Project sponsors may want to first consult with their respective state and local air quality agencies for any representative meteorological data for the project area. In addition, some state and local air agencies may maintain preprocessed meteorological data suitable for use in PM hot-spot analyses. Interagency consultation can be used to determine whether preprocessed meteorological data are available, which could reduce time and resources for PM hot-spot analyses.

To determine appropriate meteorological data inputs for AERMOD, EPA maintains the meteorological processing software called AERMET on the SCRAM website.[103] AERMET produces input data files that AERMOD reads to produce calculations of atmospheric dispersion. The AERMET user guide should be consulted for specific instructions.

The meteorological data used as an input to AERMOD should be selected on the basis of geographic and climatologic representativeness and how well measurements at one site

[102] Mechanical turbulence arises when winds blow across rough surfaces. When wind blows across areas with greater surface roughness (roughness length), more mechanical turbulence and mixing is produced. Temperature-driven mixing is driven by convection (e.g., hot air rising).
[103] These programs and their user guides may be downloaded from the SCRAM website at: https://www.epa.gov/scram/meteorological-processors-and-accessory-programs#aermet.

represent the likely transport and dispersion conditions in the area around the project. The most important attribute for these data is representativeness, although more recent meteorological data are generally preferred over older data. For example, older data from a representative meteorological data site may be better than newer data from a site that is not representative. The representativeness of the data depends on factors such as:

- The proximity of the project area to the meteorological monitoring site;
- The similarity of the project area to the meteorological monitoring site in surface characteristics (particularly surface measurements);
- The time period of data collection;
- Topographic characteristics within and around the project area; and
- Year-to-year variations in weather conditions (hence, a sufficient length of meteorological data should be employed, as discussed in Section 7.5.3 and Appendix J).

The AERMOD Implementation Guide provides up-to-date information and recommendations on how to judge the representativeness of meteorological data.[104] Modelers should consult the most recent version of the AERMOD Implementation Guide for assistance in obtaining and handling meteorological information.

7.5.2 Surface and Upper Air Data

Surface Data

AERMOD needs representative meteorological data from a near-ground surface weather monitoring station ("surface data"). When using National Weather Service (NWS) data to produce meteorological input files for AERMOD, the following surface data measurements are needed:

- Wind vector (speed and direction);
- Ambient temperature; and
- Opaque sky cover (or, in the absence of opaque sky cover, total sky cover).

Station barometric pressure is recommended, but not needed (AERMET includes a default value in the absence of such data).

For details, refer to the AERMET user guide on the SCRAM website.[105]

Upper Air Data

Upper air soundings measure vertical gradients of temperature in the atmosphere, which are used by air quality models to calculate convective mixing heights. AERMOD needs upper air sounding data from a representative measurement site; consult the AERMOD Implementation Guide for specific recommendations.

[104] See footnote 92 (Section 7.1).
[105] See https://www.epa.gov/scram/meteorological-processors-and-accessory-programs#aermet.

Obtaining Surface and Upper Air Meteorological Data

Meteorological data that is most representative of the project area should always be sought. Meteorological data that can be used for air quality modeling are routinely collected by the NWS. Other organizations, such as the Federal Aviation Administration, local universities, military bases, industrial facilities, and state and local air agencies may also collect such data. Project sponsors may also choose to collect site-specific data for use in PM hot-spot analyses, but it is not necessary to do so. If site-specific data are used, it should be obtained in a manner consistent with EPA guidance on the topic.[106]

There are several locations where such data can be obtained. The National Oceanic and Atmospheric Administration's National Climatic Data Center (NCDC) contains many years of archived surface and upper air data (www.ncdc.noaa.gov) from NWS and other sources. In addition, EPA's SCRAM web site contains archived surface and upper air data from several sources, including NWS, as well as internet links to other data sources. Some states can provide processed meteorological data for use in regulatory air quality modeling applications. Other local agencies and institutions may also provide meteorological data, as described above.

7.5.3 Time Duration of Meteorological Data Record

PM hot-spot analyses can be based on either off-site or site-specific meteorological data. When using off-site data, five consecutive years of the most recent representative meteorological data should be used.[107] Meteorological data files that have been preprocessed by the relevant state or local air agency may be used, when appropriate. If meteorological data are collected on the project area prior to analysis, at least one year of site-specific data is needed. Consult Section 8.3.1 of Appendix W for additional explanation.

AERMOD can model either five years of representative off-site meteorological data (e.g., from NWS) or one year of site-specific data in a single run, since the model handles different emissions within a year and multiple years of meteorological data with a single input file. This requires a user to externally join meteorological data files before preprocessing them with AERMET. When using five years of off-site meteorological data, it is recommended that a single, five-year meteorological data set be developed (and run in one AERMOD run) to allow for simpler post-processing and design concentration calculation. See Section 9 for more details.

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[106] See Section 8.3.3 in Appendix W to 40 CFR Part 51 ("Site Specific Data") (see footnote 18 in Section 2.4.1 of this guidance for Appendix W reference information) and the *Meteorological Monitoring Guidance for Regulatory Modeling Applications* (https://www.epa.gov/scram/air-modeling-meteorological-guidance). Other meteorological guidance documents are also available through SCRAM, including procedures for addressing missing data and for quality assuring meteorological measurements.

[107] As noted above, meteorological data are available through the NCDC website. Meteorological data are continuously collected by NWS from sources such as airports. Five years of meteorological data are also routinely used in other dispersion modeling applications.

7.5.4 Considering Surface Characteristics

In addition to surface and upper air meteorological data, three surface characteristics for the site of meteorological monitoring are needed for AERMOD and AERMET:

- The surface roughness length (z_o), which indicates how much the surface features at a given site (e.g., buildings, trees, grass) interrupt a smooth-flowing wind;
- Albedo (r), which is the amount of solar radiation reflected by the surface; and
- Bowen ratio (B_o), which indicates how much heat the ground imparts to the air, instead of evaporating moisture at the surface.

As described above, surface characteristics are also used to assess a meteorological monitor's representativeness.

The AERMOD Implementation Guide should be consulted for the latest information on processing land surface data. More detailed information about each of these characteristics is found in Appendix J.

Sources of data that can be used to determine appropriate surface characteristics include printed topographic and land use/land cover (LULC) maps available from the U. S. Geological Survey (USGS), aerial photos from web-based services, site visits and/or site photographs, and digitized databases of LULC data available from USGS. For specific transportation projects, detailed nearby LULC data may be developed as part of project design and engineering plans. Furthermore, some MPOs have adopted modeling techniques that estimate the land use impacts resulting from individual highway and transit projects.

LULC data may only be available for particular years in the past. As such, planning for modeling should consider how representative these data are for the year when meteorological data were collected, as well as the PM hot-spot analysis year(s).

The National Land Cover Database (NLCD) is a set of satellite-based land cover measurements that are updated periodically.[108] As of the writing of this guidance, the latest version of the NLCD was for 2019. Consult the AERMOD Implementation Guide for recommendations for using NLCD data when processing meteorological data.[109]

In most situations, the project area should be modeled as having flat terrain. However, in some situations a project area may include complex terrain, such that sources and receptors included in the model should be characterized at different heights. See Appendix J for information on handling complex terrain in air quality modeling.

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[108] This database can be accessed at: https://www.mrlc.gov/.

[109] The AERSURFACE model, a non-regulatory component of AERMOD, may also be used to generate information on surface roughness, albedo, and Bowen ratio. The latest version of AERSURFACE may be accessed via SCRAM (https://www.epa.gov/scram/air-quality-dispersion-modeling-related-model-support-programs#aersurface).

7.5.5 Specifying Urban or Rural Sources

In addition to surface characteristics, night-time dispersion in urban areas can be greater than in surrounding rural areas with similar surface characteristics as a result of the "urban heat island effect."[110] After sunset, urban areas cool at slower rates than surrounding rural areas, because buildings in urban areas slow the release of heat. Furthermore, the urban surface cover has greater capacity for storing thermal energy due to the presence of buildings and other urban structures. As a result, the vertical motion of urban air is enhanced through convection, a phenomenon lacking (or reduced) in rural areas. The magnitude of the urban heat island effect is driven by the urban-rural temperature difference that develops at night.

The implications for highway and transit projects are that the same emissions in a rural area will undergo less dispersion than the same source in an urban area, all other factors (e.g., surface characteristics, meteorology) being equal. For the purposes of a hot-spot analysis, then:

- In urban areas, sources should generally be treated as urban.
- In isolated rural nonattainment and maintenance areas (as defined by 40 CFR 93.101), sources should be modeled as rural.
- Near the edge of urban areas, additional considerations apply that should be addressed through the interagency consultation process.[111]

AERMOD can account for the urban/rural differences in dispersion. Modeling sources as urban or rural in AERMOD can have a large impact on predicted concentrations. When sources are modeled as urban in AERMOD, the urban area's population is a necessary input.

For projects near or beyond the edge of an urbanized area, there may be situations where the build and no-build scenarios result in different degrees of urbanization. In these situations, sources in the build scenario might be treated as urban, while in the no-build they are treated as rural. Local data on such cases may not be universally available, although some planning agencies have adopted models that may allow the impacts of projects on population growth to be described. Given the potentially large impact of modeling sources as either urban or rural, all available information on population growth in the greater area around the project should be used when modeling projects near or beyond the edge of an urbanized area.

Consult the latest version of the AERMOD Implementation Guide for additional information, including instructions on what type of population data should be used in making urban/rural determinations. Refer also to Appendix J for additional information on how to handle this data.

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[110] The *Meteorological Processor for Regulatory Models (MPRM) User's Guide*, EPA-454-B-96-002, August 1996, refers to the "urban heat island effect" as "anthropogenic heat flux."

[111] Since the urban heat island is not a localized effect, but regional in character, Section 7.2.3 of Appendix W recommends that all sources within an "urban complex" be modeled as urban. See footnote 18 (Section 2.4.1) for Appendix W reference information.

7.6 Placing Receptors[112]

7.6.1 Overview

Receptors for conformity purposes are locations in the project area where an air quality model estimates future PM concentrations. Section 93.123(c)(1) of the conformity rule requires PM hot-spot analyses to estimate air quality concentrations at "appropriate receptor locations in the area substantially affected by the project." An "appropriate receptor location" is a location that is suitable for comparison to the relevant PM NAAQS, consistent with how the PM NAAQS are established and monitored for air quality planning purposes.[113]

The paragraphs below provide general guidance for placing receptors for all PM NAAQS. Placing receptors should take into account project emissions as well as any modeled nearby sources. Project sponsors should place receptors in the project area for the relevant NAAQS consistent with applicable requirements. Evaluating and choosing the models and associated methods and assumptions for placing receptors must be completed through the process established by each area's interagency consultation procedures (40 CFR 93.105(c)(1)(i)). State and local air quality agencies have significant expertise in air quality planning for the PM NAAQS that may be relevant for PM hot-spot analyses.

7.6.2 General Guidance for Receptors for All PM NAAQS

Section 7.2.2 of Appendix W provides guidance on the selection of critical receptor sites for refined analyses, and recommends that receptor sites be placed in sufficient detail to estimate the highest concentrations and possible violations of a NAAQS.[114] The selection of receptor sites for all PM NAAQS should be determined on a case-by-case basis taking into account project-specific factors that may influence areas of expected high concentrations, such as prevailing wind directions, monitor locations, topography, and other factors. In designing a receptor network (e.g., the entire coverage of receptors for the project area), the emphasis should be placed on resolution and location, not the total number of receptors. Receptors should be placed in areas that are considered ambient air (i.e., where the public generally has access). Examples of areas where receptors should not be placed include a median strip of a highway, a right-of-way on a limited access highway, or an approach to a tunnel.

As described in Appendix W, air quality dispersion models are more reliable for estimating the magnitude of highest concentrations somewhere within a specified area and span of time than in predicting concentrations at a specific place and time.

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[112] Section 7.6 reflects EPA's 2012 PM NAAQS final rule that was published on January 15, 2013 (78 FR 3264).

[113] CAA section 176(c)(1)(B) requires that transportation activities do not cause or contribute to new NAAQS violations, worsen existing NAAQS violations, or delay timely attainment of the NAAQS or interim milestones in the project area.

[114] See footnote 18 (Section 2.4.1) for Appendix W reference information.

Therefore, receptors should be sited at all locations at which high concentrations may occur, rather than simply focusing on the expected worst-case location.

Receptor spacing in the vicinity of the source should be of sufficient resolution to capture the concentration gradients around the locations of maximum modeled concentrations. The majority of emissions from a highway or transit project will occur within several meters of the ground, and concentrations are likely to be greatest in proximity of near-ground sources. While prevailing wind directions may influence where maximum impacts are likely to occur, receptors should also be placed in all directions surrounding a project.

It should not be assumed that the location of maximum concentration will always be located closest to the project itself. Note that interagency consultation should be used to help identify the appropriate receptor locations in the area substantially affected by the project. Some examples where maximum concentrations may not be located closest to the project itself include:

- a highway project that adds additional traffic and creates maximum concentrations along an intersecting arterial that is not being modified by the project;
- a highway project that consists of a new bypass that branches off an existing highway with significant emissions where maximum concentrations may be expected at receptors farther from the project, but closer to the existing highway; and
- a highway project that influences emissions of a nearby source, such as a highway that provides access to a port. Because the highway expansion means that emissions at the port can increase, the maximum concentration could be at the port instead of the highway.

These types of effects should be considered when determining which areas are to be modeled and where receptors should be placed.

Receptors should be sited as near as five meters from a source (e.g., the edge of a traffic lane or a source in a terminal), except possibly with projects involving urban street canyons where receptors may be appropriate within 2-10 meters of a project.[115] If AERMOD is used to create a standardized receptor network (e.g., using AERMOD's Cartesian or polar grid functions), receptors may inadvertently be placed within five meters of a project, and subsequently modeled. Such receptors should not be used when calculating design concentrations in most cases.

Receptors should be placed to capture the impacts of the project and any nearby source that needs to be modeled. Receptor placement should be extended out to a sufficient distance from sources to account for emissions that affect concentrations throughout the

[115] See 40 CFR Part 58, Appendix D, Section 4.7.1(c)(1); Appendix E, Section 6.3(b) and Table E-4. The interagency consultation process should be used to determine when these provisions are relevant for a given analysis.

project area, depending on the spatial extent of the project and the impacts of other modeled sources.

Receptors should be placed with finer spacing (e.g., 25 meters) closer to a near ground source to cover a distance of at least 100 meters from the project. Given the closest set of receptors would usually be five meters from the source, five rows of receptors around the project, covering a distance from five meters away from the project to 105 meters away from the project at 25-meter intervals, would be sufficient for most projects. These rows would not be straight lines, but instead would follow the boundaries of the project area. In these rows, receptors should be placed 25 meters apart. In most cases, placing receptors in five rows around the project as described would ensure that the area of highest concentrations is captured.

However, additional receptors may be needed for some projects. Some examples of when additional receptors will be necessary include those projects where a project area includes one or more nearby sources that need to be included in the modeling, where mobile sources will be modeled at elevations above ground level such that the emissions would have a maximum impact more than 5 m from the edge of the roadway (e.g., an overpass or bridge), or where other structures or barriers such as noise walls are present. Receptors may also be important where there are communities with environmental justice concerns located in the project area. For example, if there are such communities in the project area, receptors in these communities would be important for understanding the project's effects on these residents.

Receptor placement should be extended out to a sufficient distance from sources to account for emissions that affect concentrations throughout the project area, depending on the spatial extent of the project and the impacts of other modeled sources. The area's interagency consultation procedures must be used to determine the models and associated methods and assumptions for a PM hot-spot analysis, including receptor placement. Receptor placement should be discussed in the process established by the area's interagency consultation procedures before the modeling is done. An adequate number and placement of receptors is necessary to identify maximum concentrations in communities in the area substantially affected by the project, including minority, low income, and indigenous populations.

For PM hot-spot analyses of transportation projects, EPA recommends that receptors should be sited to represent concentrations near-ground level, generally at a height of 1.8 meters above grade or less. Receptors should also be placed at multiple heights above ground level if needed to represent concentrations at several heights along multi-story buildings, such as apartment or office buildings.

When completing air quality modeling for build and no-build scenarios, receptors should be placed in the same geographic locations in both scenarios so that direct comparisons can be made between the design concentrations calculated at each receptor. Receptors are first determined based on the build scenario, and then placed in the same locations in the no-build scenario (when this scenario is modeled). See Section 9 for further

information regarding calculating design concentrations in a build/no-build analysis and appropriate receptors.

7.7 Running the Model and Obtaining Results

After preparing all model inputs, AERMOD should be run to predict concentrations. Next, background concentrations need to be determined, as described in Section 8. Finally, the resulting concentrations at receptors should be combined with background concentrations from other sources to calculate design concentrations, as described in Section 9.

For PM_{10}, $PM_{2.5}$ annual NAAQS, and most $PM_{2.5}$ 24-hr NAAQS analyses, AERMOD will produce a single value at each receptor that is appropriate to add directly to a single monitored value. See Sections 8 and 9 for information on this process.

Section 8: Determining Background Concentrations from Nearby and Other Emission Sources

8.1 Introduction

This section describes how to determine background concentrations for PM hot-spot analyses. Section 93.123(c)(1) of the conformity rule states that "estimated pollutant concentrations must be based on the total emissions burden which may result from the implementation of the project, summed together with future background concentrations…." Background concentrations do not include the emissions from the project itself.[116] EPA's Appendix W regulation provides the appropriate framework for defining the elements of background concentrations, as opposed to modeled concentrations from the project. Section 8.3.1 of Appendix W states that "background concentrations are an essential part of the total air quality concentration to be considered in determining source impacts."[117] Thus, background concentrations for PM hot-spot analyses involve:

- Nearby sources: These are individual sources other than the highway or transit project that contribute to ambient concentrations in the project area. Some nearby sources may be included in the air quality modeling for PM hot-spot analyses, while other nearby sources can be reflected in representative background concentrations. In general, nearby sources would be included in air quality modeling when they are not appropriately reflected in the background data or when those sources would be affected by the project; and

- Other sources: This term is intended to capture the background concentrations in the project area that are not from the project or any nearby sources that are modeled.

Further information is provided in Section 8.2 on when to include nearby sources in air quality modeling and in Section 8.3 on how to include the impact of other sources of emissions in a future analysis year. It is important to note that nearby sources may only be present for some PM hot-spot analyses.

Concentrations are expected to vary throughout a PM nonattainment or maintenance area, resulting from differences in emission sources, meteorology, terrain, and other factors. Section 93.123(c)(1) requirements for PM hot-spot analyses are met differently from how these requirements have historically been met for CO hot-spot analyses, due to the fundamental differences between the contributors to PM and CO pollution and the projects that are required to have quantitative PM and CO hot-spot analyses. Additional information is provided in Section 8.3 of this guidance.

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[116] See Sections 4 through 6 for more information on how to estimate project emissions.

[117] Section 8.3.3 of Appendix W recommends for "multi-source areas" that "two components of background should be determined: contributions from nearby sources and contributions from other sources." See footnote 18 (Section 2.4.1 of this guidance) for Appendix W reference information.

Evaluating and choosing the models and associated methods and assumptions for nearby sources and representative background concentrations must be completed through the process established by each area's interagency consultation procedures (40 CFR 93.105(c)(1)(i)).

State and local air quality agencies will have the primary expertise on what emission sources are expected to affect background concentrations, including any nearby sources. The state or local air agency is likely to have an understanding of the project area and knowledge about information needed to characterize background concentrations appropriately, due to experience in developing air quality demonstrations, emission inventories, and siting air quality monitors for a given NAAQS. The EPA Regional Office is also a key resource for discussions regarding the air quality monitoring network, SIP modeling, and other issues.

8.2 Nearby Sources that Require Modeling

Nearby sources are individual sources that contribute PM concentrations to the project area.[118] In general, nearby sources need to be included in air quality modeling when those sources are not appropriately reflected in the background data or would be affected by the project. An example of a project that could affect nearby sources would be a highway project whose primary purpose is to accommodate future growth in freight and goods movement; such a project could affect emissions from related activity at nearby marine ports, rail yards, or intermodal facilities. These types of nearby sources (that is, those affected by the project) need to be included in air quality modeling for the PM hot-spot analysis, as described in Section 7, because their emissions will change between build and no-build scenarios.

EPA anticipates that most PM hot-spot analyses will not involve modeling of nearby sources that are not affected by the project, such as a stationary source, since these types of nearby sources would typically be captured in the representative background concentrations described in Section 8.3.

The following questions can be used by project sponsors, the relevant state or local air agency, the EPA Regional Office, and other members of the interagency consultation process to identify any nearby sources that are affected by the project:

- Are there any nearby sources in the project area? If no, then the remainder of Section 8.2 can be skipped.
- If yes, then:
    - Do these sources emit significant levels of emissions that could affect PM concentrations in the project area?

[118] Section 8.3.3 of Appendix W describes "nearby sources" more generally as: "All sources expected to cause a significant concentration gradient in the vicinity of the source or sources under consideration for emission limit(s) should be explicitly modeled." See footnote 18 (Section 2.4.1 of this guidance) for Appendix W reference information.

- Are emissions from any nearby sources expected to differ between the build and no-build scenarios as a result of the project?

EPA notes that there may be limited cases where nearby sources not affected by the project would also need to be included in the modeling for a PM hot-spot analysis. However, such cases would only occur when these sources are not captured in background concentrations for the project area. See Section 8.3 for further information on the factors used to determine representative background concentrations for these cases.

For example, if a stationary source is located upwind of the project area, representative background concentrations should include concentrations from such a source whenever possible. As stated above, state and local air quality agencies and the EPA Regional Office are key resources in understanding how to characterize nearby sources in PM hot-spot analyses, including those nearby sources not affected by the project.

As discussed in Section 7.3, AERMOD should be used to model the project as well as any nearby sources that need to be included in the PM hot-spot analysis. The air quality modeling for nearby sources that would be affected by the project must include any reasonably expected changes in operation of the nearby source between the build and no-build scenarios when both scenarios are necessary to demonstrate conformity. Refer to Section 7 for more information about using AERMOD, placing receptors, and other information for air quality modeling.

Specific information on emissions from nearby sources should be obtained. The state and local air agency should be consulted on characterizing nearby sources. In addition, emission rates and other parameters of nearby sources should be consistent with any permits approved by the state or local air agency, when applicable. For unpermitted sources, emission information should be consistent with information used by air agencies for developing emission inventories for regulatory purposes. Tables 8.1 and 8.2 of Appendix W describe the information needed to characterize the emissions of nearby sources for air quality models. For the 24-hour $PM_{2.5}$ and PM_{10} NAAQS, it is also important to consider Section 8.3.3 of Appendix W, which states that 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) being modeled." Finally, estimation of nearby source impacts may take into account the effectiveness of anticipated control measures in the SIP if they are already enforceable in the SIP.

8.3 Options for Background Concentrations

PM hot-spot analyses should also include background concentrations from "other sources" as well as any nearby sources that are not included in modeling.[119] There are several options provided below that meet the requirements of Section 93.123(c)(1) of the conformity rule that involve using representative air quality monitoring data. Whatever option is selected, the same background concentrations would be used at every receptor used in the build and no-build scenarios for a PM hot-spot analysis. Additional options for background concentrations can be considered by the EPA Regional Office, OTAQ, and OAQPS. See Section 1.7 for contact information.

8.3.1 Using Ambient Monitoring Data to Estimate Background Concentrations

Ambient monitoring data for PM_{10} and $PM_{2.5}$ provide an important source of information to characterize the contributions from sources that affect the background concentrations in the project area, but are not captured by air quality modeling for the PM hot-spot analysis. Nonattainment and maintenance areas, and areas that surround them, have numerous sites for monitoring $PM_{2.5}$ and PM_{10} concentrations that may be appropriate for estimating background concentrations.[120] Project sponsors, relevant state or local air agencies, and the EPA Regional Office should identify the appropriate PM_{10} and $PM_{2.5}$ monitoring data, along with information on each monitor's site location, purpose, geographic scale, nearby land uses, and sampling frequency. Monitoring data can be obtained from EPA's Air Data web site, which includes an interactive map of air quality monitors as a user-friendly way to identify and visualize where monitoring sites are in operation and to obtain concentration data and descriptions of the site (such as the reported scale of spatial representation).[121]

The evaluation and selection of monitoring data for use in a particular analysis must follow the process defined in each area's interagency consultation procedures. These discussions, as well as any maps or statistical techniques used to analyze background data, should be well-documented and included in the project-level conformity determination.

Project sponsors should not use monitoring data for which EPA has granted data exclusion under the Exceptional Events rule (see 40 CFR 50.14).[122]

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[119] Section 8.3.3 of Appendix W defines "contributions from other sources" as "that portion of the background attributable to all other sources (e.g., natural sources, minor sources and distant major sources)…". See footnote 18 (Section 2.4.1 of this guidance) for Appendix W reference information.

[120] Monitors in adjacent nonattainment, maintenance, and attainment areas should also be evaluated for use in establishing background concentrations, which may be appropriate if the air quality situation at those monitors can be determined to be reasonably similar to the situation in the project area.

[121] Available online at: https://www.epa.gov/outdoor-air-quality-data.

[122] See also EPA's guidance, *Additional Methods, Determinations, and Analyses to Modify Air Quality Data Beyond Exceptional Events*, EPA-457-B-19-002, April 2019, for additional information about when air quality data may be excluded or adjusted.

Using a Single Monitor

Background concentration data should be as representative as possible for the project area examined by the PM hot-spot analysis.[123] In most cases, the simplest approach will be to use data from the monitor closest to and upwind of the project area. However, all of the following factors need to be evaluated when considering monitors for use of their data as representative background concentrations:

- Similar characteristics between the monitor location and project area: Monitors at locations that are similar to the project area should be preferred for this factor, whenever possible. If several monitors are available, preference should be given to the monitor with the most similar characteristics as the project area. Some questions to be considered include:
    - Is the density and mix of emission sources around the monitor location similar to those around the project site?
    - How well does the monitor capture the influence of nearby sources that are not affected by the project?
    - Are there differences in land use or terrain between the two locations that could influence air quality in different ways?
    - Is the monitor probe located at a similar height as the project (e.g., is the project at grade, but the monitor is on top of a high building)?
    - What is the purpose of the monitor and what geographic scale of representation does the monitor have?

- Distance of monitor from the project area: Monitors closer to the project may have concentrations most similar to the project area. If more than one such monitor is available, preference may be given to the closest representative monitor for this factor. There are some cases, however, where consideration of distance alone may mask the influence of other factors that need to also be considered (e.g., a monitor upwind of the project location may be preferred to an even closer monitor located downwind of the project).

- Wind patterns between the monitor and the project area: Monitors that are located in directions that are frequently upwind of a project are more likely to represent a project area's background concentrations than monitors that are frequently downwind.[124] Preference should be given to upwind monitors for this factor, whenever appropriate.

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[123] In particular, there should be interagency consultation prior to using any ambient monitoring data set for $PM_{2.5}$ that does not meet EPA requirements in Appendix N to 40 CFR Part 50 regarding data completeness, and any data set that reflects a sampling schedule that has been erratic or has resulted in more frequent samples in some seasons of a year than others. The guidance in Section 9 of this document assumes that the normal data completeness requirement (75% of scheduled samples in each calendar quarter of each year) has been met and that the monitoring data is evenly distributed across the year. Deviation from these conditions may make the steps given in Section 9 inappropriate.

[124] Constructing a "wind rose" (a graph that depicts the frequency of wind blowing from different directions) can be a useful tool in examining the frequency of wind blowing from different directions.

The factors considered when selecting a particular monitor to represent background concentrations should be documented as part of the PM hot-spot analysis.

Interpolating Between Several Monitors

If, during interagency consultation, agencies conclude that no single ambient monitor is sufficiently representative of the project area, interpolating the data of several monitors surrounding the project area is also an option. The advantage of interpolation is that no single monitor is used exclusively in representing air quality for a project area. There may be projects sited in locations between large emission sources and areas several miles away with relatively low emissions, suggesting a gradient in concentrations across the nonattainment or maintenance area. If there are no monitors within or near the project area, then background concentrations from other sources may be difficult to estimate. Interpolation is an approach that allows estimates of background concentrations for a project to take advantage of monitoring data from multiple monitoring sites. Any planned interpolation methods must be addressed through the interagency consultation process.

There are several approaches to interpolation that can be used. One simple method is weighted averaging, which places greater weight on nearby monitors and uses the inverse distance between the project site and the monitor to weight each monitor. For example, suppose monitors A, B, and C surround an unmonitored location, at distances 5, 10, and 15 miles from the site, respectively, the weighting of data from monitor A:

$$Weight(A) = \frac{1}{5} \Big/ \left(\frac{1}{5} + \frac{1}{10} + \frac{1}{15} \right) = 0.55$$

The weighting for monitor B:

$$Weight(B) = \frac{1}{10} \Big/ \left(\frac{1}{5} + \frac{1}{10} + \frac{1}{15} \right) = 0.27$$

The weighting for monitor C:

$$Weight(C) = \frac{1}{15} \Big/ \left(\frac{1}{5} + \frac{1}{10} + \frac{1}{15} \right) = 0.18$$

If concentrations at A, B, and C are 10.0, 20.0, and 30.0 $\mu g/m^3$, respectively, then the predicted concentration at the unmonitored site is 16.3 $\mu g/m^3$. In most situations, the inverse-distance weighted average will provide a reasonable approximation of background concentrations due to other sources. Another interpolation approach is the

EPA's SCRAM website contains two programs for calculating wind statistics and wind roses, WINDROSE and WRPLOT.

inverse-squared distance weighting that weights monitors based on how close they are to the project (1/distance squared).

Other, more advanced statistical methods to interpolate monitoring data may also be used, but these require significant geostatistical expertise.[125]

8.3.2 Adjusting Air Quality Monitoring Data to Account for Future Changes in Air Quality: Using Chemical Transport Models

Options Using Chemical Transport Models (CTMs)

To account for future emission changes, it may be appropriate in some cases to use future background concentrations that have been calculated based on modeled outputs from a CTM. CTMs are photochemistry models that are routinely used in regulatory analyses, including attainment demonstrations for PM SIPs and EPA regulatory analyses to support national or regional final rules. [126] In these types of analyses, CTM modeling is completed for a base and future year, and then these resulting PM concentrations are used to develop relative response factors (RRFs). These factors are then used to adjust the air quality monitoring data from the base year of the SIP or EPA final rule modeling. The end result will be predicted PM concentrations for monitoring locations for a future year (e.g., the attainment year addressed in the SIP). Note that this method applies in areas that have appropriate photochemical modeling outputs available. In most cases, photochemical modeling is only available to estimate $PM_{2.5}$ concentrations, however, there may be limited cases where PM_{10} information is also available.

Although project sponsors are not expected to operate CTMs, there may be available information from CTM modeling to support PM hot-spot analyses. There are two CTM-based options that may be available for PM hot-spot analyses:

1. Use existing pre-calculated future year PM concentrations from EPA or state or local air quality agency modeling. If available, the future year concentrations at a monitor used in the SIP or EPA rulemaking can be used for a PM hot-spot analysis, if the monitor is representative of the project area. Typically, projected annual average and/or 24-hour average PM design values for a future year will be available for monitoring site locations that are part of such modeling demonstrations.

2. In some cases, site-specific, post-processed concentrations may not be readily available from states or EPA. Depending on the nature of the modeling, it may be possible to obtain CTM outputs that can be used to derive background

[125] EPA's MATS (https://www.epa.gov/scram/photochemical-modeling-tools) and BenMAP (https://www.epa.gov/benmap) models incorporate another interpolation-based approach (Voronoi Neighbor Averaging). Consult those models' documentation for further information.
[126] Examples of commonly employed CTMs are shown on the SCRAM website at: https://www.epa.gov/scram/photochemical-air-quality-modeling.

concentrations.[127] This may be an option if the standard post-processed data includes only a subset of monitoring sites in the domain or a subset of averaging times (e.g., annual average results are available, but not 24-hour average results).

Details on the recommended procedures for projecting $PM_{2.5}$ concentrations using CTMs are contained in EPA's *Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze*.[128] The location where CTM modeling is completed, the location of the project, and determining representative monitors are important considerations in using CTM-based options for PM hot-spot analyses. Evaluating and choosing the models and associated methods and assumptions for using CTM-based options must be determined through interagency consultation (40 CFR 93.105(c)(1)(i)). Consult the appropriate EPA Regional Office to determine if such data are available (see Section 1.7). The EPA Regional Office should consult with OTAQ and OAQPS in applying the above options or considering other options.

Additional Information and Considerations about CTMs

EPA's photochemical modeling guidance recommends using CTM outputs in a relative sense. Therefore the absolute predictions of a CTM in a future analysis year are not used to predict future background concentrations directly. Instead, appropriate future year design values are derived from monitoring data that have been adjusted using the modeled relative change in PM concentrations. RRFs are calculated from the outputs of current (base) year and future year CTM results. These RRFs reflect the relative changes in concentrations between current and future years.[129] An RRF is generally calculated as:

$$RRF = \frac{\text{Concentrations in future year, predicted by CTM}}{\text{Concentrations in base year, predicted by CTM}}$$

Future year concentrations are then calculated by multiplying base year monitoring data by modeled RRFs, as follows:

Base year measured concentration * RRF = Future year concentration

Additionally, when using the CTM-based options, several criteria should be met:

[127] Many CTM applications are post-processed with EPA's MATS program available at: https://www.epa.gov/scram/photochemical-modeling-tools. MATS produces future year annual and quarterly $PM_{2.5}$ outputs for both the annual and 24-hour $PM_{2.5}$ NAAQS. The quarterly concentration information may not be routinely documented.

[128] EPA, *Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze*, EPA-454-R-18-009, 2018, found on EPA's web site at: https://www.epa.gov/sites/production/files/2020-10/documents/o3-pm-rh-modeling_guidance-2018.pdf.

[129] Future year concentrations of $PM_{2.5}$ are calculated based on $PM_{2.5}$ species concentrations that have been projected using RRFs for *individual* $PM_{2.5}$ species.

- The CTM has demonstrated acceptable performance for the project area using standard indicators of model performance.[130]
- The results of CTM runs are appropriate for the project and future analysis year(s) covered by the PM hot-spot analysis (e.g., the CTM modeling includes the project area and the modeling was completed for the analysis year or a year earlier than the analysis year).
- Any future emission reductions for sources within the CTM modeling demonstration are based on enforceable commitments in the SIP and/or are consistent with the conformity rule's latest planning assumptions requirements (40 CFR 93.110).
- EPA or state modeling which includes future emissions reductions from a proposed rule or hypothetical emissions reductions that are not associated with enforceable SIP commitments or state or Federal rules should not be used.
- Any future emission reductions for sources within the CTM modeling demonstration should take effect prior to the year(s) for which the PM hot-spot analysis is conducted.

The PM hot-spot analysis year(s) will often be after a year for which CTM modeling is performed. In this case, the future background concentration for the analysis year should be the same year for which CTM modeling was performed. It is not technically justified to extrapolate background concentrations beyond the year in which data are available for the CTM modeling. For example, if future background concentrations were estimated based on CTM modeling for the year 2020, and the PM hot-spot analysis year is 2030, then the 2020 background estimate could be used for 2030. A project sponsor could not make a further adjustment based on an extrapolation to the year 2030; such an extrapolation would not be based on credible modeling or mathematical practices. Similarly, emissions-based "roll-back" and "roll-forward" techniques for adjusting current air quality monitoring data for future background concentrations are also not technically supported and would not allow projects sponsors to meet Section 93.123(c)(1) requirements.

Note that in some cases, CTM adjusted background predictions for a future year may already incorporate emissions from the project's no-build scenario (e.g., if the monitor used in the SIP modeling demonstration included emissions from the current project area). Adding modeled concentrations for the build scenario to this value would be essentially adding build emissions to the no-build emissions already accounted for in the background. In these cases, an adjustment may be appropriate only <u>when comparing the build scenario to the NAAQS.</u> In such cases, to evaluate predicted concentrations in the build scenario, the difference between modeled concentrations at each receptor in the build and no-build scenarios should be calculated as:

$$\text{Difference}_{\text{receptor i}} = \text{Concentration}_{\text{receptor i build scenario}} - \text{Concentration}_{\text{receptor i no-build scenario}}$$

[130] Details on model performance evaluation and examples of model evaluation statistics may be found in *Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze*, see reference information in footnote 128 above.

The result – the difference between the build and no-build scenarios at each receptor – should be added to background concentrations when calculating design concentrations for the build scenario. Comparing a build scenario to the no-build scenario to demonstrate conformity will not involve any similar adjustments, since the same background concentrations are used in the build and no-build scenarios. Using this approach, only the changes in receptor concentrations affected by emission changes from the project or modeled nearby sources should be used in calculating design concentrations. Evaluating and choosing the models and associated methods and assumptions for using these adjustments must be determined through interagency consultation (40 CFR 93.105(c)(1)(i)).

Section 9: Calculating PM Design Concentrations and Determining Conformity

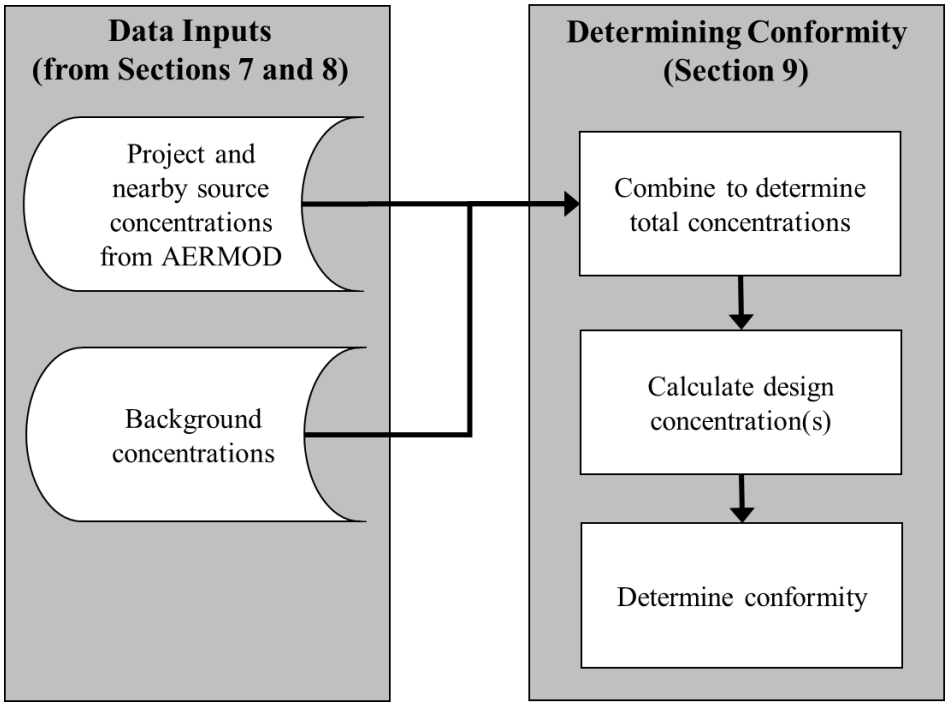
9.1 Introduction

This section describes how to combine all previous steps of a PM hot-spot analysis into a design concentration so that a project sponsor can determine if conformity requirements are met. For conformity purposes, a design concentration is a statistic that describes a future air quality concentration in the project area that can be compared to a particular NAAQS.[131] In general, design concentrations are calculated by combining two pieces of data:

- Modeled PM concentrations from the project and nearby sources (Sections 7 and 8); and
- Monitored background PM concentrations from other sources (Section 8).

Exhibit 9-1 illustrates the conceptual flow of information described in this section, which is similar for all PM NAAQS.

Exhibit 9-1. General Process for Calculating Design Concentrations for PM Hot-Spot Analyses



[131] Design values based on monitoring data are used to determine the air quality status of a given nonattainment or maintenance area (40 CFR Part 50). Design values are also used for SIP modeling and other air quality planning purposes.

This section describes how to calculate the specific statistical form of design concentrations for each PM NAAQS and how to apply design concentrations in build/no-build analyses for conformity purposes. This section also discusses appropriate receptors for the annual $PM_{2.5}$ NAAQS.

This guidance is consistent with how design values are calculated for designations and other air quality planning purposes for each PM NAAQS and with how design concentrations are calculated for stationary sources for NAAQS compliance demonstrations. This guidance is written for current and future $PM_{2.5}$ and PM_{10} NAAQS. EPA will re-evaluate the applicability of this guidance as needed, if different PM NAAQS are promulgated in the future.

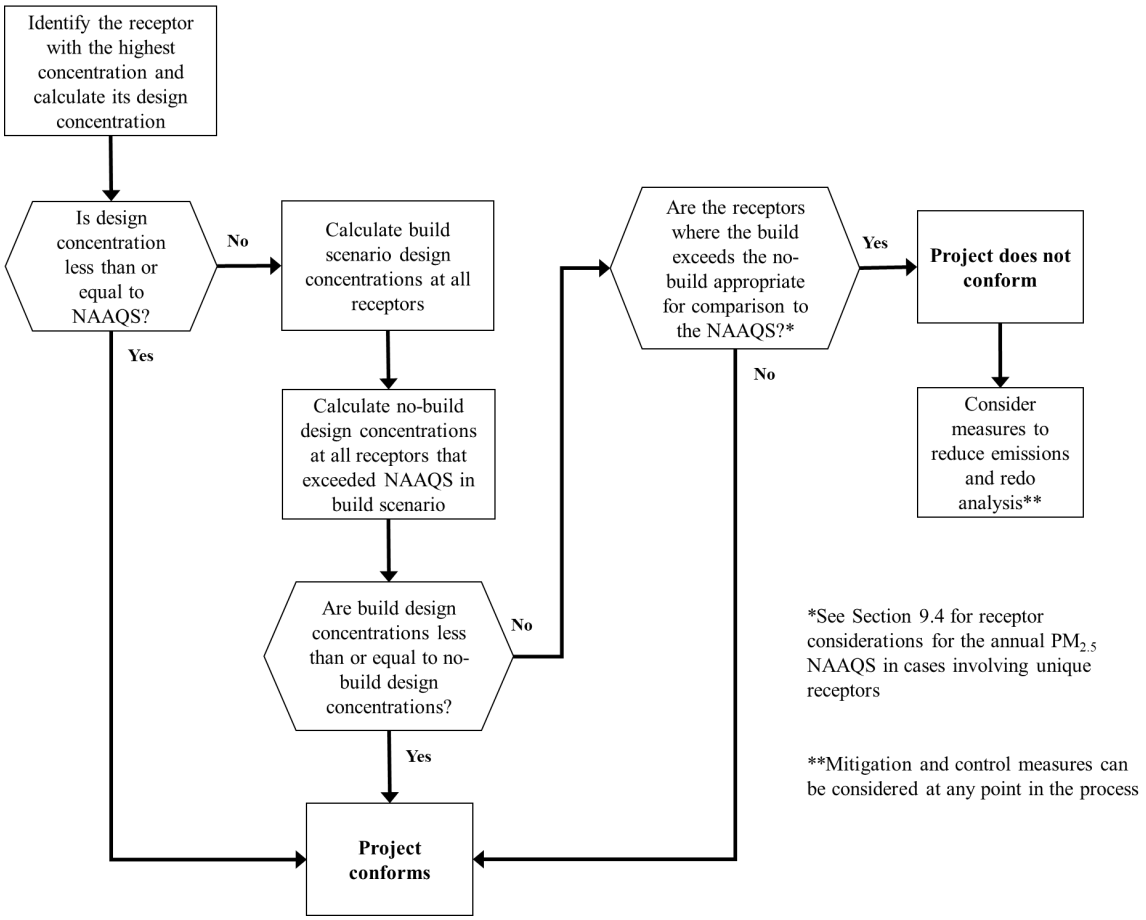
The interagency consultation process must be used to determine the models, methods, and assumptions used for PM hot-spot analyses, including those used in calculating design values and completing build/no-build analyses (40 CFR 93.105(c)(1)(i)). State and local air quality agencies and EPA have significant expertise in air quality planning that may be useful resources for the topics covered by this section. Project sponsors should document the data and other details used for calculating design concentrations for the build and no-build scenarios for a project-level conformity determination, as well as how appropriate receptors were determined in cases involving unique locations as described in Section 9.4.

9.2 Using Design Concentrations in Build/No-Build Analyses

Design concentrations are a fundamental component of PM hot-spot analyses, as they are the values compared to the NAAQS and between build and no-build scenarios. In general, a hot-spot analysis compares air quality concentrations with the proposed project (the build scenario) to air quality concentrations without the project (the no-build scenario). The conformity rule requires that the build scenario not cause or contribute to any new violations of the NAAQS, increase the frequency or severity of existing violations, or delay timely attainment or any required interim emission reductions or other milestones as compared to the no-build scenario (40 CFR 93.116(a) and 93.123(c)(1)).

Exhibit 9-2 (following page) illustrates the build/no-build analysis approach suggested in Section 2.4.

Exhibit 9-2. General Process for Using Design Concentrations in Build/No-build Analyses



In general, project sponsors could begin by determining the design concentration for only one receptor in the build scenario: the receptor with the highest modeled air quality concentration, as described in Section 9.3. If the design concentration for this receptor is less than or equal to the relevant NAAQS, it can be assumed that conformity requirements are met at all receptors in the project area, without further analysis. If this is not the case, the project sponsor could choose to add mitigation or control measures and then determine if the new build scenario concentrations at the receptor with the highest modeled concentrations is less than or equal to the relevant NAAQS. If this is not the case, the project sponsor would calculate the design concentrations at all receptors in the build scenario and also model the no-build scenario. Design concentrations should then be calculated for the no-build scenario at all receptors with design concentrations that exceeded the NAAQS in the build scenario. Conformity requirements are met if the design concentration for every appropriate receptor in the build scenario is less than or equal to the same receptor in the no-build scenario.[132] If not, then the project does not

[132] This would be the receptor at the same geographic location in the build and no-build scenarios.

meet conformity requirements without further mitigation or control measures to address air quality concentrations at such receptors, except in certain cases described below.[133]

A build/no-build analysis is typically based on design concentration comparisons done on a receptor-by-receptor basis. However, there may also be cases where a possible "new" violation at one receptor (in the build scenario) is relocated from a different receptor (in the no-build scenario). It would be necessary to calculate the design concentrations for all receptors in the build and no-build scenarios to determine whether a "new" violation is actually a relocated violation. EPA addressed this issue in the preamble to the November 24, 1993 transportation conformity rule (58 FR 62213), where a "new" violation within the same intersection could be considered a relocated violation. Since 1993, EPA has made this interpretation only in limited cases with CO hot-spot analyses where there is a clear relationship between such changes (e.g., a reduced CO NAAQS violation is relocated from one corner of an intersection to another due to traffic-related changes from an expanded intersection). Any potential relocated violations in PM hot-spot analyses should be determined through the process established by each area's interagency consultation procedures.

When completing air quality modeling for build and no-build scenarios, receptors should be placed in identical locations so that direct comparisons can be made between design concentrations calculated at receptors under each scenario. Also, design concentrations are compared to the relevant NAAQS and between build and no-build scenarios after rounding has been done, which occurs in the final steps of the calculations. That is, conformity requirements would be met at a receptor if the final build design concentration is less than or equal to the final no-build design concentration, even if the pre-rounding build scenario results are greater than the pre-rounding no-build design concentration. Further details on rounding conventions for different PM NAAQS are included in Section 9.3 below.

Section 9.4 provides further information on determining appropriate receptors for the annual $PM_{2.5}$ NAAQS in cases involving unique locations.

[133] Additional mitigation or control measures can be considered at any point in the hot-spot analysis process. When such measures are considered, additional emissions and air quality modeling would need to be completed and new design concentrations calculated to ensure that conformity requirements are met. See 40 CFR 93.123(c)(4) and 93.125 for more information about including mitigation and control measures in a hot-spot analysis.

9.3 Calculating Design Concentrations and Determining Conformity for PM Hot-Spot Analyses

9.3.1 General

As noted above, this conformity guidance is generally consistent with how design values and design concentrations are calculated for air quality monitoring and other EPA regulatory programs.[134]

Further details are included below about how design concentrations should be calculated at receptors for build/no-build analyses, and examples of each design concentration calculation can be found in Appendix K of this guidance. These details and examples are primarily narrative in nature.

EPA recognizes that there may be local phenomena that affect background concentrations and emissions that may call for alternative considerations for determining design concentrations (see Section 8.3 of Appendix W for combining background concentrations with modeling data).[135] More advanced methods of calculating a PM NAAQS design concentration, such as combining modeled and monitored concentrations on a quarterly basis, may be considered on a case-by-case basis by the EPA Regional Office, OTAQ, and OAQPS. Any alternative methods for calculating PM NAAQS design concentrations must be evaluated and chosen through the process established by each area's interagency consultation procedures (40 CFR 93.105(c)(1)(i)).

9.3.2 Annual $PM_{2.5}$ NAAQS

Design Value

The annual $PM_{2.5}$ design value is currently defined as the average of three consecutive years' annual averages, each estimated using equally-weighted quarterly averages.[136] This NAAQS is met when the three-year average concentration is less than or equal to the annual $PM_{2.5}$ NAAQS (the primary standard for this NAAQS is 12.0 $\mu g/m^3$):[137]

Annual $PM_{2.5}$ design value = ([Y1] average + [Y2] average + [Y3] average) ÷ 3

[134] EPA notes that design value calculations for PM hot-spot analyses involve using air quality modeling results based on either one year of site-specific measured meteorological data or five years of off-site measured meteorological data, rather than three years.
[135] See footnote 18 (Section 2.4.1) for Appendix W reference information.
[136] The design value for the annual $PM_{2.5}$ NAAQS is defined for air quality monitoring purposes in 40 CFR Part 50.13.
[137] In December 2012, EPA promulgated a revised annual primary $PM_{2.5}$ NAAQS of 12.0 $\mu g/m^3$. Note that there are still some areas designated nonattainment for the 1997 annual $PM_{2.5}$ NAAQS (15.0 $\mu g/m^3$), which is revoked as areas attain it.

Where:
[Y1] = Average annual $PM_{2.5}$ concentration for the first year of air quality monitoring data
[Y2] = Average annual $PM_{2.5}$ concentration for the second year of air quality monitoring data
[Y3] = Average annual $PM_{2.5}$ concentration for the third year of air quality monitoring data

The annual $PM_{2.5}$ NAAQS is rounded to the nearest tenth of a $\mu g/m^3$. For example, 12.049 rounds to 12.0, and 12.050 rounds to 12.1.[138] These rounding conventions should be followed when calculating design concentrations for this NAAQS.

Necessary Data

This design concentration calculation assumes the project sponsor already has the following data in hand:

- Air quality modeling results: Average annual concentrations from the project and any nearby sources should be calculated from the air quality model output files.[139] The methodology for post-processing the air quality model output files will vary depending on what air quality model is used. Refer to Appendix J for details on preparing air quality model outputs for use in design concentration calculations.
- Air quality monitoring data: 12 quarters of background concentration measurements (four quarters for each of three consecutive years). See Section 8 for more details on determining representative monitored background concentrations that meet all applicable monitoring requirements (such as data completeness).[140]

Calculating Design Concentrations and Determining Conformity

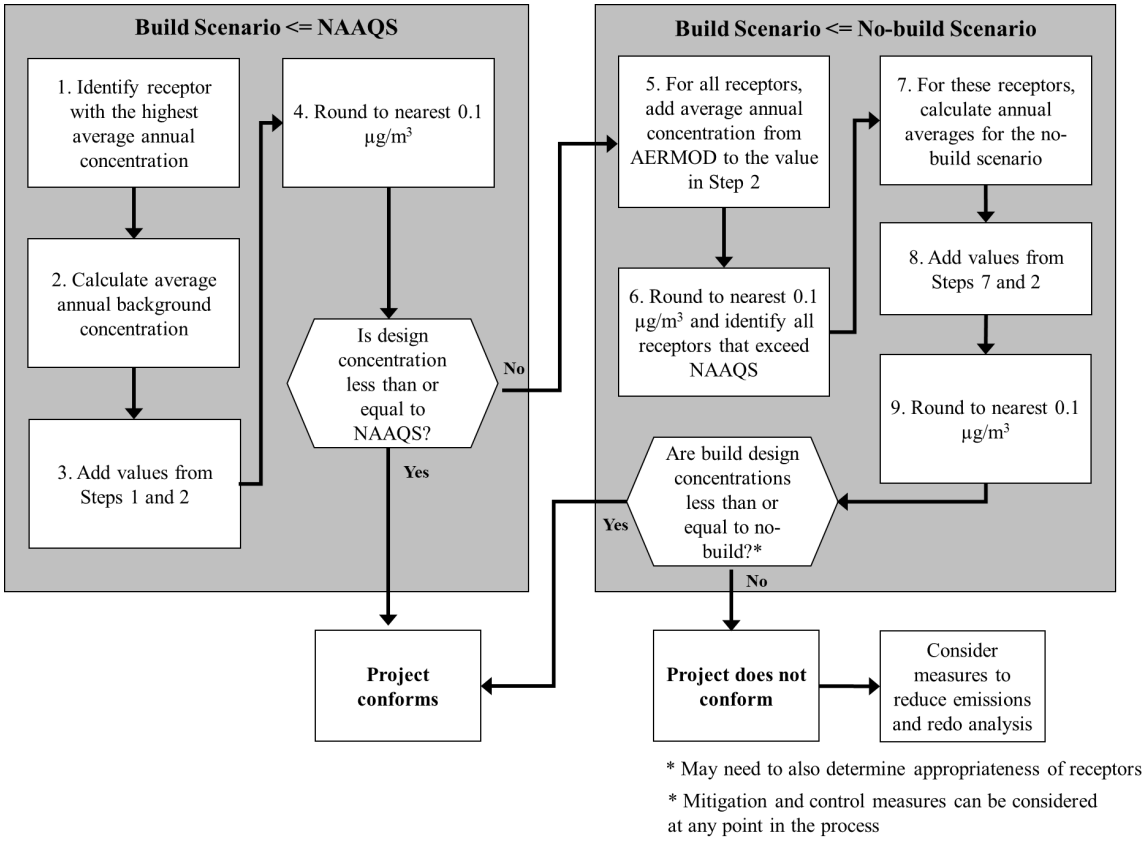
Exhibit 9-3 (following page) illustrates how a design concentration is to be calculated and conformity determined for the annual $PM_{2.5}$ NAAQS. This exhibit assumes that the project sponsor would first compare the receptor with the highest average annual concentration in the build scenario to the NAAQS to determine conformity. If conformity is not met at this receptor, design concentrations would be calculated at all receptors in the build scenario. For any receptors with design concentrations above the NAAQS in the build scenario, the project sponsor would then model the no-build scenario and calculate design concentrations to determine if conformity requirements are met.

[138] A sufficient number of decimal places (3-4) should be retained during intermediate calculations for design values, so that there is no possibility of intermediate rounding or truncation affecting the final result. Rounding to the tenths place should only occur during final design value calculations, pursuant to Appendix N to 40 CFR Part 50.
[139] See Section 7.5.3 for further information on the number of years of meteorological data used in air quality modeling. For most PM hot-spot analyses, five years of meteorological data will be used.
[140] The interagency consultation process should be used when situations require incorporation of any CTM results into design value calculations.

An example of how to calculate design concentrations for the annual $PM_{2.5}$ NAAQS using this procedure is included in Appendix K.

The steps shown in Exhibit 9-3 are described below. The initial step is to compare the build scenario to the NAAQS to see if the project conforms:

Exhibit 9-3. Determining Conformity to the Annual $PM_{2.5}$ NAAQS



- Step 1. Identify the receptor with the highest modeled average annual concentration from the AERMOD output.
- Step 2. Obtain or calculate the average annual background concentration for the most recent three years. One way of accomplishing Step 2 is to use the average annual background concentration already calculated by EPA for the appropriate background monitor.[141] However, if data are to be excluded, this concentration will need to be calculated as follows: For each year of background data, first

[141] See the interactive map at EPA's website, https://www.epa.gov/outdoor-air-quality-data/interactive-map-air-quality-monitors. Using the interactive map, select the layer "PM2.5 Active" and zoom in on the area, and click the monitor on the map. From there, download the monitor report spreadsheet file. The data can be found on the tab labeled, "Table 6a. Site-Level Design Value History for the 2012 Annual PM2.5 NAAQS."

determine the average monitored concentration in each quarter. Then, within each year of background data, add the average concentrations of all four quarters and divide by four to calculate the average annual background concentration for each year of monitoring data. Next, add the average annual concentrations from each of the consecutive years of monitoring data and divide by three. This value is the average annual background concentration based on monitoring data.

- Step 3. Add the average annual background concentration (from Step 2) to the average annual modeled concentration at the highest receptor (from Step 1) to determine the total average annual background concentration at this receptor.
- Step 4. Round to the nearest 0.1 $\mu g/m^3$. This result is the annual $PM_{2.5}$ design concentration at the highest receptor in the build scenario.

The project sponsor should then compare the design concentration from Step 4 to the annual $PM_{2.5}$ NAAQS (currently 12.0 $\mu g/m^3$). If the value is less than or equal to the NAAQS, the project conforms. If the design concentration is greater than the NAAQS, the project sponsor should then continue to Step 5:

- Step 5. For all receptors, add the average annual modeled concentrations from AERMOD to the average annual background concentrations (from Step 2).[142] The result will be the total average annual concentration at each receptor in the build scenario.
- Step 6. Round to the nearest 0.1 $\mu g/m^3$. At each receptor, this value is the annual $PM_{2.5}$ design concentration for the build scenario. Identify all receptors that exceed the annual $PM_{2.5}$ NAAQS.
- Step 7. From the no-build air quality modeling results, calculate the average annual concentrations at each receptor identified in Step 6.
- Step 8. For the no-build scenario, add the average annual modeled concentrations for the no-build scenario (from Step 7) to the average annual background concentrations (from Step 2). The result will be the total average annual concentration for each receptor identified in Step 6 under the no-build scenario.
- Step 9. Round to the nearest 0.1 $\mu g/m^3$. This result is the annual $PM_{2.5}$ design concentration for each receptor identified in Step 6 under the no-build scenario.

For each receptor with a design concentration that exceeded the NAAQS in the build scenario, compare the build design concentration (Step 6) to the no-build design concentration (Step 9). For the project to conform, the build design concentration must be less than or equal to the no-build design concentration at each receptor in the build scenario that exceeded the NAAQS (Step 6). If this is not the case, it may be necessary to determine if any receptors are at unique locations and are not appropriate for conformity purposes (see Section 9.4).[143]

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[142] As discussed in Section 8, the same air quality monitoring concentrations would not be expected to change between the build and no-build scenarios. As a result, the same background concentrations would be used for every receptor in the build and no-build scenario.

[143] Project sponsors could decide to determine if any receptors are at unique locations for this NAAQS at Step 8, for any receptors where a NAAQS violation is predicted to occur. Also, in certain cases, project sponsors can also decide to calculate the design values for all receptors in the build and no-build scenarios

If a build scenario design concentration is greater than the no-build design concentration at any appropriate receptor, the sponsor should then consider additional mitigation and control measures, and revise the PM hot-spot analysis accordingly. Mitigation and control measures could also be considered at any other point in the analysis before the project-level conformity determination is made. Refer to Section 10 for a discussion of potential measures.

9.3.3 24-hour $PM_{2.5}$ NAAQS

Design Value

The 24-hour $PM_{2.5}$ design value is currently defined as the average of three consecutive years' 98th percentile concentrations of 24-hour values for each of those years.[144] The NAAQS is met when that three-year average concentration is less than or equal to the currently applicable 24-hour $PM_{2.5}$ NAAQS for a given area's nonattainment designation (currently 35 $\mu g/m^3$ for nonattainment areas for the 2006 $PM_{2.5}$ NAAQS and 65 $\mu g/m^3$ for nonattainment areas for the 1997 $PM_{2.5}$ NAAQS).[145]

The design value for comparison to any 24-hour $PM_{2.5}$ NAAQS is rounded to the nearest 1 $\mu g/m^3$ (decimals 0.5 and greater are rounded up to the nearest whole number; decimals lower than 0.5 are rounded down to the nearest whole number). For example, 35.499 rounds to 35 $\mu g/m^3$, while 35.500 rounds to 36.[146] These rounding conventions should be followed when calculating design values for this NAAQS.

There are two analysis options, or tiers, that are available to project sponsors to estimate a 24-hour $PM_{2.5}$ design concentration.[147] Project sponsors should begin with the first tier approach as it requires significantly less post-processing than the second tier. However, if through interagency consultation, it is determined that the impacts from the project's $PM_{2.5}$ emissions are highest in one season, and are not temporally correlated with background $PM_{2.5}$ levels that are highest during a different season, combining modeled and monitored contributions through a first tier approach may potentially be overly conservative. In such cases a second tier approach may be used, as described in Appendix L.

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and use the interagency consultation process to determine whether a "new" violation has been relocated (see Section 9.2).

[144] The design value for the 24-hour $PM_{2.5}$ NAAQS is defined for air quality monitoring purposes in 40 CFR Part 50.13.

[145] There are only two areas where conformity currently applies for both the 1997 and 2006 24-hour $PM_{2.5}$ NAAQS. While both 24-hour NAAQS must be considered in these areas, in practice if the more stringent 2006 24-hour $PM_{2.5}$ NAAQS is met, then the 1997 24-hour $PM_{2.5}$ NAAQS is met as well.

[146] A sufficient number of decimal places (3-4) should be retained during intermediate calculations for design values, so that there is no possibility of intermediate rounding or truncation affecting the final result. Rounding should only occur during final design value calculations, pursuant to Appendix N to 40 CFR Part 50.

[147] This approach is consistent with EPA's approach for calculating design values for other EPA regulatory programs. See EPA's *Guidance for PM2.5 Permit Modeling*, EPA 454-B-14-001, 2014, available at https://www.epa.gov/scram/clean-air-act-permit-modeling-guidance.

Under either tier, the contributions from the project, any nearby sources, and background concentrations from other sources are combined for a given analysis year. The first tier approach is described further below.

An example of how to calculate design concentrations for the 24-hour $PM_{2.5}$ NAAQS using a first tier approach is included in Appendix K.

Necessary Data

This design concentration calculation assumes the project sponsor already has the following data in hand:

- Air quality modeling results: For each receptor, the 98th percentile 24-hour concentration in each year, averaged across the five years of meteorological data, from the project and any nearby sources. Refer to Appendix J for a discussion of air quality model output file formats.
- Air quality monitoring data: 12 quarters of background concentration measurements (four quarters for each of three consecutive years). See Section 8 for more details on determining representative monitored background concentrations that meet all applicable monitoring requirements (such as data completeness).[148]

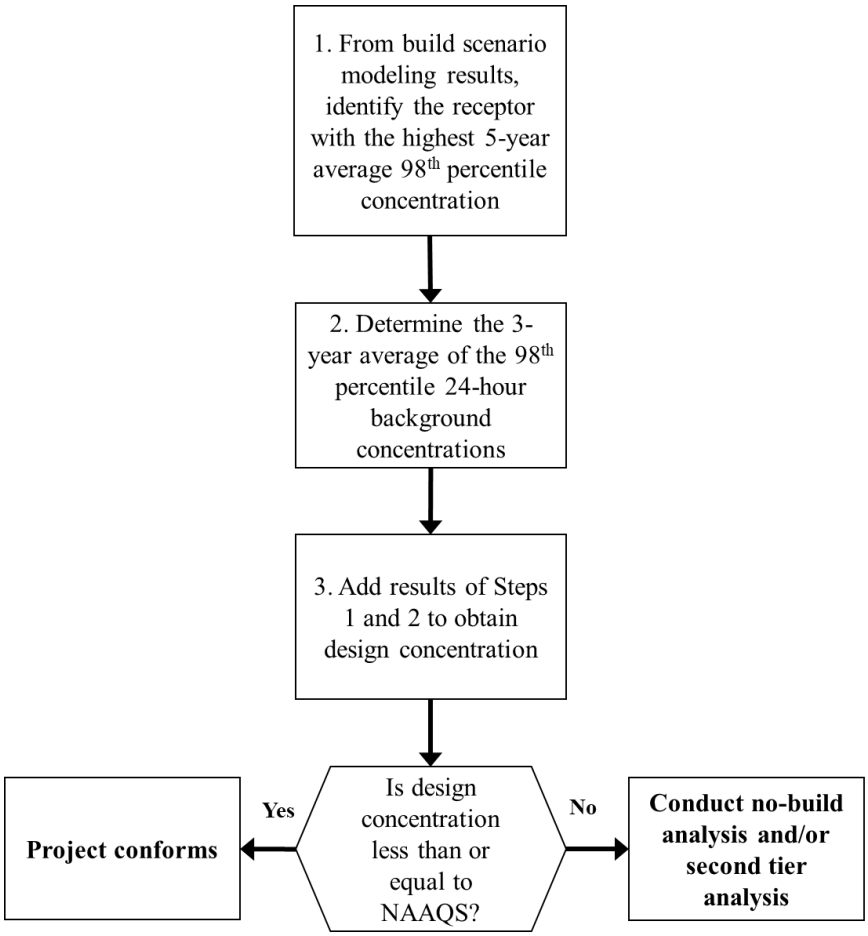
Calculating Design Concentrations and Determining Conformity

The first tier approach consists of directly adding the five-year average 98th percentile modeled 24-hour concentrations to the three-year average 98th percentile 24-hour background concentrations.

Exhibit 9-4 (following page) illustrates how a design concentration would be calculated under a first tier approach for a given receptor. The steps shown in Exhibit 9-4 are described in detail below.

[148] The interagency consultation process should be used when situations require incorporation of any CTM results into design value calculations.

Exhibit 9-4. Determining Conformity to the 24-hour $PM_{2.5}$ NAAQS Using First Tier Approach



The initial step in a first tier approach is to compare the build scenario to the NAAQS to see if the project conforms:

- Step 1. From the air quality modeling results from the build scenario, identify the receptor with the highest average 98th percentile 24-hour concentration. AERMOD reports this directly in the output.

- Step 2. Obtain or calculate the 98th percentile 24-hour background concentration for the most recent three years. One way of accomplishing Step 2 is to use the concentration already calculated by EPA for the appropriate background monitor.[149] However, if data are to be excluded, this concentration will need to be calculated. To calculate the 98th percentile background concentrations for each year of monitoring data, first count the number of 24-hour background

[149] See the interactive map at EPA's website, https://www.epa.gov/outdoor-air-quality-data/interactive-map-air-quality-monitors. Using the interactive map, select the layer "PM2.5 Active" and zoom in on the area, and click the monitor on the map. From there, download the monitor report spreadsheet file. The data can be found on the tab labeled, "Table 5b. Site-Level Design Values for the 2006 24-hour PM2.5 NAAQS."

measurements in each year. Next, order the highest eight monitoring values in each year from highest to lowest and rank each value from 1 (highest) to 8 (eighth highest). Consult Exhibit 9-5 below to determine which of these eight values is the 98th percentile value. Using the results from the three years of monitoring data, calculate the three-year average of the 98th percentile concentrations.

- Step 3. Add the average 98th percentile 24-hour modeled concentration (Step 1) to the average 98th percentile 24-hour background concentration (Step 2) and round to the nearest 1 $\mu g/m^3$. The result is the 24-hour $PM_{2.5}$ design concentration at the highest receptor in the build scenario.

Exhibit 9-5. Ranking of 98th Percentile Background Concentration Values[150]

Number of Background Concentration Values	Rank of Value Corresponding to 98th Percentile Concentration
1-50	1
51-100	2
101-150	3
151-200	4
201-250	5
251-300	6
301-350	7
351-366	8

If the design concentration calculated in Step 3 is less than or equal to the relevant 24-hour $PM_{2.5}$ NAAQS, then the project conforms. If it is greater than the 24-hour $PM_{2.5}$ NAAQS, conformity is not met, and the project sponsor has two options:

- Repeat the first tier approach for the no-build scenario at all receptors that exceeded the NAAQS in the build scenario. If the calculated design concentration for the build scenario is less than or equal to the design concentration for the no-build scenario at all of these receptors, then the project conforms;[151] or
- Conduct a second tier approach as described in Appendix L.

[150] This exhibit is based on a table in Appendix N to 40 CFR Part 50 and ranks the 98th percentile of background concentrations pursuant to the total number of air quality monitoring measurements.

[151] In certain cases, project sponsors can also decide to calculate the design values for all receptors in the build and no-build scenarios and use the interagency consultation process to determine whether a "new" violation has been relocated (see Section 9.2).

9.3.4 24-hour PM_{10} NAAQS

Design Value

Compliance with the 24-hour PM_{10} NAAQS is based on the expected number of 24-hour exceedances of a particular level (currently 150 $\mu g/m^3$), averaged over three consecutive years.[152] Currently, the NAAQS is met when the expected number of exceedances is less than or equal to 1.0.[153]

The 24-hour PM_{10} NAAQS design value is rounded to the nearest 10 $\mu g/m^3$. For example, 155.000 rounds to 160, and 154.999 rounds to 150.[154] These rounding conventions should be followed when calculating design values for this NAAQS.

The contributions from the project, any nearby sources, and background concentrations from other sources are combined for a given analysis year, as described further below. Examples of how to calculate design concentrations for the 24-hour PM_{10} NAAQS are included in Appendix K.

Necessary Data

This design concentration calculation assumes the project sponsor already has the following data in hand:

- Air quality modeling results: In most PM hot-spot analyses, five years of meteorological data will be used to complete air quality modeling for the project and any nearby sources.[155] In this case, the sixth-highest 24-hour modeled concentration should be calculated for each receptor.[156] AERMOD can be configured to produce these values directly. See more details below and refer to Appendix J for a discussion of air quality model output file formats.
- Air quality monitoring data: 12 quarters of background concentration measurements (four quarters for each of three consecutive years). See Section 8 for more details on determining representative monitored background

[152] The 24-hour PM_{10} NAAQS and supporting technical documentation can be found in 40 CFR Part 50.6.
[153] The term "expected" means that the actual number of observed exceedances is adjusted upwards when observations are missing for some days, to reflect the air quality statistically expected for those days. The design value for the 24-hour PM_{10} NAAQS is the next highest observed (monitored or modeled) concentration after the concentrations that could be above 150 $\mu g/m^3$ without causing the expected number of exceedances to be greater than 1.0.
[154] This is the rounding convention at Appendix K to 40 CFR Part 50. A sufficient number of decimal places (3-4) in modeling results should be retained during intermediate calculations for design values, so that there is no possibility of intermediate rounding or truncation affecting the final result. Rounding to the nearest 10 ug/m^3 should only occur during final design value calculations, pursuant to Appendix K. Monitoring values typically are reported with only one decimal place.
[155] Section 7.5.3 of this guidance provides further information on the number of years of meteorological data used in air quality modeling.
[156] See description in Section 7.2.1.1 of Appendix W. Users with one year of site-specific meteorological data should select the 2nd highest 24-hour PM_{10} concentration. If using less than one year of meteorological data (such as one quarter), users should select the highest 24-hour concentration. See footnote 18 (Section 2.4.1 of this guidance) for Appendix W reference information.

concentrations that meet all applicable monitoring requirements (such as data completeness).[157]

Calculating Design Concentrations and Determining Conformity

The 24-hour PM_{10} design concentration is calculated at each receptor by directly adding the sixth-highest modeled 24-hour concentrations (if using five years of meteorological data) to the appropriate monitor value for the 24-hour background concentration from three years of monitoring data, based on Exhibit 9-6.[158]

Exhibit 9-6: Monitor Value Used for Design Concentration Calculation

Number of Background Concentration Values from the Monitor	Monitor Value Used for Design Concentration Calculation
< 347	Highest Monitor Value
348 - 695	Second Highest Value
696 - 1042	Third Highest Value
1043 - 1096	Fourth Highest Value

For example, if the sampling frequency of the monitor was every day and there are 15 days where the monitor did not sample, there would be 1080 background concentration values (3 years x 365 days – 15 = 1080). In this case, the design concentration would be calculated by adding the sixth highest modeled concentration to the fourth highest monitored concentration.

Exhibit 9-7 (following page) illustrates how a design concentration would be calculated. The steps shown in Exhibit 9-7 are described in detail below.

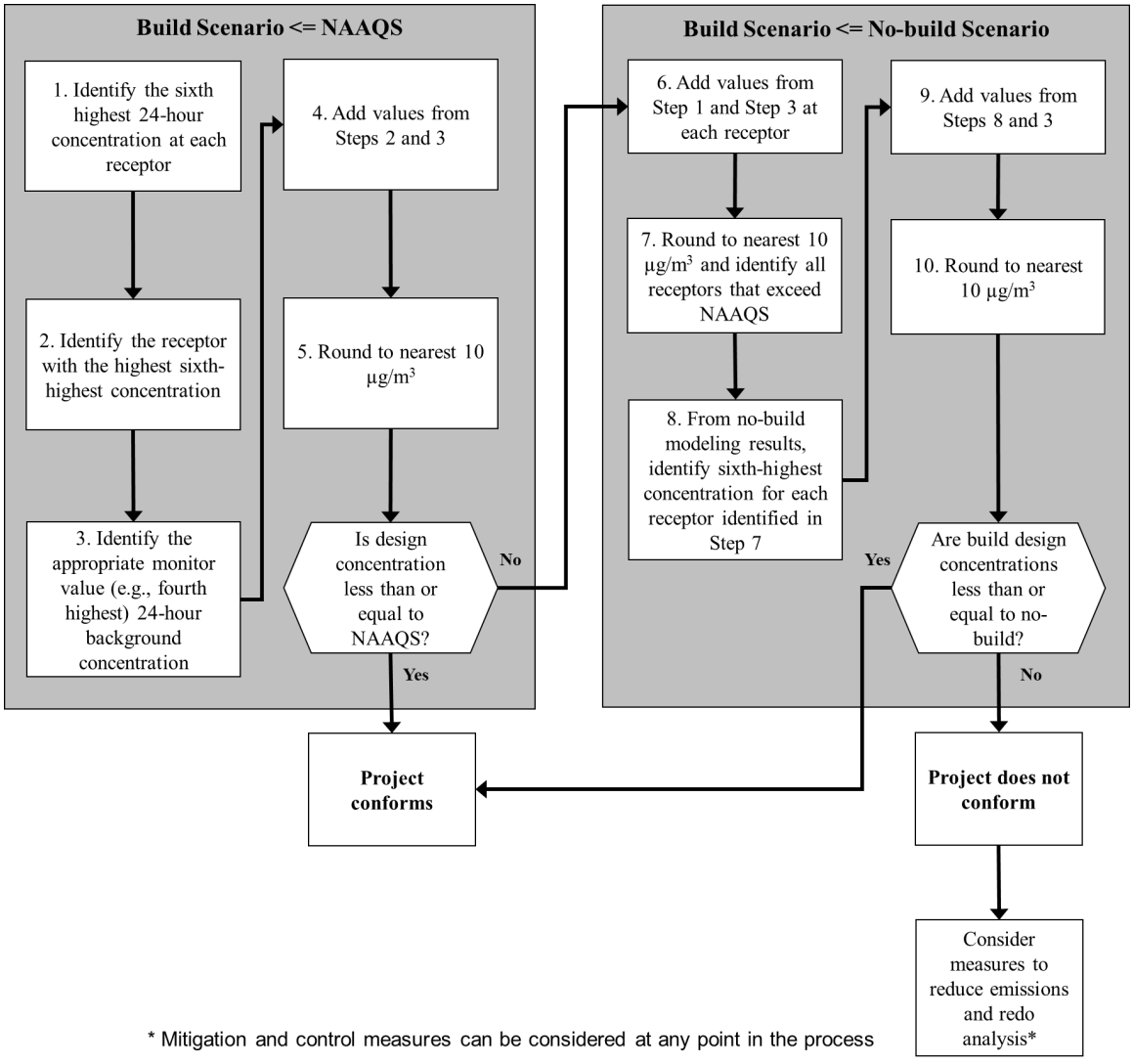
The initial step is to compare the build scenario to the NAAQS to see if the project conforms:

- Step 1. From the air quality modeling results for the build scenario, identify the sixth-highest 24-hour concentration for each receptor (across five years of meteorological data, in most cases). AERMOD can be configured to produce these values.[159]
- Step 2. Identify the receptor with the highest sixth-highest 24-hour concentration. That is, compare the sixth-highest modeled concentrations (i.e., the concentrations at Rank 6) across receptors and identify the receptor with the highest value at Rank 6.

[157] The interagency consultation process should be used when situations require incorporation of any CTM results into design value calculations.
[158] Exhibit 9-6 is adapted from EPA's *PM_{10} SIP Development Guideline*, EPA-450/2-86-001, June 1987, Table 6-1, "Tabular Estimation of PM_{10} Design Concentrations," p. 6-5, and is based on the form of the PM_{10} design value that allows one exceedance per year.
[159] For example, users could employ the RECTABLE keyword in the AERMOD output pathway. See Appendix J to this guidance for further information.

- Step 3. Identify the appropriate 24-hour background concentration from the three most recent years of air quality monitoring data based on Exhibit 9-6.[160]
- Step 4. For the receptor identified in Step 2, add the sixth-highest 24-hour modeled concentration to the appropriate 24-hour background concentration (from Step 3).
- Step 5. Round to the nearest 10 µg/m^3. The result is the highest 24-hour PM_{10} design concentration in the build scenario.

Exhibit 9-7. Determining Conformity to the 24-hour PM_{10} NAAQS



The project sponsor should then compare the design concentration from Step 5 to the 24-hour PM_{10} NAAQS (150 µg/m^3). If the design concentration calculated in Step 5 is less

[160] 24-hour PM_{10} concentrations for any monitoring site reported to EPA's Air Quality System can be obtained by using the data download tools available at: https://www.epa.gov/outdoor-air-quality-data.

than or equal to the NAAQS, the project conforms. If the design concentration is greater than the NAAQS, the project sponsor should then continue to Step 6:

- Step 6. For each receptor in the build scenario, add the sixth-highest 24-hour modeled concentration (from Step 1) to the appropriate 24-hour background concentration from the three most recent years of air quality monitoring data based on Exhibit 9-6 (from Step 3).
- Step 7. Round to the nearest 10 $\mu g/m^3$. At each receptor, this value is the 24-hour PM_{10} design concentration for the build scenario. Identify all receptors that exceed the 24-hour PM_{10} NAAQS.
- Step 8. From the no-build air quality modeling results, identify the sixth-highest 24-hour concentration for each receptor identified in Step 7.
- Step 9. Add the sixth-highest 24-hour modeled concentration in the no-build scenario (from Step 8) to the appropriate 24-hour background concentration from the three most recent years of air quality monitoring data (from Step 3).
- Step 10. Round to the nearest 10 $\mu g/m^3$. The result is the 24-hour PM_{10} design concentration under the no-build scenario for each receptor identified in Step 7.

For each receptor with a design concentration that exceeded the NAAQS in the build scenario, compare the build design concentration (from Step 7) to the no-build design concentration (from Step 10). For the project to conform, the build design concentration must be less than or equal to the no-build design concentration at each receptor in the build scenario that exceeded the NAAQS (Step 7).[161]

If the build scenario design concentration is greater than the no-build design concentration at any appropriate receptor, the project sponsor should then consider additional mitigation and control measures and revise the PM hot-spot analysis accordingly. Mitigation and control measures could also be considered at any other point in the analysis before the project-level conformity determination is made. Refer to Section 10 for a discussion of potential measures.

9.4 Determining Appropriate Receptors for Comparison to the Annual $PM_{2.5}$ NAAQS

Note: Section 9.4 was revised in the 2015 version of this guidance in accordance with EPA's 2012 PM NAAQS final rule that was published on January 15, 2013 (78 FR 3264).[162] It has not been changed in this version.

[161] In certain cases, project sponsors can also decide to calculate the design values for all receptors in the build and no-build scenarios and use the interagency consultation process to determine whether a "new" violation has been relocated (see Section 9.2).

[162] EPA committed to "review whether there is a need to issue new or revised transportation conformity guidance in light of this final rule." (78 FR 3264) EPA fulfilled this commitment by revising this guidance in November 2015, EPA-420-B-15-084. The previous version of Section 9.4 was issued in December 2010, EPA-420-B-10-040.

9.4.1 Overview

When hot-spot analyses are done for the annual $PM_{2.5}$ NAAQS, there is an additional step that may be necessary in certain cases to determine whether a receptor is appropriate to compare to this NAAQS. In the March 2006 final rule, EPA stated that $PM_{2.5}$ hot-spot analyses would be consistent with how the $PM_{2.5}$ NAAQS are developed, monitored, and implemented (71 FR 12471). Receptors cannot be used for $PM_{2.5}$ hot-spot analyses if they are at locations that would not be appropriate for air quality monitoring purposes for the NAAQS. An "appropriate receptor location" under Section 93.123(c)(1) of the conformity rule is a location that is suitable for comparison to the relevant NAAQS, consistent with how the PM NAAQS are established and monitored for air quality planning purposes.[163]

As a result of EPA's 2012 PM NAAQS final rule, in the majority of hot-spot analyses for the annual $PM_{2.5}$ NAAQS, project sponsors will not need to determine whether air quality modeling receptor locations are appropriate for conformity purposes, because all locations will generally be considered appropriate. However, there may be cases in which the analysis area includes receptors that are not representative of area-wide air quality because they are at *unique locations*, pursuant to the PM NAAQS final rule including Section 58.1, Section 58.30(a) and Section 4.7.1 of Appendix D to 40 CFR Part 58. In these cases, further consideration may be needed after air quality modeling is completed to determine whether any of the modeled receptors are not appropriate for comparison to the annual $PM_{2.5}$ NAAQS, as discussed further below. If conformity requirements are met at all receptors, it is unnecessary to determine whether receptors are appropriate for comparison to the annual $PM_{2.5}$ NAAQS; in such a case, project sponsors can conclude that conformity requirements are met at all appropriate receptors.

9.4.2 2012 PM NAAQS Final Rule and Conformity Guidance

The paragraphs below describe the relevant regulatory provisions and guidance for calculating design concentrations and determining conformity for the annual $PM_{2.5}$ NAAQS, through the steps described in Section 9.3.2.

<u>Overview of 2012 PM NAAQS Final Rule</u>

In the 2012 PM NAAQS final rule, EPA revised the form of the annual $PM_{2.5}$ NAAQS to protect the public health of "populations living near important sources of $PM_{2.5}$, including the large populations that live near major roadways." (78 FR 3127)[164] This final rule also included revisions to the $PM_{2.5}$ monitoring regulations which are covered in more detail below.

[163] See CAA Section 176(c)(1)(B). EPA interprets "NAAQS" in this provision to mean the specific NAAQS that has been established through rulemaking.
[164] See 78 FR 3124-7 for more on the form of the annual $PM_{2.5}$ NAAQS.

The annual $PM_{2.5}$ NAAQS is to be monitored at "area-wide" locations, which is defined under 40 CFR 58.1:

> "*Area-wide* means all monitors sited at neighborhood, urban, and regional scales, as well as those monitors sited at either micro- or middle-scale that are representative of many such locations in the same CBSA."[165]

In order to be consistent with the revised annual $PM_{2.5}$ NAAQS, an appropriate receptor for hot-spot analyses for this NAAQS must also represent area-wide air quality. EPA also added a near-road component to the $PM_{2.5}$ monitoring network "to provide characterization of concentrations in near-road environments including for comparison to the NAAQS." (78 FR 3238). In establishing this new requirement, EPA has "made a determination to protect all area-wide locations, including those locations with populations living near major roads that are representative of many such locations throughout an area." (78 FR 3240)

In the final rule, EPA also clarified what monitoring sites are eligible for comparison to the annual $PM_{2.5}$ NAAQS, and what unique locations may not be appropriate for comparison to the annual $PM_{2.5}$ NAAQS. Section 58.30(a) of the monitoring regulations states:

> "$PM_{2.5}$ measurement data from all eligible monitors that are representative of area-wide air quality are comparable to the annual $PM_{2.5}$ NAAQS. Consistent with appendix D to this part, section 4.7.1, when micro- or middle-scale $PM_{2.5}$ monitoring sites collectively identify a larger region of localized high ambient $PM_{2.5}$ concentrations, such sites would be considered representative of an area-wide location and, therefore, eligible for comparison to the annual $PM_{2.5}$ NAAQS. $PM_{2.5}$ measurement data from monitors that are not representative of area-wide air quality but rather of relatively unique micro-scale, or localized hotspot, or unique middle-scale impact sites are not eligible for comparison to the annual $PM_{2.5}$ NAAQS. $PM_{2.5}$ measurement data from these monitors are eligible for comparison to the 24-hour $PM_{2.5}$ NAAQS. For example, if a micro- or middle-scale $PM_{2.5}$ monitoring site is adjacent to a unique dominating local $PM_{2.5}$ source, then the $PM_{2.5}$ measurement data from such a site would only be eligible for comparison to the 24-hour $PM_{2.5}$ NAAQS." [166]

EPA finalized generally what was proposed for Section 58.30(a), recognizing that "there are cases where near-road environments can be considered a unique location...Examples of such locations that are considered unique and should therefore not be considered applicable to the annual $PM_{2.5}$ NAAQS are explained later in section VIII.B.3.b.i." (78 FR 3237) In this part of the preamble, EPA stated:

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[165] This requirement does not have to be satisfied for monitoring the 24-hour $PM_{2.5}$ NAAQS or the 24-hour PM_{10} NAAQS.

[166] See Section 4.7.1(b) and Section 4.7.1(c) of Appendix D to 40 CFR Part 58 for further background on middle and microscale locations.

> "We do recognize, however, the possibility that some near-road monitoring stations may be representative of relatively unique locations versus the more representative area-wide situation mentioned above. This could occur because an air agency made a siting decision based on NO_2 criteria that resulted in the characterization of a microscale environment that is not considered area-wide for $PM_{2.5}$; for example, due to proximity to a unique source like a tunnel entrance, nearby major point source, or other relatively unique microscale hot spot. In these types of scenarios, air agencies would identify the site as a unique monitor comparable only to the 24-hour $PM_{2.5}$ NAAQS per the language in section 58.30…." (78 FR 3241)

See 78 FR 3234-41 of the preamble to the PM NAAQS final rule for further information on the above revisions to the $PM_{2.5}$ monitoring regulations.

Conformity Guidance

Section 9.3.2 includes an approach for conducting build/no-build analyses for the annual $PM_{2.5}$ NAAQS, in which the appropriateness of receptors is determined only in cases where a design concentration in the build scenario is higher than the NAAQS and the design concentration in the no-build scenario. As noted above, if conformity requirements are met at all receptors, it is unnecessary to determine whether receptors are not appropriate for comparison to the annual $PM_{2.5}$ NAAQS; in such a case, project sponsors can conclude that conformity requirements are met at all appropriate receptors. Also as noted above, the majority of hot-spot analyses for the annual $PM_{2.5}$ NAAQS will meet Section 93.123(c)(1) of the conformity rule without specifically determining whether air quality modeling receptor locations are appropriate for conformity purposes, because all locations will generally be considered appropriate under the revised annual $PM_{2.5}$ NAAQS and monitoring regulations. However, for those cases involving unique locations – e.g., a tunnel entrance, a nearby major point source, or other relatively unique microscale hot-spot – further consideration for appropriate receptors would be needed after air quality modeling is completed for the annual $PM_{2.5}$ NAAQS.[167]

Consistent with 40 CFR 58.30(a) of the $PM_{2.5}$ monitoring regulations, the air quality modeling results for the PM hot-spot analysis will provide critical information for determining whether there is a large region of high $PM_{2.5}$ concentrations, especially if high concentrations are predicted in a large number of adjacent receptors. In order to determine if "a larger region of localized high ambient $PM_{2.5}$ concentrations" is present in a given PM hot-spot analysis, it is critical to know which receptors have concentrations above the NAAQS. If a significant number of similar adjacent receptors have high concentrations representing a large portion of the project area, such receptors may represent area-wide air quality, and not represent unique locations. Such an assessment cannot be done qualitatively prior to air quality modeling.

[167] As discussed in Section 7.6, receptors can be placed prior to air quality modeling for all PM NAAQS. Furthermore, the appropriateness of receptor locations for the 24-hour $PM_{2.5}$ NAAQS (and 24-hour PM_{10} NAAQS) can be determined prior to air quality modeling.

Evaluating and choosing the models and associated methods and assumptions, including appropriate receptor locations for the annual $PM_{2.5}$ NAAQS, must be completed through the process established by each area's interagency consultation procedures (40 CFR 93.105(c)(1)(i)). State and local air quality agencies and EPA have significant expertise in air quality planning and monitoring purposes and may be useful resources in determining appropriate receptor locations for the annual $PM_{2.5}$ NAAQS.

9.5 Documenting Conformity Determination Results

Once a PM hot-spot analysis is completed, details need to be documented in the conformity determination. See Section 3.10 for more information on properly documenting a PM hot-spot analysis, including modeling data, assumptions, and results.

Section 10: Mitigation and Control Measures

10.1 Introduction

This section describes mitigation and control measures that could be considered by project sponsors to reduce emissions and any predicted new or worsened PM NAAQS violations. These measures can be applied to the transportation project itself or other PM sources in the project area, and their emissions benefit included in the hot-spot analysis. Written commitments for mitigation or control measures must be obtained from the project sponsor and/or operator, or other emission source's owner and/or operator, as appropriate, prior to making a project-level conformity determination (40 CFR 93.123(c)(4) and 93.125(a)). If measures are selected, additional emissions and air quality modeling will need to be completed and new design concentrations calculated to ensure that conformity requirements are met.

The following information provides more details on potential measures for PM hot-spot analyses; others may be possible. Evaluating and choosing any models and associated methods and assumptions for any measures that are relied upon in the PM hot-spot analysis must be completed through the process established by each area's interagency consultation procedures (40 CFR 93.105(c)(1)(i)). The models, methods, and assumptions used to quantify reductions should be documented in the final project-level conformity determination.

General categories of mitigation and control measures that could be considered include:

- Retrofitting, replacing vehicles/engines, and using cleaner fuels;
- Reducing idling;
- Redesigning the transportation project itself;
- Controlling fugitive dust; and
- Controlling other sources of emissions.

More information is provided for each of these categories below.

10.2 Mitigation and Control Measures by Category

10.2.1 Retrofitting, Replacing Vehicles/Engines, and Using Cleaner Fuels

- The installation of retrofit devices on older, higher emitting vehicles is one way to reduce emissions. Retrofit devices such as Diesel Particulate Filters (DPFs) or Diesel Oxidation Catalysts (DOCs) can be installed on diesel truck or bus fleets, and off-road construction equipment when applicable to lower emissions cost-effectively.[168]

[168] It would be appropriate to replace or retrofit construction equipment in those cases where construction emissions are included in the analysis (i.e., when construction emissions are not considered temporary).

- Replacing older engines with newer, cleaner engines, including engines powered by compressed natural gas (CNG), liquefied natural gas (LNG), biodiesel, or electricity is another way to reduce emissions from existing diesel truck or bus fleets. Many engines can also benefit from being rebuilt, repaired, upgraded to a more recent standard, and properly maintained. The emission reduction calculations should take into account whether retired vehicles or engines are permanently scrapped.

- The accelerated retirement or replacement of older heavy-duty diesel vehicles with cleaner vehicles is another way to reduce emissions. A replacement program could apply to buses, trucks, or construction equipment.[169] In some areas, local regulations to ban older trucks at specific port facilities have encouraged early replacement of vehicles. Such an option would need to be discussed with the local government with implementing authority.

    - For additional information about quantifying the benefits of retrofitting and replacing diesel vehicles and engines for conformity determinations, see EPA's website for the most recent guidance on this topic: https://www.epa.gov/state-and-local-transportation/policy-and-technical-guidance-state-and-local-transportation.

    - Also see EPA's Verified Technologies for SmartWay and Clean Diesel website, which includes information about technologies that save fuel and reduce emissions, including lists of EPA-verified technologies and information about grant and partnership programs: www.epa.gov/verifieddiesel-tech/verified-technologies-list-clean-diesel.

10.2.2 Reduced Idling Programs

- Anti-idling programs for diesel trucks or buses may be relevant for projects where significant numbers of diesel vehicles are congregating for extended periods of time (e.g., restrictions on long duration truck idling, truck stop electrification, or time limits on bus idling at a terminal).

    - A list of EPA-verified anti-idle technologies for trucks can be found at: https://www.epa.gov/verified-diesel-tech/idling-reduction-technologies-irts-trucks-and-school-buses.

[169] The Federal Transit Administration (FTA) has minimum service life requirements for transit vehicles purchased with FTA funds. Any disposition of federally assisted property before the end of its useful life requires prior FTA approval. FTA is entitled to its share of the remaining federal interest. Please refer to Chapter IV of FTA Circular 5010.1E for the establishment and calculation of a vehicle's useful service life. In addition, Appendix E of the circular address the useful life calculation and disposition of vehicles acquired with FTA funds: https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/regulations-and-guidance/fta-circulars/58051/5010-1e-circular-award-management-requirements-7-16-18.pdf.

10.2.3 Transportation Project Design Revisions

- For transit and other terminals, project sponsors could consider redesigning the project to reduce the number of diesel vehicles congregating at any one location. Terminal operators can also take steps to improve gate operations to reduce vehicle idling inside and outside the facility. Fewer diesel vehicles congregating could reduce localized $PM_{2.5}$ or PM_{10} emissions for transit and other terminal projects.

- It may be possible in some cases to route existing or projected traffic away from populated areas to an industrial setting (e.g., truck only lanes). Project sponsors should take into account any changes in travel activity, including additional VMT, that would result from rerouting this traffic. Note that this option may also change the air quality modeling receptors that are examined in the PM hot-spot analysis.

- Finally, project sponsors could consider additional modes for travel and goods movement. An example would be transporting freight by cleaner rail instead of by highway (e.g., putting port freight on electric trains instead of transporting it by truck).

10.2.4 Fugitive Dust Control Programs

Fugitive dust control programs will primarily be applicable in PM_{10} hot-spot analyses, since all PM_{10} nonattainment and maintenance areas must include these emissions in such analyses. However, there may be $PM_{2.5}$ nonattainment and maintenance areas that also could take advantage of these measures if re-entrained road dust or construction dust is required for a $PM_{2.5}$ hot-spot analysis. See Section 2.5 for further background.

- A project sponsor could commit to cover any open trucks used in construction of the project if construction emissions are included in an analysis year. Some states have laws requiring that open truck containers be covered to reduce dispersion of material. Laws may differ in terms of requirements, e.g., some require covering at all times, some require covering in limited circumstances, and some restrict spillage.

- A project sponsor could employ or obtain a commitment from another local agency to implement a street cleaning program. There is a variety of equipment available for this purpose and such programs could include vacuuming or flushing techniques. There have been circumstances where municipalities have implemented street sweeping programs for air quality purposes.

- Another option to reduce dust could be a site-watering program, which may be relevant during the construction phase of a project, if construction emissions are included in the PM hot-spot analysis.

- Project sponsors may consider street and shoulder paving and runoff and erosion control in the project area, which can reduce significant quantities of dust.

- It may also be possible to reduce the use of sand in snow and ice control programs, to apply additional chemical treatments, or to use harder material (that is less likely to grind into finer particles).

10.2.5 Addressing Emissions from Other Sources

Note: Controlling emissions from other sources may sufficiently reduce background concentrations in the PM hot-spot analysis.

- Reducing emissions from ships, cargo handling equipment and other vehicles at ports may change the result of the PM hot-spot analysis. Options such as retrofitting, repowering, or replacing engines or vehicles, use of cleaner fuels, or "cold ironing" (that allows ships to plug in to shore-side power units) could be relevant where these sources significantly influence background concentrations in the project area.

    - See EPA's Ports Initiative website (https://www.epa.gov/ports-initiative) for additional information on potential mobile source strategies for reducing port-related activity from drayage trucks, locomotives, ocean-going vessels, harbor craft, and cargo handling equipment.

    - See also EPA's *Port Emissions Inventory Guidance*, which provides methodologies on how to develop port-related and goods movement emissions inventories, including emissions of PM. This guidance describes the latest, state-of-the-science methodologies for preparing an emissions inventory in the following mobile source sectors: ocean-going vessels, harbor craft, recreational marine, and cargo handling equipment.[170] Note that while the *Port Emissions Inventory Guidance* also includes sections on estimating emissions from onroad vehicles and locomotives, Section 4 of the *PM Hot-Spot Guidance* (this guidance) provides the latest information on estimating PM emissions from onroad vehicles for PM hot-spot analyses, and Appendix I of the *PM Hot-Spot Guidance* provides information for estimating emissions from locomotives for PM hot-spot analyses.

[170] EPA, *Port Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions*, EPA-420-B-20-046, September 2020, available on EPA's website at: https://www.epa.gov/state-and-local-transportation/port-emissions-inventory-guidance.

- Adopting locomotive anti-idling policies or other measures. For additional information, see the following EPA resources:

    - *Guidance for Quantifying and Using Long Duration Switch Yard Locomotive Idling Emission Reductions in State Implementation Plans*, EPA420-B-04-09-037 (October 2009) available at: https://www.epa.gov/state-and-local-transportation/policy-and-technical-guidance-state-and-local-transportation.

    - EPA-verified anti-idle technologies for locomotives can be found at: https://www.epa.gov/verified-diesel-tech/locomotive-technology.

- Remanufacturing existing locomotives to meet more stringent standards at a rate faster than the historical average, or using only Tier 3 and/or Tier 4 locomotives at a proposed terminal (once such locomotives become available).

- Reducing emissions from a stationary source might also change the result of the PM hot-spot analysis. Reductions could come from adding a control technology to a stationary source or adopting policies to reduce peak emissions at such a source. EPA and the state and/or local air quality agency could provide input on the feasibility and implementation of such a measure, as well as any necessary commitments to such measures from operators.

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Appendix A:
Clearinghouse of Websites, Guidance, and Other Technical Resources for PM Hot-Spot Analyses

A.1 Introduction

This appendix is a centralized compilation of documents and websites referenced in the guidance, along with additional technical resources that may be of use when completing quantitative PM hot-spot analyses. Refer to the appropriate sections of the guidance for complete discussions on how to use these resources in the context of completing a quantitative PM hot-spot analysis. The references listed are current as of this writing; readers are reminded to check for the latest versions when using them for a particular PM hot-spot analysis.

A.2 Transportation Conformity and Control Measure Guidance

EPA's transportation conformity guidance can be found online at: https://www.epa.gov/state-and-local-transportation/policy-and-technical-guidance-state-and-local-transportation (unless otherwise noted). See guidance and other information for hot-spot analyses under "Project-Level Conformity," as well as other headings such as "Emission Models and Conformity" and "Quantifying Benefits of Control Measures in SIPs and Conformity." The following specific guidance documents may be useful references when implementing PM hot-spot analyses:

- The most recent version of the MOVES policy guidance, e.g., *Policy Guidance on the Use of MOVES3 for State Implementation Plan Development, Transportation Conformity, General Conformity, and Other Purposes*. This document describes how and when to use the latest version of MOVES for SIP development, conformity determinations, and other purposes.

- The most recent version(s)[1] of the MOVES technical guidance, e.g., *MOVES3 Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity*. This document provides guidance on appropriate input assumptions and sources of data for the use of MOVES in SIP submissions and regional emissions analyses for transportation conformity purposes.

[1] More than one version may be available at the same time because of the new emission model grace period in the conformity regulation at 40 CFR 93.111. During such a grace period, more than one version of a model may be used for conformity.

- *EPA and DOT Joint Guidance for the Use of Latest Planning Assumptions in Transportation Conformity Determinations,* EPA-420-B-08-901, December 2008.

- *Guidance for Developing Transportation Conformity State Implementation Plans,* EPA-420-B-09-001, January 2009.

- *Diesel Retrofit and Replacement Projects: Quantifying and Using Their Emissions Benefits in SIPs and Conformity,* EPA-420-B-18-017, March 2018.

FHWA's transportation conformity site has additional conformity information, including examples of quantitative PM hot-spot analyses. Available at: www.fhwa.dot.gov/environment/air_quality/conformity/practices/.

A.3 MOVES Model Technical Information

MOVES, including the latest version of the model and technical information, can be found at https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves. MOVES3 onroad technical reports can be found at https://www.epa.gov/moves/moves-onroad-technical-reports#moves3, including the following:[2]

- *Overview of EPA's MOtor Vehicle Emissions Simulator (MOVES3),* EPA-4220-R-21-004, March 2021. This report is a high-level overview of MOVES3 that includes references to technical documentation and other MOVES information.

- *Brake and Tire Wear Emissions from Onroad Vehicles in MOVES3,* EPA-420-R-20-014, November 2020.

- *Emission Adjustments for Temperature, Humidity, Air Conditioning, and Inspection and Maintenance for Onroad Vehicles in MOVES3,* November 2020, EPA-420-R-20-013.

- *Exhaust Emission Rates for Heavy-Duty Onroad Vehicles in MOVES3,* November 2020, EPA-420-R-20-018.

- *Exhaust Emission Rates for Light-Duty Onroad Vehicles in MOVES3,* November 2020, EPA-420-R-20-019.

- *Fuel Effects on Exhaust Emissions from Onroad Vehicles in MOVES3,* November 2020, EPA-420-R-20-016.

[2] Note that older model versions and their accompanying documentation can also be found on this EPA website, under the links on the left for "MOVES Limited Use Models" for models that can still be used during the model grace period, and "Previous MOVES versions" for versions no longer in use.

Policy guidance and *Federal Register* announcements related to the MOVES model can be found on the EPA's website at: https://www.epa.gov/state-and-local-transportation/policy-and-technical-guidance-state-and-local-transportation#emission.

Guidance on using the MOVES model at the project level, as well as illustrative examples of using MOVES for quantitative PM hot-spot analyses, can be found in Section 4 of this guidance, in Appendix D of this guidance, and within EPA's Project Level Training for Quantitative PM Hot-Spot Analyses, which can be downloaded from https://www.epa.gov/state-and-local-transportation/project-level-training-quantitative-pm-hot-spot-analyses.

A.4 EMFAC Model Technical Information

EPA approves the EMFAC model for use in California and EPA's most recent *Federal Register* notice approving EMFAC is found at: https://www.epa.gov/state-and-local-transportation/policy-and-technical-guidance-state-and-local-transportation#emission. The approved version of EMFAC, user guides, supporting documentation, and any future versions of the model can be downloaded from the California Air Resources Board (CARB) website at: https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/msei-modeling-tools-emfac-software-and. General guidance on using EMFAC for PM hot-spot analyses can be found in Section 5. Note that additional information for project-level modeling with EMFAC is included in documents titled, "PL Handbook" on CARB's website.

There may be versions of EMFAC available at this website that have not been approved by EPA for use in SIP and transportation conformity purposes. Modelers must use the latest version of the model approved by EPA according to the details of that approval. *Federal Register* announcements related to EPA's approval of the EMFAC model can be found on the EPA's website at: https://www.epa.gov/state-and-local-transportation/policy-and-technical-guidance-state-and-local-transportation#emission. In addition to the link above, see also CARB's EMFAC welcome website at: https://arb.ca.gov/emfac/. This link as well as the CARB EMFAC training website, https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/msei-training-materials, include training videos.

A.5 Dust Emissions Methods and Guidance

Information on calculating emissions from paved roads, unpaved roads, and construction activities can be found in AP-42, Chapter 13 (Miscellaneous Sources). AP-42 is EPA's compilation of data and methods for estimating average emission rates from a variety of activities and sources from various sectors. Refer to EPA's website to access the latest versions of AP-42 sections and for more information about AP-42 in general:

https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors.

Guidance on calculating dust emissions for PM hot-spot analyses can be found in Section 6 of this guidance.

A.6 Locomotive Emissions Guidance

The following guidance documents, unless otherwise noted, can be found on or through the EPA's locomotive emissions website at: https://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-emissions-locomotives:

- *Procedure for Emission Inventory Preparation - Volume IV: Mobile Sources*, Chapter 6. Available online at: https://nepis.epa.gov/Exe/ZyPDF.cgi/P1009ZEK.PDF?Dockey=P1009ZEK.PDF. Note that the emissions factors listed in Volume IV have been superseded by the April 2009 publication listed below for locomotives certified to meet EPA standards.

- *Emission Factors for Locomotives*, EPA-420-F-09-025, April 2009. Available online at: https://nepis.epa.gov/Exe/ZyPDF.cgi/P100500B.PDF?Dockey=P100500B.PDF.

- *Control of Emissions from Idling Locomotives*, EPA-420-F-08-014, March 2008. Available online at: https://www.epa.gov/nscep.

- *Guidance for Quantifying and Using Long Duration Switch Yard Locomotive Idling Emission Reductions in State Implementation Plans*, EPA-420-B-09-037, October 2009. Available online at: https://nepis.epa.gov/Exe/ZyPDF.cgi/P1005MER.PDF?Dockey=P1005MER.PDF .

- EPA-verified anti-idle technologies for locomotives can be found at: https://www.epa.gov/verified-diesel-tech/smartway-verified-list-idling-reduction-technologies-irts-locomotives.

- *Port Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions*, EPA-420-B-20-046, September 2020, available on EPA's website at: https://www.epa.gov/state-and-local-transportation/port-emissions-inventory-guidance. Section 8 of the *Port Emission Inventory Guidance* provides methodologies for preparing an emissions inventory for the rail sector of a port.

Guidance on calculating locomotive emissions for PM hot-spot analyses can be found in Section 6 of this guidance and in Appendix I.

A.7 AERMOD Model Technical Information and User Guides

The latest version of the regulation titled, *Guideline on Air Quality Models* (Appendix W to 40 CFR Part 51, dated 2017 as of this writing) can be found on EPA's website at: https://www.epa.gov/scram/2017-appendix-w-final-rule.

AERMOD and related documentation can be obtained through EPA's Support Center for Regulatory Air Models (SCRAM) web site at: https://www.epa.gov/scram/air-quality-dispersion-modeling-preferred-and-recommended-models. In particular, the following guidance may be useful:

- AERMOD Implementation Guide
- *User's Guide for the AMS/EPA Regulatory Model – AERMOD*, ("AERMOD User's Guide")
- AERMET User Guide

Information on locating and considering air quality monitoring sites can be found in 40 CFR Part 58 (Ambient Air Quality Surveillance), particularly in Appendices D and E to that part.

Guidance on using an air quality model for quantitative PM hot-spot analyses can be found in Sections 7 and 8 of the guidance and in Appendix J. Illustrative examples of using an air quality model for a PM hot-spot analysis can be found within EPA's Project Level Training for Quantitative PM Hot-Spot Analyses, which can be downloaded from https://www.epa.gov/state-and-local-transportation/project-level-training-quantitative-pm-hot-spot-analyses.

A.8 Transportation Data and Modeling Considerations

Below are technical resources on transportation data and modeling which may help implementers determine the quality of their inputs and the sensitivity of various data.

A.8.1 Transportation model improvement

The FHWA Travel Model Improvement Program (TMIP) provides a wide range of services and tools to help planning agencies improve their travel analysis techniques. Available online at: www.fhwa.dot.gov/planning/tmip/.

A.8.2 Project level planning

National Cooperative Highway Research Program (NCHRP) Report 765: *Analytical Travel Forecasting Approaches for Project-Level Planning and Design* describes methods, data sources, and procedures for producing travel forecasts for highway project-level analyses. This report provides an update to NCHRP Report 255: *Highway Traffic Data for Urbanized Area Project Planning and Design*. Available online at: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_765.pdf.

A.8.3 Traffic analysis

Traffic Analysis Toolbox website: http://ops.fhwa.dot.gov/trafficanalysistools/.

Traffic Analysis Toolbox Volume I: Traffic Analysis Tools Primer, Federal Highway Administration, FHWA-HRT-04-038, June 2004. Available online at: http://ops.fhwa.dot.gov/trafficanalysistools/tat_vol1/vol1_primer.pdf.

Highway Capacity Manual, Sixth Edition: A Guide for Multimodal Mobility Analysis, Transportation Research Board, Washington, D.C., 2020. Not available online; purchase information available at: http://www.trb.org/Main/Blurbs/175169.aspx. The most recent version of the manual, and the associated guidebook, should be consulted when completing PM hot-spot analyses. (As of this writing, the 2016 edition is most current.)

The Highway Capacity Manual Application Guidebook, Transportation Research Board, Washington, D.C., 2003. Available online at: http://hcmguide.com/.

Appendix B:
Examples of Projects of Local Air Quality Concern

B.1 Introduction

This appendix gives additional guidance on what types of projects may be projects of local air quality concern requiring a quantitative PM hot-spot analysis under 40 CFR 93.123(b)(1). However, as noted elsewhere in this guidance, PM_{10} nonattainment and maintenance areas with approved conformity SIPs that include PM_{10} hot-spot provisions from previous rulemakings must continue to follow those approved conformity SIP provisions until the SIP is revised; see Appendix C for more information.

B.2 Examples of Projects that Require PM Hot-Spot Analyses

EPA noted in the March 2006 final rule that the examples below are considered to be the most likely projects that would be covered by 40 CFR 93.123(b)(1) and require a $PM_{2.5}$ or PM_{10} hot-spot analysis (71 FR 12491).[1]

Some examples of projects of local air quality concern that would be covered by 40 CFR 93.123(b)(1)(i) and (ii) are:

- A project on a new highway or expressway that serves a significant volume of diesel truck traffic, such as facilities with greater than 125,000 annual average daily traffic (AADT) and 8% or more of such AADT is diesel truck traffic;
- New exit ramps and other highway facility improvements to connect a highway or expressway to a major freight, bus, or intermodal terminal;
- Expansion of an existing highway or other facility that affects a congested intersection (operated at Level-of-Service D, E, or F) that has a significant increase in the number of diesel trucks; and,
- Similar highway projects that involve a significant increase in the number of diesel transit buses and/or diesel trucks.

Some examples of projects of local air quality concern that would be covered by 40 CFR 93.123(b)(1)(iii) and (iv) are:

- A major new bus or intermodal terminal that is considered to be a "regionally significant project" under 40 CFR 93.101[2]; and,

[1] EPA also clarified 93.123(b)(1)(i) in the January 24, 2008 final rule (73 FR 4435-4436).

[2] 40 CFR 93.101 defines a "regionally significant project" as "a transportation project (other than an exempt project) that is on a facility which serves regional transportation needs (such as access to and from the area outside of the region, major activity centers in the region, major planned developments such as new retail malls, sports complexes, etc., or transportation terminals as well as most terminals themselves) and would normally be included in the modeling of a metropolitan area's transportation network, including

- An existing bus or intermodal terminal that has a large vehicle fleet where the number of diesel buses increases by 50% or more, as measured by bus arrivals.

A project of local air quality concern covered under 40 CFR 93.123(b)(1)(v) could be any of the above listed project examples.

B.3 Examples of Projects that Do Not Require PM Hot-Spot Analyses

The March 2006 final rule also provided examples of projects that would not be covered by 40 CFR 93.123(b)(1) and would not require a $PM_{2.5}$ or PM_{10} hot-spot analysis (71 FR 12491).

The following are examples of projects that are not a local air quality concern under 40 CFR 93.123(b)(1)(i) and (ii):

- Any new or expanded highway project that primarily services gasoline vehicle traffic (i.e., does not involve a significant number or increase in the number of diesel vehicles), including such projects involving congested intersections operating at Level-of-Service D, E, or F;
- An intersection channelization project or interchange configuration project that involves either turn lanes or slots, or lanes or movements that are physically separated. These kinds of projects improve freeway operations by smoothing traffic flow and vehicle speeds by improving weave and merge operations, which would not be expected to create or worsen PM NAAQS violations; and,
- Intersection channelization projects, traffic circles or roundabouts, intersection signalization projects at individual intersections, and interchange reconfiguration projects that are designed to improve traffic flow and vehicle speeds, and do not involve any increases in idling and capacity.

Examples of projects that are not a local air quality concern under 40 CFR 93.123(b)(1)(iii) and (iv) would be:

- A new or expanded bus terminal that is serviced by non-diesel vehicles (e.g., compressed natural gas) or hybrid-electric vehicles; and,
- A 50% increase in daily arrivals at a small terminal (e.g., a facility with 10 buses in the peak hour).

EPA expanded on these examples in 2018, based on decisions made in the field about projects in these general categories since the requirement for quantitative PM hot-spot analyses took effect.[3] These examples are repeated here.

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at a minimum all principal arterial highways and all fixed guideway transit facilities that offer an alternative to regional highway travel."

[3] See *PM Hot-spot Analyses: Frequently Asked Questions*, EPA-420-F-18-011, June 2018, available on EPA's website at: https://www.epa.gov/state-and-local-transportation/project-level-conformity-and-hot-spot-analyses#faq.

The following projects typically do not involve "a significant number of diesel vehicles" or "a significant increase in the number of diesel vehicles" as described in 40 CFR 93.123(b)(1), and thus typically would not need a $PM_{2.5}$ or PM_{10} hot-spot analysis:

- New high occupancy vehicle (HOV) lanes and ramp HOV lanes which do not involve a "a significant number of diesel vehicles" or "a significant increase in the number of diesel vehicles" as described in 40 CFR 93.123(b)(1);
- Bus rapid transit projects where the buses are non-diesel, (e.g., CNG buses);
- New transit stations or transit lines with no diesel vehicles; and
- Light rail projects powered by electricity.

In addition to these examples, projects listed in 40 CFR 93.126, "Table 2 – Exempt Projects" are exempt from conformity and as a result, would not need a PM hot-spot analysis. In 2017, based on information from implementation in the field, EPA and Federal Highway Administration (FHWA) determined the following projects belong to categories listed in Table 2, and thus would not need a PM hot-spot analysis:

- Road diets: A road diet is a project where one or more vehicle travel lanes are removed to accommodate a variety of transportation modes.[4] Road diets are done for safety purposes. If a road diet is part of a state's Highway Safety Improvement Program, the road diet is exempt under the Table 2 item, "Highway Safety Improvement Program implementation." If not, a road diet can still be considered exempt under the Table 2 item, "Projects that correct, improve, or eliminate a hazardous location or feature." For more information about road diets, including the "Road Diet Informational Guide," please refer to FHWA's webpage at https://safety.fhwa.dot.gov/road_diets/.

- Auxiliary lanes less than 1 mile in length: An auxiliary lane is defined as the portion of the roadway adjoining the traveled way for speed change, turning, weaving, truck climbing, maneuvering of entering and leaving traffic, and other purposes supplementary to through traffic movement.[5] If an auxiliary lane is less than 1 mile in length, it can be considered exempt under the Table 2 item, "Projects that correct, improve, or eliminate a hazardous location or feature." For more information about auxiliary lanes, please refer to FHWA's webpage at https://ops.fhwa.dot.gov/freewaymgmt/publications/frwy_mgmt_handbook/chapter5.htm#5-4.

- Ramp metering: Ramp metering projects involve installing traffic signals on highway on-ramps to control the frequency at which vehicles enter the flow of traffic, and they are also exempt under the Table 2 item, "Projects that correct,

[4] A typical road diet involves converting an existing four-lane undivided roadway segment to a three-lane segment consisting of two through lanes and a center, two-way left-turn lane. The reclaimed space can be allocated for other uses, such as turn lanes, bus lanes, pedestrian refuge islands, bike lanes, sidewalks, etc.
[5] "A Policy on Geometric Design of Highways and Streets," American Association of State Highway and Transportation Officials, Washington, D.C., 2001. As cited in FHWA's "Freeway Management and Operations Handbook," Chapter 5, found at https://ops.fhwa.dot.gov/freewaymgmt/publications/frwy_mgmt_handbook/chapter5.htm#ref5.

improve, or eliminate a hazardous location or feature." For more information about ramp metering projects, please refer to FHWA's webpage at https://ops.fhwa.dot.gov/publications/fhwahop14020/sec1.htm.

Note that 40 CFR 93.126 states that a project on the list in Table 2 is not exempt if, through interagency consultation procedures, it is determined that the project has potentially adverse emissions impacts. Government agencies should refer to the governing interagency consultation procedures for the process to evaluate whether it should be treated as non-exempt.

Appendix C:
Hot-Spot Requirements for PM_{10} Areas with Pre-2006 Approved Conformity SIPs

C.1 Introduction

This appendix describes what projects require a quantitative PM_{10} hot-spot analysis in those limited cases where a state's approved conformity SIP is based on pre-2006 conformity requirements.[1] The March 10, 2006 final hot-spot rule defined the current federal conformity requirements for what projects require a PM hot-spot analysis (i.e., only certain highway and transit projects that involve significant levels of diesel vehicle traffic or any other project identified in the PM SIP as a local air quality concern).[2] However, there are some PM_{10} nonattainment and maintenance areas where PM_{10} hot-spot analyses are required for different types of projects, as described further below.

This appendix will be relevant for only a limited number of PM_{10} nonattainment and maintenance areas with pre-2006 approved conformity SIPs. This appendix is not relevant for any $PM_{2.5}$ nonattainment or maintenance areas, since the current federal $PM_{2.5}$ hot-spot requirements apply in all such areas. Project sponsors can use the interagency consultation process to verify applicable requirements before beginning a quantitative PM_{10} hot-spot analysis. Agencies in PM_{10} areas can contact their state air agency and/or the EPA Regional Office if there are questions regarding the status of the conformity SIP.

C.2 PM_{10} Areas Where the Pre-2006 Hot-Spot Requirements Apply

Prior to the March 2006 final rule, the federal conformity rule required some type of hot-spot analysis for all non-exempt federally funded or approved projects in PM_{10} nonattainment and maintenance areas. These pre-2006 requirements are in effect for those states with an approved conformity SIP that includes the pre-2006 hot-spot requirements.

In PM_{10} areas with approved conformity SIPs that include the pre-2006 hot-spot requirements, a <u>quantitative</u> PM_{10} hot-spot analysis is required for the following types of projects:

- Projects which are located at sites at which PM_{10} NAAQS violations have been verified by monitoring;

[1] A "conformity SIP" includes a state's specific criteria and procedures for certain aspects of the transportation conformity process (40 CFR 51.390).
[2] See Section 2.2 and Appendix B of this guidance and the preamble of the March 2006 final rule (71 FR 12491-12493).

- Projects which are located at sites which have vehicle and roadway emission and dispersion characteristics that are essentially identical to those of sites with verified violations (including sites near one at which a violation has been monitored); and
- New or expanded bus and rail terminals and transfer points which increase the number of diesel vehicles congregating at a single location.

In addition, a qualitative PM_{10} hot-spot analysis is required in the pre-2006 hot-spot requirements for all other non-exempt federally funded or approved projects. For such analyses, consult the 2006 EPA-FHWA qualitative hot-spot guidance.[3]

These pre-2006 hot-spot requirements continue to apply in PM_{10} areas with approved conformity SIPs that include them until the state acts to change the conformity SIP. The conformity rule at 40 CFR 51.390 states that conformity requirements in approved conformity SIPs "remain enforceable until the state submits a revision to its [conformity SIP] to specifically remove them and that revision is approved by EPA."

C.3 Revising a Conformity SIP

EPA strongly encourages affected states to revise pre-2006 provisions and take advantage of the streamlining flexibilities provided by the Clean Air Act.[4] EPA's January 2008 final conformity rule significantly streamlined the requirements for conformity SIPs in 40 CFR 51.390.[5] As a result, conformity SIPs are now required to include only three provisions (consultation procedures and procedures regarding written commitments) rather than all of the provisions of the federal conformity rule.

EPA recommends that states with pre-2006 PM_{10} hot-spot requirements in their conformity SIPs act to revise them to reduce the number of projects where a hot-spot analysis is required. In affected PM_{10} areas, the current conformity rule's PM_{10} hot-spot requirements at 40 CFR 93.123(b)(1) and (2) will be effective only when a state either:

- Withdraws the existing provisions from its approved conformity SIP and EPA approves this SIP revision, or
- Revises its approved conformity SIP consistent with the requirements found at 40 CFR 93.123(b) and EPA approves this SIP revision.

Affected states should contact their EPA Regional Office to proceed with one of these two options. For more information about conformity SIPs, see EPA's *Guidance for*

[3] "Transportation Conformity Guidance for Qualitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Nonattainment and Maintenance Areas," EPA420-B-06-902, March 2006. This guidance can be found at EPA's National Service Center for Environmental Publications (NSCEP) at https://nepis.epa.gov/ by searching using the document number "420b06902".

[4] The 2005 Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) amended the Clean Air Act's requirements for conformity SIPs.

[5] "Transportation Conformity Rule Amendments to Implement Provisions Contained in the 2005 Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU); Final Rule," 73 FR 4420.

Developing Transportation Conformity State Implementation Plans (SIPs), EPA-420-B-09-001, January 2009; available online at: https://www.epa.gov/state-and-local-transportation/policy-and-technical-guidance-state-and-local-transportation#state.

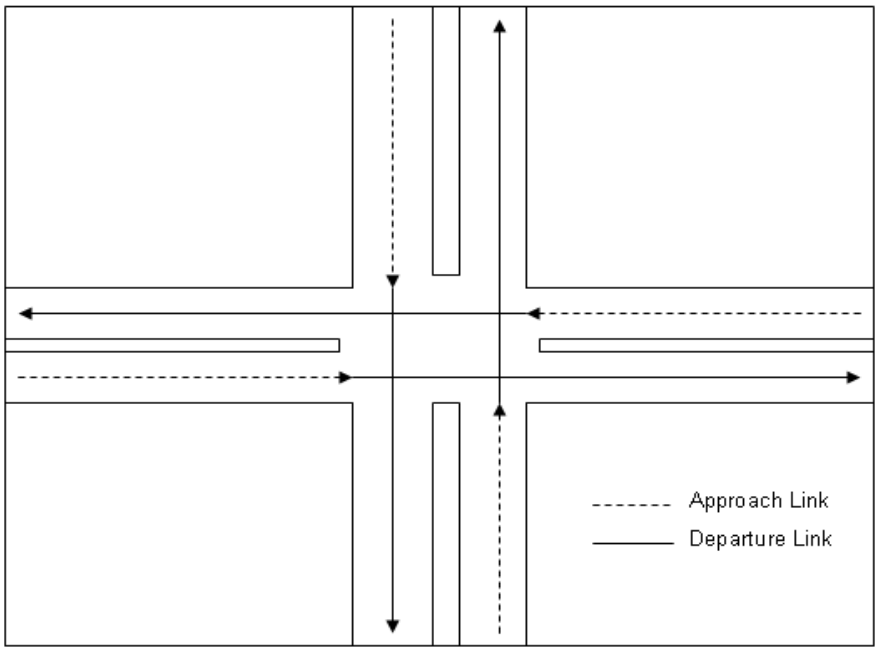
Appendix D:
Characterizing Intersection Projects for MOVES

D.1 Introduction

This appendix expands upon the discussion in Section 4.2 on how to characterize links when modeling an intersection project using MOVES. The MOVES emissions model allows users to represent intersection traffic activity with a higher degree of sophistication compared to previous models. This appendix provides several options to describe vehicle activity to take advantage of the capabilities MOVES offers to complete more accurate PM hot-spot analyses of intersection projects. MOVES is the latest emissions model for PM hot-spot analyses in areas outside of California.

Exhibit D-1 is an example of a simple signalized intersection showing the intersection divided into areas of approach and departure. The dotted arrows represent where vehicles approach the signal, and the solid arrows represent where vehicles depart from the signal.

Exhibit D-1. Example of a Simple Intersection



When modeling an intersection, each area of approach and departure can be modeled as one or more links in MOVES depending on the option chosen to enter traffic activity. This guidance suggests three possible options for characterizing activity:

- Option 1: Using average speeds
- Option 2: Using link drive schedules
- Option 3: Using Op-Mode distributions

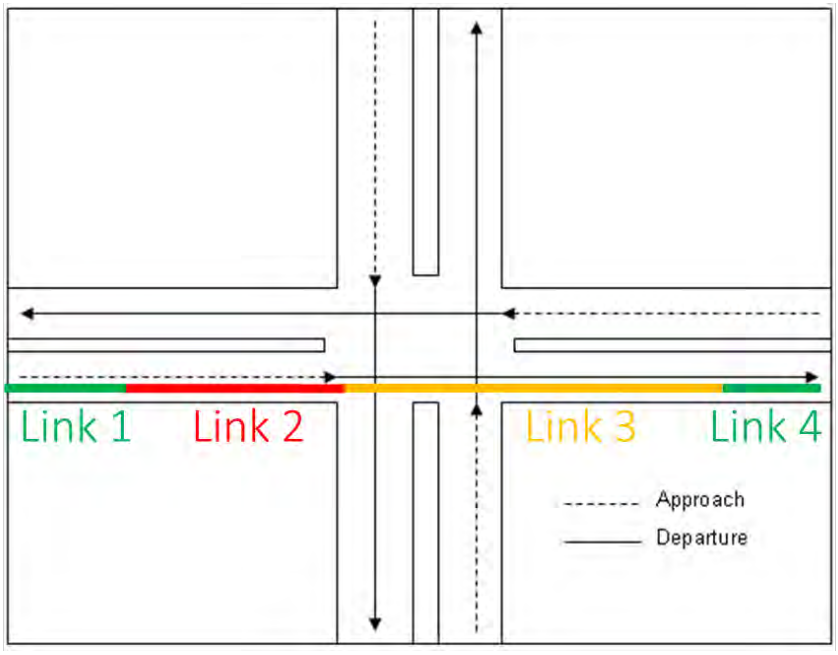
While Option 1 may need to be relied upon more during the initial transition to using MOVES, as more detailed data are available to describe vehicle activity, users are encouraged to consider using the Options 2 and 3 to take full advantage of the capabilities of MOVES.

Once a decision has been made on how to characterize links, users should continue to develop the remaining MOVES inputs as discussed in Section 4 of the guidance.

D.2 Option 1: Using Average Speeds

The first option is for the user to estimate the average speeds for each link in the intersection based on travel time and distance. Travel time should account for the total delay attributable to traffic signal operation, including the portion of travel when the light is green and the portion of travel when the light is red. The effect of a traffic signal cycle on travel time includes deceleration delay, move-up time in a queue, stopped delay, and acceleration delay. Using the intersection example given in Exhibit D-1, one example is to model each direction as a series of links that represent different areas of activity. Each of these links could have a unique average speed based on all the activity occuring on that link.

Exhibit D-2. Example Links at a Simple Intersection



In this example:

- Link 1 represents a "cruise" link where activity is not affected by the traffic signal.
- Link 2 represents a "queue" link that reflects the higher emissions associated with vehicle idling through lower speeds affected by stopped delay. Activity on this link includes deceleration, idle, and acceleration when the signal is red; and cruise activity when the signal is green.
- Link 3 represents an "acceleration" link that reflects the higher emissions associated with vehicle acceleration through lower speeds affected by acceleration delay when the signal is red; and cruise activity when the signal is green.
- Link 4, like Link 1, represents a cruise link where activity is not affected by the traffic signal. Cruise links further away from intersections would not have any delay from the traffic signal.

Project sponsors can determine congested speeds by using appropriate methods based on best practices for highway analyses. Some resources are available through FHWA's Travel Model Improvement Program (TMIP).[1] Methodologies for computing intersection control delay are provided in the Highway Capacity Manual.[2] All assumptions, methods, and data underlying the estimation of average speeds and delay should be documented as part of the PM hot-spot analysis.

Project sponsors will also need to determine the length of each link, which is influenced by the traffic signal's impact on the length of the queueing vehicles, the deceleration rate of vehicles, and the acceleration rate of vehicles.

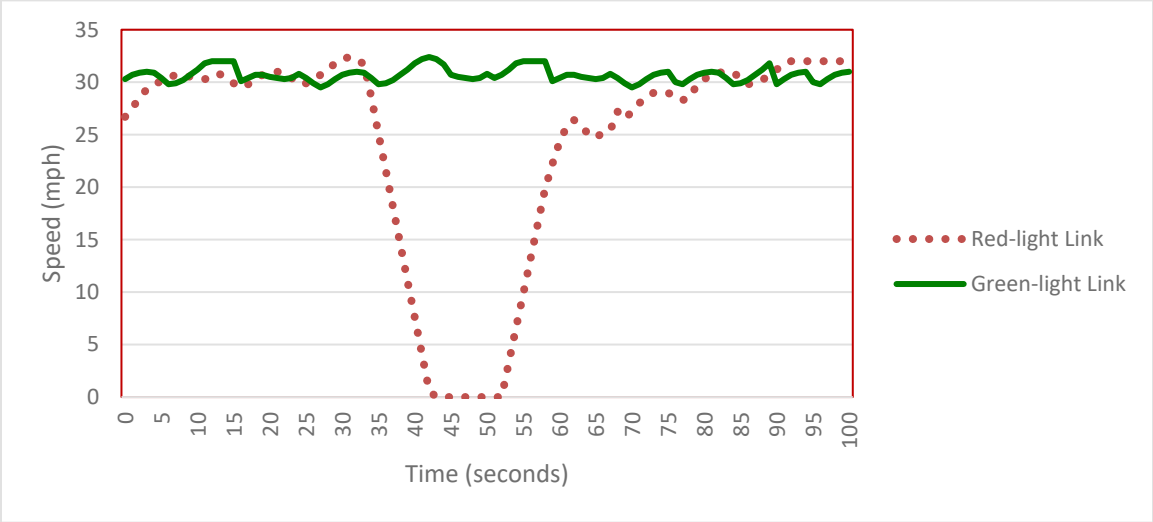
D.3 Option 2: Using Link Drive Schedules

A more refined approach is to enter vehicle activity into MOVES as one or more link drive schedules to represent cruise, deceleration, idle, and acceleration activity of a congested intersection. A link drive schedule defines a speed trajectory to represent the entire vehicle fleet via second-by-second changes in speed and highway grade. Unique link drive schedules can be defined to describe types of vehicle activity that have distinct emission rates, including cruise, deceleration, idle, and acceleration. By defining a link drive schedule, all of these activity types can be included in the link.

Exhibit D-2 illustrates why using this more refined approach can result in a more detailed emissions analysis. This exhibit shows the trajectories of two vehicles approaching and progressing through an intersection: one vehicle that stops because of the red phase of a traffic light cycle (the red-light link, shown as the red dotted line), and a second vehicle that does not stop because the light is green (the green-light link, shown as the solid green line).

[1] See FHWA's TMIP website: https://www.fhwa.dot.gov/planning/tmip/.
[2] Users should consult the most recent version of the Highway Capacity Manual. See Appendix A8.

Exhibit D-3. Example Link Drive Schedules for Links Representing a Signalized Intersection



For the example intersection in Exhibit D-1, two links could be used to represent each direction of travel. If the vehicle mix and drive schedules are the same for each direction of travel, then two links could be used for all directions (with a total volume representing all four directions of travel). If the streets have different speed limits, or have different percentages of trucks, then two links would be needed for each direction.[3]

The two links would have distinct drive schedules that represent either the vehicles encountering the red light or vehicles encountering the green light, as shown in Exhibit D-3:

- Red-light link: The red-light link is characterized by several distinct phases: a steady cruise speed, decelerating to a stop for the red light, idling during the red signal phase, and accelerating when the light turns green. Each vehicle approaching the intersection when the light is red (or yellow) would have a similar speed trace except for the duration of idle time, which would vary depending on whether the vehicle was stopped at the beginning, middle, or end of the red light phase. Therefore, the red-light link drive schedule can be input with the average idle time of vehicles that stop at that signal.
- Green-light link: In contrast, vehicles progressing through an intersection during the green signal phase of a traffic light cycle can be characterized by a more or less steady cruise speed through the intersection. These vehicles can be represented with a separate link with a link drive schedule reflecting this steady cruise activity.
- Vehicle volumes for the red-light link and the green-light link should total the number of vehicles proceeding through the intersection in the hour. (The vehicle

[3] Regardless, the modeler will need to ensure that MOVES results for these links are included in AERMOD correctly and should document how the results from these links are input into AERMOD.

volumes may or may not be equal; it depends on the percent of time that the light is red vs. green.)

- The link lengths of these two links should be the same.

Modelers should use additional links if necessary to capture the differences in vehicle types. For instance, heavy-duty vehicles decelerate and accelerate at slower rates than passenger cars. These could be defined with additional links that have unique link drive schedules. In this case, the links need to reflect the appropriate vehicle types (done through the Link Source Type Input).

Drivers tend not to decelerate at a constant rate, but through a combination of coasting and light and heavy braking. Acceleration rates are initially higher when starting from a complete stop at an intersection, becoming progressively lower to make a smooth transition to cruise speed.

In the case of an uncongested intersection, the rates of vehicles approaching and departing the intersection are in equilibrium. Some vehicles may slow, and then speed up to join the dissipating queue without having to come to a full stop. Once the queue clears, approaching vehicles during the remainder of the green phase of the cycle will cruise through the intersection virtually unimpeded.

In the case of a congested intersection, the rate of vehicles approaching the intersection is greater than the rate of departure, with the result that no vehicle can travel through without stopping; vehicles approaching the traffic signal, whether it is red or green, will have to come to a full stop and idle for one or more cycles before departing the intersection. In this case, the green-light link could either be not included in the Links table or given a vehicle volume of zero. The latest Highway Capacity Manual is a good source of information for vehicle operation through signalized intersections. All assumptions, methods, and data underlying the development of link drive schedules should be documented as part of the PM hot-spot analysis.

The MOVES results for each road segment obtained via individual link drive schedules need to be appropriately post-processed before being used in AERMOD. For example, if Inventory mode is used, the results for all the link drive schedules representing a specific source in AERMOD would need to be summed. If Emission Rates mode is used, the results for the link drive schedules representing a specific source in AERMOD have to be multiplied by the appropriate factors, then summed. Note that AERMOD sources can also be defined by vehicle type: a source could include emissions from all vehicles, or two sources could be defined at the same location, one for light-duty and one for heavy-duty emissions. Modelers should take care to document specifically how results from MOVES are applied in AERMOD, i.e., list the post-processing steps taken. See Sections 4.6 and Section 7 of the guidance as well as Appendix J.

For both free-flow highway and intersection links, users may directly enter output from traffic simulation models in the form of second-by-second individual vehicle trajectories. These vehicle trajectories for each road segment can be input into MOVES using the

Link Drive Schedule Importer and defined as unique LinkIDs. There are no limits in MOVES as to how many links can be defined; however, model run times increase as the user defines more links. A representative sampling of vehicles can be used to model higher volume segments by adjusting the resulting sum of emissions to account for the higher traffic volume. For example, if a sampling of 5,000 vehicles (5,000 links) was used to represent the driving patterns of 150,000 vehicles, then the sum of emissions would be multiplied by a factor of 30 to account for the higher traffic volume (i.e., 150,000 vehicles/5,000 vehicles). Since the vehicle trajectories include idling, acceleration, deceleration, and cruise, separate roadway links do not have to be explicitly defined to show changes in driving patterns (i.e., both the red light and green light driving cycles are going to be represented in these 5000 links). The sum of emissions from each vehicle trajectory (LinkID) represents the total emission contribution of a given road segment.

D.4 Option 3: Using Op-Mode Distributions

A third option is for a user to generate representative Op-Mode distributions for approach and departure links by calculating the fraction of fleet travel times spent in each mode of operation. For any given signalized intersection, vehicles are cruising, decelerating, idling, and accelerating. Op-Mode distributions can be calculated from the ratios of individual mode travel times to total travel times on approach links and departure links. This type of information could be obtained from Op-Mode distribution data from:

(1) existing intersections with similar geometric and operational (traffic) characteristics, or
(2) output from traffic simulation models for the proposed project or similar projects.

Acceleration and deceleration assumptions, methods, and data underlying the activity-to-Op-Mode calculations should be documented as part of the PM hot-spot analysis.

The following methodology describes a series of equations to assist in calculating vehicle travel times on approach and departure links. Note that a single approach and single departure link should be defined to characterize vehicles approaching, idling at, and departing an intersection (e.g., there is no need for an "idling link," as vehicle idling is captured as part of the approach link).

D.4.1 Approach links

When modeling each approach link, the fraction of fleet travel times in seconds (s) in each mode of operation should be determined based on the fraction of time spent cruising, decelerating, accelerating, and idling:

Total Fleet Travel Time (s) = Cruise Time + Decel Time + Accel Time + Idle Time

The cruise travel time can be represented by the number of vehicles cruising multiplied by the length of approach divided by the average cruise speed:

Cruise Time (s) = Number of Cruising Vehicles * (Length of Approach (mi) ÷ Average Cruise Speed (mi/hr)) * 3600 s/hr

The deceleration travel time can be represented by the number of vehicles decelerating multiplied by the average cruise speed divided by the average deceleration rate:

Decel Time (s) = Number of Decelerating Vehicles * (Average Cruise Speed (mi/hr) ÷ Average Decel Rate (mi/hr/s))

The acceleration travel time occurring on an approach link can be similarly represented. However, to avoid double-counting acceleration activity that occurs on the departure link, users should multiply the acceleration time by the proportion of total acceleration that occurs on the approach link (Accel Length Fraction on Approach):

Accel Time (s) = Number of Accelerating Vehicles * (Average Cruise Speed (mi/hr) ÷ Average Accel Rate (mi/hr/s)) * Accel Length Fraction on Approach

The idle travel time can be represented by the number of vehicles idling multiplied by the average stopped delay (average time spent stopped at an intersection):

Idle Time (s) = Number of Idling Vehicles * Average Stopped Delay (s)

Control delay (total delay caused by an intersection) may be used in lieu of average stopped delay, but control delay includes decelerating and accelerating travel times, which should be subtracted out (leaving only idle time).

After calculating the fraction of time spent in each mode of approach activity, users should select the appropriate MOVES Op-Mode corresponding to each particular type of activity (see Section 4.5.7 for more information). The operating modes in MOVES typifying approach links include:

- Cruise/acceleration (OpModeID 11-16, 22-25, 27-30, 33, 35, 37-40);
- Low and moderate speed coasting (OpModeID 11, 21);
- Braking (OpModeID 0, 501);
- Idling (OpModeID 1); and
- Tire wear (OpModeID 400-416).

The relative fleet travel time fractions can be allocated to the appropriate Op-Modes in MOVES. The resulting single Op-Mode distribution accounts for relative times spent in the different driving modes (cruise, deceleration, acceleration, and idle) for the approach link.

D.4.2 Departure links

When modeling each departure link, the fraction of fleet travel times spent in each mode of operation should be determined based on the fraction of time spent cruising and accelerating:

Total Fleet Travel Time (s) = Cruise Time + Accel Time

The cruise travel time can be represented by the number of vehicles cruising multiplied by the travel distance divided by the average cruise speed:

Cruise Time (s) = Number of Cruising Vehicles * (Length of Departure (mi) ÷ Average Cruise Speed (mi/hr)) * 3600 s/hr

The acceleration travel time occurring during the departure link can be represented by the number of vehicles accelerating multiplied by the average cruise speed divided by the average acceleration rate. However, to avoid double-counting acceleration activity that occurs on the approach link, users should multiply the resulting acceleration time by the proportion of total acceleration that occurs on the departure link (Accel Length Fraction on Departure):

Accel Time (s) = Number of Accelerating Vehicles * (Average Cruise Speed (mi/hr) ÷ Average Accel Rate (mi/hr/s)) * Accel Length Fraction on Departure

After calculating fraction of time spent in each mode of departure activity, users should select the appropriate MOVES Op-Mode corresponding to each particular type of activity (see Section 4.5.7 for more information). The operating modes typifying departure links include:

- Cruise/acceleration (OpModeID 11-16, 22-25, 27-30, 33, 35, 37-40); and
- Tire wear (OpModeID 401-416).

The relative fleet travel time fractions can be allocated to the appropriate Op-Modes. The resulting single Op-Mode distribution accounts for relative times spent in the different driving modes (cruise and acceleration) for the departure link.

Appendix E: Reserved

Note: EPA removed the example of a PM hot-spot analysis of a highway project in Appendix E in the previous version of this guidance (2015) because it was superseded by the example analyses found in EPA's quantitative PM hot-spot analysis training course. The course materials, including the presentation of the example analysis and all of the files necessary to repeat the analysis are available for download at: https://www.epa.gov/state-and-local-transportation/project-level-training-quantitative-pm-hot-spot-analyses.

Appendix F: Reserved

Note: EPA removed the example of a PM hot-spot analysis of a transit project in Appendix F in the previous version of this guidance (2015) because it was superseded by the example analyses found in EPA's quantitative PM hot-spot analysis course. The course materials, including the presentation of the example analysis and all of the files necessary to repeat the analysis are available for download at: https://www.epa.gov/state-and-local-transportation/project-level-training-quantitative-pm-hot-spot-analyses.

Appendix G: Reserved

Note: EPA removed the example using EMFAC in Appendix G because it pertained to a version of EMFAC no longer in use. See Appendix A.4 for more information on EMFAC available at California Air Resources Board's website.

Appendix H: Reserved

Note: EPA removed the example using EMFAC in Appendix H because it pertained to a version of EMFAC no longer in use. See Appendix A.4 for more information on EMFAC available at California Air Resources Board's website.

Appendix I:
Estimating Locomotive Emissions

I.1 Introduction

This appendix describes how to quantify locomotive emissions when they are a component of a transit or freight terminal or otherwise a source in the project area being modeled. Note that state or local air quality agencies may have experience modeling locomotive emissions and therefore could be of assistance when quantifying these emissions for a PM hot-spot analysis.

Note that Section 8 of EPA's *Port Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions*, EPA-420-B-20-046, September 2020, available on EPA's website at: https://www.epa.gov/state-and-local-transportation/port-emissions-inventory-guidance is also a useful reference. Section 8 covers methodologies for preparing an emissions inventory for the rail sector of a port.

Generally speaking, locomotive emissions can be estimated in the following manner:

1. Determine where in the project area locomotive emissions should be estimated.

2. Determine when to analyze emissions.

3. Describe the locomotive activity within the project area, including:
    - The locomotives present in the project area (the "locomotive roster"); and
    - The percentage of time each locomotive spends in various throttle settings (the "duty cycle").

4. Calculate locomotive emissions using either:
    - Horsepower rating and load factors, or
    - Fuel consumption data.[1]

The estimated locomotive emission rates that result from this process would then be used for air quality modeling. The interagency consultation process must be used to evaluate and choose the model and associated method and assumptions used for quantifying locomotive emissions for PM hot-spot analyses (40 CFR 93.105(c)(1)(i)).

[1] These are the two methods described in this appendix; others may be possible. See Appendix I.5 for details.

I.2 Determining Where in the Project Area Locomotive Emissions Should Be Estimated

Under certain circumstances, it is appropriate to model different locations within the project area as separate sources to characterize differences in locomotive type and/or activity appropriately. This step is analogous to dividing a highway project into links (as described in Sections 4.2 and 5.2 of the guidance) and improves the accuracy of emissions modeling and subsequent air quality modeling. For example, in an intermodal terminal, emissions from a mainline track (which will have a large percentage of higher speed operations with little idling) should be estimated separately from the associated passenger or freight terminal (which would be expected to experience low speed operations and significant idling).

The following activities are among those typically undertaken by locomotives and are candidates for being modeled as separate sources if they occur at different locations within the project area:

- Idling within the project area;
- Trains arriving into, or departing from, the project area (e.g., terminal arrival and departure operations);
- Testing, idling, and service movements in maintenance areas or sheds;
- Switching operations;
- Movement of trains passing through, but not stopping in, the project area.

The project area may also be divided into separate sources if it includes several different locomotive rosters (see Appendix I.4.1, below)

I.3 Determining When to Analyze Emissions

The number of hours and days that have to be analyzed depends on the range of activity expected to occur within the project area. For rail projects where activity varies from hour to hour, day to day, and possibly month to month, it is recommended that, at a minimum, project sponsors calculate emissions based on 24 hours of activity for both a typical weekday and weekend day and for four representative quarters of the analysis year when comparing emissions to all $PM_{2.5}$ NAAQS.[2] Or, project sponsors could calculate emissions based on the highest 24 hours of activity during the year, and use those emissions to represent all days of the year.

These resulting emission rates should be applied to AERMOD and used to calculate design concentrations to compare with the applicable PM NAAQS as described in Sections 7 through 9 of the guidance.

[2] If there is no difference in activity between weekday and weekend activity, it may not be necessary to examine weekend day activity separately. Similarly, if there is no difference in activity between quarters, emission rates can be determined for one quarter, which can then be used to represent every quarter of the analysis year.

I.4 Describing the Locomotive Rosters and Duty Cycles

Before calculating locomotive emission rates, it is necessary to know what locomotives are present in the locations being analyzed in the project area (see Appendix I.2, above) and what activities these locomotives are undertaking at these locations. This data will impact how emissions are calculated.

I.4.1 Locomotive Rosters

Because emissions can vary significantly depending on a locomotive's make, model, engine, and year of engine manufacture (or re-manufacture), it is important to know what locomotives are expected to be operating within the project area. Project sponsors should develop a "locomotive roster" (i.e., a list of each locomotive's make, model, engine, and year) for the locomotives that will be operating within the specific project area being analyzed. The more detailed the locomotive roster, the more accurate the estimated emissions will be.

In some cases, it will be necessary to develop more than one locomotive roster to reflect the operations in the project area accurately (for example, switcher locomotives may be confined to one portion of a facility and therefore may be represented by their own roster). In these situations, users should model areas with different rosters as separate sources to account for the variability in emissions (see Appendix I.2).

I.4.2 Locomotive Duty Cycles

Diesel locomotive engine power is controlled by "notched" throttles; idling, braking, and moving the locomotive is conducted by placing the throttle in one of several available "notch settings."[3] A locomotive's "duty cycle" is a description of how much time, on average, the locomotive spends in each notch setting when operating. Project sponsors should use the latest locally-generated or project-specific duty cycles whenever possible; this information may be available from local railway authorities or the state or local air agency.[4] The default duty cycles for line-haul and switch locomotives, found in Tables 1 and 2 of 40 CFR 1033.530 (EPA's regulations on controlling emissions from locomotives), should be used only if they adequately represent the locomotives that will be present in the project area and no local or project-specific duty cycles are available.

[3] A diesel locomotive typically has eight notch settings for movement (run notches), in addition to one or more idle or dynamic brake notch settings. Dynamic braking is when the locomotive engine, rather than the brake, is used to control speed.

[4] The state or local air agency may have previously developed locally-appropriate duty cycles for emissions inventory purposes.

I.5 Calculating Locomotive Emissions

Once a project's locomotive rosters and respective duty cycles have been determined, locomotive emissions can then be calculated for each part of the project area using either (1) horsepower rating and load factors, or (2) fuel consumption data. These two methods are summarized below. Unless otherwise determined through consultation, only one method should be used for a given project.

I.5.1 Finding Emission Factors

Regardless of method chosen, locomotive emissions factors will be needed for the analysis. Locomotive emission factors depend on the type of engine, the power rating of the locomotive (engine horsepower), and the year of engine manufacture (or re-manufacture). Default PM_{10} emission factors for line-haul and switch locomotives can be obtained from Tables 1 and 2 of EPA's "Emission Factors for Locomotives," EPA-420-F-09-025 (April 2009).[5] These PM_{10} emission factors are in grams/horsepower-hour and can easily be converted to $PM_{2.5}$ emission factors. However, these are simply default values; locomotive-specific data may be available from manufacturers and should be used whenever possible. In addition, see Appendix I.5.4 for other variables that must be considered when determining the appropriate locomotive emission factors.

Note that the default locomotive emission factors promulgated by EPA may change over time as new information becomes available. The April 2009 guidance cited above contains the latest emission factors as of this writing. Project sponsors should consult the EPA's website at https://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-emissions-locomotives for the latest locomotive default emission factors and related information. In addition, see https://www.epa.gov/state-and-local-transportation/transportation-related-documents-state-and-local-transportation for related guidance.

I.5.2 Calculating Emissions Using Horsepower Rating and Load Factors

One way locomotive emissions can be calculated is to use $PM_{2.5}$ or PM_{10} locomotive emission factors, the horsepower rating of the engines found on the locomotive roster, and engine load factors (which are calculated from the duty cycle).

Calculating Engine Load Factors

The horsepower of the locomotive engines, including the horsepower used in each notch setting, should be available from the rail operator or locomotive manufacturer.

[5] Table 1 of EPA's April 2009 document includes default emission factors for higher power cycles representative of general line-haul operation; Table 2 includes emission factors for lower power cycles used for switching operations. The April 2009 document also includes information on how to convert PM_{10} emission factors for $PM_{2.5}$ purposes. Note that Table 6 (PM_{10} Emission Factors) should not be used for PM hot-spot analyses, since these factors are national fleet averages rather than emission factors for any specific project.

Locomotive duty cycle data (see Appendix I.4.2) can then be used to determine how much time each locomotive spends in each notch setting, including braking and idling. An engine's "load factor" is the percent of maximum available horsepower it uses over the course of its duty cycle. In other words, a load factor is the weighted average power used by the locomotive divided by the engine's maximum rated power.[6] Load factors can be calculated by summing the actual horsepower-hours of work generated by the engine in a given period of time and dividing it by the engine's maximum horsepower and the hours during which the engine was being used, with the result expressed as a percentage. For example, if a 4000 hp engine spends one hour at full power (generating 4000 hp-hrs) and one hour at 50 percent power (generating 2000 hp-hrs), its load factor would be 75 percent:

((4000 hp-hrs + 2000 hp-hrs) / (4000 hp* 2 hrs)) * 100% = 75%

Note that, in this example, it would be equivalent to calculate the load factor using the percent power values instead: ((100% * 1 hr) + (50% * 1 hr)) / 2 hrs = 75%. To simplify emission factor calculations, it is recommended that locomotive activity be generalized into the operational categories of "moving" and "idling," with separate load factors calculated for each.

An engine's load factor is calculated by completing the following steps:

Step 1. Determine the number of notch settings the engine being analyzed has and the horsepower used by the engine in each notch setting.[7] Alternatively, as described above, the percent of maximum power available in each notch could instead be used.

Step 2. Identify the percentage of time the locomotive being analyzed spends in each notch setting based on its duty cycle (see Appendix I.4.2).

Step 3. To make emission rate calculations easier, it is useful to calculate two separate load factors for an engine: one for when the locomotive is idling and one for when it is moving.[8] Therefore, the percentage of time the locomotive spends in each notch (from Step 2) needs to be adjusted so that all idling and all moving notches are considered separately. For example, if a locomotive has just one idle notch setting, it spends 100% of its idling time in that setting, even if it only idles during part of its duty cycle. While calculating the time spent idling will usually be simple, for the non-idle (moving) notch settings some additional adjustment to the locomotive's duty cycle percentages will be required to determine the time spent in each moving notch as a fraction of total time spent moving, disregarding any time spent idling.

[6] "Weighted average power" in this case is the average power used by the locomotive weighted by the time spent in each notch, as explained further below.
[7] For locomotives that are equipped with multiple dynamic braking notches and/or multiple idle notches, it may be necessary to assume a single dynamic braking notch and a single idle notch, depending on what information is available about the particular engine.
[8] In this case, "moving" refers to all non-idle notch settings: that is, dynamic braking and all run notches.

For example, say a locomotive spends 30% of its time idling and 70% of its time moving over the course of its duty cycle and that 15% of this total time (idling and moving together) is spent in notch 2. When calculating the moving load factor, this percentage needs to be adjusted to determine what fraction of just the 70% of time spent moving is spent in notch 2. In this example, 15% of the total duty cycle spent in notch 2 would equal 21.4% (15% * 100% ÷ 70%) of the locomotive's time when it is not at idle; that is, whenever it is moving, this locomotive spends 21.4% of its time in notch 2. This calculation is repeated for each moving notch setting. The result will be the fraction of time spent in each notch when considering idle and moving modes of operation separately.

Step 4. The next step is to calculate what fraction of maximum available horsepower is being used based on the time spent in each notch setting as was calculated in Step 3. This is determined by summing the product of the percentage of time spent in each notch (calculated in Step 3) by the horsepower generated by the engine at that notch setting (determined in Step 1). For example, if the locomotive with a rated engine power of 3000 hp spends 21.4% of its moving time in notch 2 and 78.6% of its moving time in notch 6, and is known to generate 500 hp while in notch 2 and 2000 hp while in notch 6, then its weighted average power would be 1679 hp (107 hp (500 hp * 0.214) + 1572 hp (2000 hp * 0.786) = 1679 hp).

Step 5. The final step is to determine the load factors. This is done by dividing the weighted average horsepower (calculated in Step 4) by the maximum engine horsepower. For idling, this should be relatively simple. For example, if there is one idle notch setting and it is known that a 4000 hp engine uses 20 hp when in its idle notch, then its idle load factor will be 0.5% (20 hp ÷ 4000 hp). To determine the load factor for all power notches, the weighted horsepower calculated in Step 4 should be divided by the total engine horsepower. For example, if the same 4000 hp engine is determined to use an average of 1800 hp while in motion (as determined by adjusting the horsepower by the time spent in each "moving" notch setting in Step 4), then the moving load factor would be 45% (1800 hp ÷ 4000 hp).

The resulting idling and moving load factors represent the average amount of the total engine horsepower the locomotive is using when idling and moving, respectfully. These load factors can then be used to modify PM emission factors and generate emission rates as described below.

Generating Emission Rates Based on Load Factors

As noted above, EPA's "Emission Factors for Locomotives" provides emission factors in grams/brake horsepower-hour. This will also likely be the case with any specific emission factors obtained from manufacturer's specifications. These units can be converted into grams/second (g/s) emission rates by using the load factor on the engines and the time spent in each operating mode, as described below.

The first step is to adjust the PM emission factors to reflect how the engine will actually be operating.[9] This is done by multiplying the appropriate PM emission factor by the idling and moving load factors calculated for that particular engine.[10] Next, to determine the emission rate, this adjusted emission factor is further multiplied by the amount of time the locomotive spends idling and moving while in the project area.[11]

For example, if the PM emission factor known to be 0.18 g/bhp-hr, the engine being analyzed has an idling load factor of 0.5%, and the locomotive is anticipated to idle 24 minutes per hour in the project area, then the resulting emission rate would be 0.035 grams/hour (0.18 g/bhp-hr * 0.5% * 0.4 hours).

Emission rates need to be converted into g/s for use by AERMOD, as described further in Sections 7 through 9 of the guidance. These calculations should be repeated until the entire locomotive roster is represented in each part of the project area being analyzed.

Appendix I.7 provides an example of calculating g/s locomotive emission rates using this methodology.

I.5.3 Calculating Emissions Using Fuel Consumption Data

Another method to calculate locomotive emissions involves using fuel consumption data. Chapter 6.3 of EPA's "Procedure for Emission Inventory Preparation -- Volume IV: Mobile Sources" (reference information provided in Appendix I.6, below) is a useful reference and should be consulted when using this method.

Note that, for this method, it may be useful to scale down data already available to the project sponsor. For example, if rail car miles/fuel consumption is known for trains operating in situations identical to those being estimated in the project area, this data can be used to estimate fuel consumption rates for a defined track length within the project area.

Calculating Average Fuel Consumption

Locomotive fuel consumption is specific to a particular locomotive engine and the throttle (notch) setting it is using. Data on the fuel consumption of various engines at different notch settings can often be obtained from the locomotive or engine manufacturer's specifications. When only partial data is available (e.g., only data for the lowest and highest notch settings are known), interpolation combined with best available engineering judgment can be used to determine fuel consumption at the intermediate notch settings.

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[9] Because combustion characteristics of an engine vary by throttle notch position, it is appropriate to adjust the emission factor to reflect the average horsepower actually being used by the engine.

[10] Project sponsors are reminded to ensure the latest default emission factors for idle and moving emissions are being used. See Appendix Section I.5.1.

[11] Note that this may or may not match up with the idle and moving time as described by the duty cycle used to calculate the load factors, depending on how project-specific that duty cycle is.

A locomotive's average fuel consumption can be calculated by determining how long each locomotive is expected to spend in each notch setting based on its duty cycle (see Appendix I.4.2). This data can be aggregated to generate an average fuel consumption rate for each locomotive type. See Chapter 6.3 of Volume IV for details on how to generate this data based on a specific locomotive roster and duty cycle.

Once the average fuel consumption rates have been determined, they should be multiplied by the appropriate emission factors to determine a composite average hourly emission rate for each engine in the roster. Since the objective is to determine an average fuel consumption rate for the entire locomotive roster, this calculation should be repeated for each engine on the roster at each location analyzed.

If several individual sources will be modeled at different sections of the project area as described in Appendix I.2, train schedule data should be consulted to determine the hours of operation of each locomotive within each section of the project area. Hourly emission rates per locomotive should then be multiplied by the number of hours the locomotive is operating, for each hour of the day in each section of the project area to provide average hourly emission rates for each section of the project. These should then be converted to grams/second for use in AERMOD, as described further in Sections 7 through 9 of the guidance.

Examples of calculating locomotive emissions using this method can be found in Chapter 6 of Volume IV.

I.5.4 Factors Influencing Locomotive Emissions and Emission Factors

The following considerations will influence locomotive emissions regardless of the method used and should be examined when determining how to characterize locomotives for emissions modeling or when choosing the appropriate emission factors:

- Project sponsors should be aware of the emission reductions that would result from remanufacturing existing locomotives (or replacing existing locomotives with new locomotives) that meet EPA's Tier 3 or Tier 4 emission standards when they become available. The requirements that apply to existing and new locomotives were addressed in EPA's 2008 rulemaking entitled "Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression-Ignition Engines Less Than 30 liters Per Cylinder" (73 FR 37095). Beginning in 2012, all locomotives must use ultra-low sulfur diesel fuel (69 FR 38958). Additionally, when existing locomotives are remanufactured, certified remanufacture systems have to be installed to reduce emissions. Beginning in 2011, new locomotives must meet tighter Tier 3 emission standards. Finally, beginning in 2015 even more stringent Tier 4 emission standards for new locomotives were phased in.

- For locomotives manufactured before 2005, a given locomotive may be in one of three possible configurations, depending on when it was last remanufactured: (1)

uncertified; (2) certified to the standards in 40 CFR Part 92; or (3) certified to the standards in 40 CFR Part 1033. Each of these configurations should be treated as a separate locomotive type when conducting a PM hot-spot analysis.

- Emissions from locomotives certified to meet Family Emission Limits (FELs) may differ from the emission standard identified on the engine's Emission Control Information label. Rail operators will know if their locomotives participate in this program. Any locomotives in the project area participating in this program should be identified so that the actual emissions from the particular locomotives being analyzed are considered in the analysis, rather than the family emissions level listed on their FEL labels.

I.6 Available Resources

These resources and websites should be checked prior to beginning any PM hot-spot analysis to ensure that the latest data (such as emission factors) are being used:

- *Port Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions*, EPA-420-B-20-046, September 2020, available on EPA's website at: https://www.epa.gov/state-and-local-transportation/port-emissions-inventory-guidance. Section 8, which covers methodologies for preparing an emissions inventory for the rail sector of a port, includes PM emission factors for line-haul and switcher locomotives.

- *Emission Factors for Locomotives*, EPA-420-F-09-025, April 2009. Available online at: https://nepis.epa.gov/. Use the document number (420F09025) to search for this document.

- Chapter 6 of *Procedure for Emission Inventory Preparation - Volume IV: Mobile Sources*. Available online at: https://nepis.epa.gov/. Note that, as of this writing, the emission factors listed in Volume IV have been superseded by the April 2009 publication listed above for locomotives certified to meet current EPA standards.[12]

- *Control of Emissions from Idling Locomotives*, EPA-420-F-13-50, December 2013. Available online at: https://nepis.epa.gov/Exe/ZyPdf.cgi?Dockey=P100HP4Q.pdf. .

- See Section 10 of the guidance for additional information regarding potential locomotive emission control measures.

[12] Although the emission factors have been superseded, the remainder of the Volume IV guidance remains in effect.

I.7 Example of Calculating Locomotive Emission Rates Using Horsepower Rating and Load Factor Estimates

The following example demonstrates how to estimate locomotive emissions using the engine horsepower rating/load factor method described in Appendix I.5.2.

The hypothetical proposed project in this example includes the construction of an intermodal terminal in an area that is designated as nonattainment for both the 2012 annual $PM_{2.5}$ NAAQS and the 2006 24-hour $PM_{2.5}$ NAAQS. The terminal in this example is to be completed and operational in 2025. The hot-spot analysis is performed for 2030, because it is determined through interagency consultation that this will be the year of peak emissions, when considering the project's emissions and the other emissions in the project area.

In this example, the operational schedule anticipates that 32 locomotives will be in the project area over a 24-hour period, with 16 locomotives in the project area during the peak hour. Based on the schedule, it is further determined that while in the project area each train will spend 540 seconds idling and 76 seconds moving.

The locomotive $PM_{2.5}$ emissions are calculated based on horsepower rating and load factors.

I.7.1 Calculate Idle and Moving Load Factors

As described in I.5.2, the project sponsor uses a series of steps to calculate load factors. These steps are described below and the results from each step are shown in table form in Exhibit I-1.

Step 1: The project sponsor first needs some information about the locomotives expected to be operating at the terminal in the analysis year.

For each locomotive, the horsepower used by the locomotive in each notch setting as well as under dynamic braking and at idle must be determined. For the purpose of this example it is assumed that all of the locomotives that will serve this terminal are very similar: all use the same horsepower under each of operating conditions, and all have only one idle and dynamic braking notch setting. The horsepower generated at each notch setting is obtained from the engine specifications (see second column of Exhibit I-1). In this case, the rated engine horsepower is 4000 hp (generated at notch 8).

Step 2: The next step is to determine the average amount of time that the locomotives spend in each notch and expressing the results as a percentage of the locomotive's total operating time. In this example, it is determined that, based on their duty cycle, the locomotives that will service this terminal spend 38% of their time idling and 62% of their time in motion in one of the eight run notch settings or under dynamic braking. The percentage of time spent in each notch is shown in the third column of Exhibit I-1.

Step 3: To make emission factor calculations easier, it is decided to calculate separate idling and moving load factors. The next step, then, is for the project sponsor to calculate the actual percentage of time that the locomotives spend in each notch, treating idling and moving time separately. This is done by excluding the time spent idling and recalculating the percentage of time spent in the other notches (i.e., dynamic braking and each of the eight notch settings) so that the total time spent in non-idle notches adds to 100%. The results are shown in the fourth column of Exhibit I-1.

Step 4: The next step is to calculate the weighted average horsepower for this engine using the horsepower generated in each notch and the percentage of time spent in each notch as adjusted in Step 3. For locomotives that are idling, this is simply the horsepower used at idle. For the other notches, the actual horsepower for each notch is determined by multiplying the horsepower generated in a given notch (determined in Step 1) by the actual percentage of time that the locomotive is in that notch, as adjusted (calculated in Step 3). The results are shown in the fifth column of Exhibit I-1.

Step 5: The final step in this part of the analysis is to determine the idle and moving load factors. The idle load factor is just the horsepower generated at idle divided by the maximum engine horsepower, with the result expressed as a percentage. To determine the moving load factor, the weighted average horsepower for all non-idle notches (calculated in Step 4) is divided by the maximum engine horsepower, with the result expressed as a percentage. The final column of Exhibit I-1 shows the results of these calculations, with the idling and moving load factors highlighted.

Exhibit I-1. Calculating Locomotive Load Factors

Notch Setting	Step 1: Horsepower (hp) used in notch	Step 2: Average % time spent in notch	Step 3: Reweighted time spent in each notch (adjusted so that non-idle notches add to 100%)	Step 4: Time-weighted hp used, based on time spent in notch	Step 5: Load factors (idle and moving)
Idling load factor:					
Idle	14	38.0%	100.0%	14.0	0.4%
Moving load factor:					
Dynamic Brake	136	12.5%	20.2%	27.5	
1	224	6.5%	10.5%	23.5	
2	484	6.5%	10.5%	50.8	
3	984	5.2%	8.4%	82.7	
4	1149	4.4%	7.1%	81.6	
5	1766	3.8%	6.1%	107.8	
6	2518	3.9%	6.3%	158.6	
7	3373	3.0%	4.8%	161.9	
8	4,000	16.2%	26.1%	1,044.0	
Total		62.0%	100.0%	1,752.4	43.8%

I.7.2 Using the load factors to calculate idle and moving emission rates

Now that the idle and moving load factors have been determined, the gram/second (g/s) emission rates can be calculated for the idling and moving locomotives.

First, the project sponsor would determine how many locomotives are projected to be idling and how many are projected to be in motion during the peak hour of operation and over a 24-hour period. As previously noted, it is anticipated that 32 locomotives will be in the project area over a 24-hour period, with 16 locomotives in the project area during the peak hour. It was further determined that, while in the project area, each train will spend 540 seconds idling and 76 seconds moving.

For the purpose of this example, it has been assumed that each locomotive idles for the same amount of time and is in motion for the same amount of time. Note that, in this case, the number of locomotives considered "moving" will be double the actual number of locomotives present in order to account for the fact that each locomotive moves twice through the project area (as it arrives and departs the terminal).

Next, the project sponsor would determine the $PM_{2.5}$ emission factor to be used in this analysis for 2015. These emission factors can be determined from the EPA guidance titled *Emission Factors for Locomotives* (see Appendix I.6).

Table 1 of *Emission Factors for Locomotives* presents PM_{10} emission factors in terms of grams/brake horsepower-hour (g/bhp-hr) for line haul locomotives that are typically used by commuter railroads. Emission factors are presented for uncontrolled locomotives, locomotives manufactured to meet Tier 0 through Tier 4 emission standards, and locomotives remanufactured to meet more stringent emission standards. It's important to determine the composition of the fleet of locomotives that will use the terminal in the year that is being analyzed so that the emission factors in Table 1 can be used in the calculations. This information would be available from the railway operator.

In this example, we are assuming that all of the locomotives meet the Tier 2 emission standard. However, an actual PM hot-spot analysis would likely have a fleet of locomotives that meets a combination of these emission standards. The calculations shown below would have to be repeated for each different standard that applies to the locomotives in the fleet.

The final step in these calculations is to use the information shown in Exhibit I-1 and the other project data collected to calculate the $PM_{2.5}$ emission rates for idling and moving locomotives during both the peak hour and over a 24-hour basis.[13]

Calculating Peak Hour Idling Emissions

The following calculation would be used to determine the idling emission rate during the peak hour of operation:[14]

$PM_{2.5}$ Emission Rate = (16 trains/hr) * (1 hr/3,600 s) * (540 s/train) * (4,000 hp) * (0.004) * (0.18 g/bhp-hr) * (1 hr/3,600 s) * (0.97)
$PM_{2.5}$ Emission Rate = 0.0019 g/s

Where:

- Trains per hour = 16 (number of trains present in peak hour)
- Idle time per train = 540 s (from anticipated schedule)
- Locomotive horsepower = 4,000 hp (from engine specifications)
- Idle load factor = 0.004 (0.4%, calculated in Exhibit I-1)
- Tier 2 Locomotive Emission Factor = 0.18 g/bhp-hr (from "Emission Factors for Locomotives")
- Ratio of $PM_{2.5}$ to PM_{10} = 0.97 (from "Emission Factors for Locomotives")

[13] Peak hour emission rates will not be necessary for all analyses; however, for certain projects that involve very detailed air quality modeling analyses, peak hour emission rates may be necessary to more accurately reflect the contribution of locomotive emissions to air quality concentrations in the project area.
[14] Note that, for the calculations shown here, any units expressed in hours or days need to be converted to seconds since a g/s emission rate is required for AERMOD.

Calculating 24-hour Moving Emissions

Similarly, the following equation would be used to calculate the moving emission rate for the 24-hour period:

$PM_{2.5}$ Emission Rate = (64 trains/day) * (76 s/train) * (1 day/86,400 s) * (4,000 hp) * (0.438) * (0.18 g/bhp-hr) * (1hr/3,600 s) * (0.97)
$PM_{2.5}$ Emission Rate = 0.0048 g/s

Where:

- Trains per day = 64 (double the actual number of trains present over 24 hours to account for each train moving twice through the project area)
- Moving time per train = 76 s (from anticipated schedule)
- Locomotive horsepower = 4,000 hp (from engine specifications)
- Moving load factor = 0.438 (43.8%, calculated in Exhibit I-1)
- Tier 2 Locomotive Emission Factor = 0.18 g/bhp-hr (from "Emission Factors for Locomotives")
- Ratio of $PM_{2.5}$ to PM_{10} = 0.97 (from "Emission Factors for Locomotives")

A summary of the variables used in the above equations and the resulting emission rates can be found in Exhibit I-2, below.

Exhibit I-2. $PM_{2.5}$ Locomotive Emission Rates

Operational Mode	**Number of Locomotives**		**Time/ Train**	**$PM_{2.5}$ Emission Factor**	**Calculated Peak Hour Emission Rate**	**Calculated 24-hour Emission Rate**
	Peak hour	24 hours	(s)	(g/bhp-hr)	(g/s)	(g/s)
Idle	16	32	540	0.18	0.0019	0.00016
Moving	32	64	76	0.18	0.057	0.0048

These peak and 24-hour emission rates can now be used in air quality modeling for the project area, as described in Sections 7 through 9 of the guidance.

Note that, since this area is designated as nonattainment for both the 2012 annual $PM_{2.5}$ NAAQS and the 2006 24-hour $PM_{2.5}$ NAAQS, the results of the analysis will be compared to both NAAQS (see Section 3.3.4 of the guidance). If there is no change in locomotive activity across quarters, the emission rates calculated here could be used for each quarter of the year (see Appendix I.3).

Appendix J:
Additional Reference Information on AERMOD

J.1 Introduction

This appendix supplements Section 7's discussion of AERMOD. Specifically, this appendix describes how to configure AERMOD for PM hot-spot analysis modeling, as well as additional information on handling the data required to run the model for these analyses. This appendix is not intended to replace the "User's Guide for the AMS/EPA Regulatory Model (AERMOD)" (in this document, "AERMOD User's Guide"), but discusses specific model inputs, keywords, and formats for PM hot-spot modeling.[1] This appendix is organized so that it references the appropriate discussions in Section 7 of the guidance.

J.2 AERMOD Input and Output Units

The following discussion supplements Section 7.3 of the guidance.
There are no specific commands unique to transportation projects that are necessary when using AERMOD. By default, AERMOD produces output for particulate matter in units of micrograms per cubic meter of air ($\mu g/m^3$). All source types in AERMOD require that emissions are specified in terms of emissions per unit time, although AREA-type sources also require specification of emissions per unit time per unit area. AERMOD has no traffic queuing mechanisms. Emissions output from MOVES, EMFAC, AP-42, and other types of methods should be formatted as described in the AERMOD User's Guide.[2]

J.3 Characterizing Emission Sources

The following discussion supplements Section 7.4 of the guidance and describes in more detail how to characterize sources in AERMOD, including the physical characteristics, location, and timing of sources. This discussion assumes the user is familiar with handling data in these models, including the use of specific keywords. For additional information, refer to the AERMOD User's Guide and EPA's quantitative PM hot-spot analysis training course, available for download at https://www.epa.gov/state-and-local-transportation/project-level-training-quantitative-pm-hot-spot-analyses.

[1] *User's Guide for the AMS/EPA Regulatory Model (AERMOD)*, EPA-454/B-21-001, April 2021, can be found on EPA's website at: https://www.epa.gov/scram/air-quality-dispersion-modeling-preferred-and-recommended-models#aermod.
[2] Extensive documentation is available describing the various components of AERMOD, including user guides, model formulation, and evaluation papers. See EPA's SCRAM website for AERMOD documentation: www.epa.gov/scram001/dispersion_prefrec.htm#aermod.

J.3.1 Physical Characteristics and Locations of Sources in AERMOD

The following discussion gives guidance on how to best characterize a source. AERMOD includes different commands (keywords) for line, area, volume, and point sources. It is acceptable to use either line/area or volume sources to simulate roadways in AERMOD. When modeling roadway links, experience in the field has shown that line/area sources may be easier to characterize correctly compared to volume sources.[3] Volume sources can also have longer run time than line/area sources. Users may want to be particularly mindful of making errors when using volume sources.[4]

Modeling Area Sources

AERMOD can represent rectangular, polygon-shaped, and circular area sources using the AREA, AREAPOLY, AREACIRC, or LINE keywords. Sources that may be modeled as area sources may include areas within which emissions occur relatively evenly, such as a single link modeled using MOVES or EMFAC. Evenly-distributed ground-level sources might also be modeled as area sources. EPA recommends that the LINE source keyword be used for modeling roadway sources as it greatly simplifies defining the physical location and orientation of sources.

AERMOD requires the following information when modeling an area source using the LINE source keyword:

- The emission rate per unit area (mass per unit area per unit time);
- The coordinates of midpoint of the ends (X_1,Y_1, X_2,Y_2)
- The width of the source in meters;
- The initial vertical dimension of the area source plume and initial vertical dispersion coefficient; and
- The release height above the ground.

Width of the Source. To estimate the width of the source, one of the following options should be used:

a) The width of the traveled way, typically 3.7 m (12 ft) per lane for a high-speed, high volume roadway and 3.3 m (11 ft) per lane for an arterial/collector; or
b) The width of the traveled way (all travel lanes) + 6 meters.[5]

Initial Vertical Dimension. A typical approach is to assume the initial vertical dimension is about 1.7 times the average vehicle height, to account for the effects of vehicle-induced

[3] Sources defined by the LINE keyword are equivalent to rectangular AREA sources; input parameters for LINE are streamlined.
[4] For additional information on issues related to applying volume sources, see slides 16-19 in EPA's "PM Hot-spot Modeling: Lessons Learned in the Field" presentation (January 2014) found on: https://www.epa.gov/state-and-local-transportation/project-level-conformity-and-hot-spot-analyses#training.
[5] Option (b) is based on the Haul Road Workgroup Final Report (December 2011), found on the web at https://www.epa.gov/sites/production/files/2020-10/documents/haul_road_workgroup-final_report_package-20120302.pdf.

turbulence. For light-duty vehicles, this is about 2.6 meters, using an average vehicle height of 1.53 meters or 5 feet. For heavy-duty vehicles, this is about 6.8 meters, using an average vehicle height of 4.0 meters. Since most road links will consist of a combination of light-duty and heavy-duty traffic, the initial vertical dimension should be a combination of their respective values. There are two options available to estimate initial vertical dimension:

a) Estimate the initial vertical dimension using an emissions-weighted average. For example, if light-duty and heavy-duty vehicles contribute 40% and 60% of the emissions of a given volume source, respectively, the initial vertical dimension would be (0.4 * 2.6) + (0.6 * 6.8) = 5.1 meters.
b) Alternatively, the initial vertical dimension may be estimated using a traffic volume weighted approach based on light-duty and heavy-duty vehicle fractions.

Initial Vertical Dispersion Coefficient. The AERMOD User's Guide recommends that the initial vertical dispersion coefficient (σ_{zo}), termed *Szinit* in AERMOD, be estimated by dividing the initial vertical dimension by 2.15. For typical light-duty vehicles, this corresponds to a *Szinit* (σ_{zo}) of 1.2 meters. For typical heavy-duty vehicles, the initial value of *Szinit* (σ_{zo}) is 3.2 meters.

Release Height. The source release height (*Relhgt*), which is the height at which wind effectively begins to affect the plume, may be estimated as the midpoint of the initial vertical dimension. In other words, *Relhgt* is the initial vertical dimension multiplied by 0.5. As noted above, most road links will consist of a combination of light-duty and heavy-duty traffic. For each roadway source, the source release height (*Relhgt*) should be based on the same initial vertical dimension used for calculated its *Szinit*, as described above.

Another way of dealing with *Szinit* and/or release height (*Relhgt*) parameters that change as a result of different fractions of light-duty and heavy-duty vehicles is to create two overlapping versions of each roadway source, corresponding to either light-duty and heavy-duty traffic. These two sources could be superimposed in the same space, but would have emission rates and *Szinit* and *Relhgt* parameters that are specific to light-duty or heavy-duty traffic.

Also, AERMOD allows *Szinit*, and *Relhgt* to change by hour of the day, which may be considered if the fraction of heavy-duty vehicles is expected to significantly change throughout a day. Users should consult the latest information on AERMOD when beginning a PM hot-spot analysis.

Groups of idling vehicles may also be modeled as one or more area sources. In those cases, the initial vertical dimension of the source, dispersion coefficients, and release heights should be calculated assuming that the vehicles themselves are inducing no turbulence. Source characterization should be based on the type of vehicles idling, e.g., if the vehicles idling are primarily heavy-duty trucks, then the release height would be 4 meters.

Modeling Volume Sources

Another option for modeling sources in a PM hot-spot analysis is to use volume sources. When modeling highway and intersection links, experience in the field has shown that line/area sources may be easier to characterize compared to volume sources. Project sponsors using volume sources should seek the assistance of their EPA Region through the interagency consultation process, based on 40 CFR 93.105(c)(1)(i). Consulting with EPA on parameters that will be used to describe the sources may save time in avoiding errors.

Examples of project sources that may be modeled with volume sources could include areas designated for truck or bus queuing or idling, driveways and pass-throughs in transit or freight terminals, and locomotive emissions.[6] AERMOD can also approximate a highway using a series of adjacent volume sources (see the AERMOD User's Guide for suggestions), but as noted above, experience in the field has shown that line/area sources may be easier to characterize correctly compared to volume sources. Volume sources can also have longer run time as compared to line/area sources. Certain nearby sources that have been selected to be modeled may also be appropriately treated as a volume source (see Section 8 of the guidance for more information on considering background concentrations from other sources).

When using volume sources, users need to provide the following information:

- The emission rate (mass per unit time, such as g/s);
- The initial lateral dispersion coefficient determined from the initial lateral dimension (width) of the volume;
- The initial vertical dispersion coefficient determined from the initial vertical dimension (height) of the volume; and
- The source release height of the volume source center, (i.e., meters above the ground).

Within AERMOD, the volume source algorithms are applicable to line sources with some initial plume depth (e.g., highways, rail lines).[7] See the above discussion on area sources for guidance on defining release height and initial vertical dispersion coefficients.

The goal of using volume sources to represent a roadway is to create a uniform emissions characterization. Ensure that volume sources are not spaced too widely along the roadway. Adjacent volume sources should overlap and the distance between them should be equal to the width of the source, as described in the AERMOD User's Guide. Any other approximation of roadways with volume sources will result in adjacent receptors being over or under-estimated depending on their proximity to the center of the volume source.

[6] See Section 6 and Appendix I for information regarding calculating locomotive emissions.

[7] The vehicle-induced turbulence around roadways with moving traffic suggests that prior to transport downwind, a roadway plume has an initial size; that is, the emissions from the tailpipe are stirred because the vehicle is moving and therefore the plume "begins" from a three-dimensional volume, rather than from a point source (the tailpipe).

To specify the initial lateral dispersion coefficient (σ_{yo}), referred to as *Syinit* in AERMOD, the AERMOD User's Guide recommends dividing the initial width by 2.15. This is to ensure that the overlapping distributions from adjacent volume sources simulate a line source of emissions.

Groups of idling vehicles may also be modeled as one or more volume sources. In those cases, the initial dimensions of the source, dispersion coefficients, and release heights should be calculated assuming that the vehicles themselves are inducing no turbulence. Source characterization should be based on the type of vehicles idling, e.g., if the vehicles idling are primarily heavy-duty diesel trucks, then the release height would be 4 meters.

In addition, when the source-receptor spacing in AERMOD is shorter than the distance between adjacent volume sources, AERMOD may produce aberrant results. Therefore, ensure that no receptors are placed within a distance of (2.15 x *Syinit* + 1 meter) of the center of a volume source, known as the "receptor exclusion zone." As a practical recommendation, when using volume sources to simulate a roadway where receptors are placed five meters from the edge of the roadway, the width of a volume source should be less than eight meters. This will ensure that no receptors fall within the receptor exclusion zone. If the width of the roadway is larger than eight meters, it is recommended that additional volume sources be defined (e.g., separate each lane of traffic), or area sources be used.

Modeling Point Sources

It may be appropriate to model some emission sources as fixed point sources, such as exhaust fans or stacks on a bus garage or terminal building. If a source is modeled with the POINT keyword in AERMOD, the model requires:

- The emission rate (mass per unit time);
- The release height above the ground;
- The exhaust gas exit temperature;
- The stack gas exit velocity; and,
- The stack inside diameter in meters.

These parameters can often be estimated using the plans and engineering diagrams for ventilation systems.

For projects with emissions on or near rooftops, such as bus terminals or garages, building downwash should also be modeled for the relevant sources. The potential for building downwash should also be addressed for nearby sources whose emissions are on or near rooftops in the project area. Building downwash occurs when air moving over a building mixes to the ground on the "downwind" side of the building. AERMOD includes algorithms to model the effects of building downwash on plumes from nearby or adjacent point sources. Consult the AERMOD User's Guide for additional detail on how to enter building information.

J.3.2 Placement and sizing of sources within AERMOD

There are several general considerations with regard to placing and sizing sources within AERMOD.

First, line/area, volume, and point sources should be placed in the locations where emissions are most likely to occur. For example: if buses enter and exit a bus terminal from a single driveway, the driveway should be modeled using one or more discrete volume or area sources in the location of that driveway, rather than spreading the emissions from that driveway across the entire terminal yard.

Second, for emissions from the sides or tops of buildings (as may be found from a bus garage exhaust fan), it may be necessary to use the BPIPPRIME utility in AERMOD to appropriately capture the characteristics of these emissions (such as downwash).

Third, the initial dimensions and other parameters of each source should be as realistic as is feasible. Chapter 3 of the AERMOD User's Guide includes recommendations for how to appropriately characterize the shape of area and volume sources.

Finally, if nearby sources are to be included in air quality modeling (see discussion in Section 8 of the guidance), a combination of all these source types may be needed to appropriately represent their emissions within AERMOD. For instance, evenly-distributed ground-level sources might also be modeled as area sources, while a nearby power plant stack might be modeled as a point source.

J.3.3 Timing of Emissions in AERMOD

Within AERMOD, emissions that vary across a year should be described with the EMISFACT keyword (see Section 3.3.11 of the AERMOD User's Guide). The number of quarters that need to be analyzed may vary based on a particular PM hot-spot analysis. See Section 2.5 of the guidance for more information on when PM emissions need to be evaluated, and Sections 4 and 5 of the guidance on determining the number of MOVES and EMFAC runs.

The emission model runs for each day should be mapped to the hours they represent in the AERMOD input file, corresponding to the relevant hours of the day based on the traffic analysis. The *Qflag* parameter under EMISFACT may be used with a secondary keyword to describe different patterns of emission variations throughout a year. *Qflag* can be used to represent emission rates that vary by season, hour of day, and day of the week. Consult the AERMOD User's Guide for details.

Note that AERMOD defines seasons in the following manner: winter (December, January, February), spring (March, April, May), summer (June, July, August), and fall (September, October, November).

Emission data obtained from MOVES or EMFAC should be appropriately matched with the relevant time periods in AERMOD:

- If only four MOVES runs are done based on Section 4.3 of this guidance, those four runs would be applied to the 24 hours of every month. In this case, the *Qflag* parameter to use would be HRODAY, so that emission rates vary by hour-of-day only.
- If additional MOVES or EMFAC runs are completed to capture seasonal variation in emissions, such as 16 runs to model four times of the day in each season of a year, the *Qflag* parameter to use would be SEASHR to allow emission rates to vary by season and hour-of-day.[8]
- If separate weekend emission rates are available, season-specific weekday runs should be used for the Monday-Friday entries; weekend runs would be assigned to the Saturday and Sunday entries.

For additional information, see the AERMOD User's Guide.

J.4 Incorporating Meteorological Data

This discussion supplements Section 7.5 of the guidance and describes in more detail how to handle meteorological data in AERMOD. Section 7.2.3 of Appendix W to 40 CFR Part 51 provides the basis for determining the urban/rural status of a source. Consult the AERMOD Implementation Guide for instructions on what type of population data should be used in making urban/rural determinations.

As described in Section 7 of the guidance, AERMOD employs nearby population as a surrogate for the magnitude of differential urban-rural heating (i.e., the urban heat island effect). When modeling urban sources in AERMOD, users should use the URBANOPT keyword to enter this data.

When considering urban roughness lengths, users should consult the AERMOD Implementation Guide. Any application of AERMOD that utilizes a value other than 1 meter for the urban roughness length should be considered a non-regulatory application and would require appropriate documentation and justification as an alternate model (see Section 7.3.3 of the guidance).

For urban applications using representative National Weather Service (NWS) meteorological data, consult the AERMOD Implementation Guide. For urban applications using NWS data, the URBANOPT keyword should be selected, regardless of whether the NWS site is located in a nearby rural or urban setting. When using site-

[8] In the case of 16 runs, for example, the January morning MOVES run emissions would be used in AERMOD for all the morning hours of December, January, and February. Similarly, the January midday MOVES run emissions would apply for all the midday hours of December, January, and February. In this way, the modeler would apply the emissions from the 16 MOVES runs to the 24 hours in the four seasons in AERMOD as appropriate.

specific meteorological data in urban applications, consult the AERMOD Implementation Guide.

J.5 Modeling Complex Terrain

This discussion supplements Section 7.5 of the guidance and describes in more detail how to address complex terrain in AERMOD. In most situations, the project area should be modeled as having flat terrain. Additional detail on how this should be accomplished in each model is found below. However, in some situations a project area may include complex terrain, such that sources and receptors included in the model are found at different heights.
Analysts should consult the most recent AERMOD Implementation Guide for the latest guidance on modeling complex terrain.

For most highway and transit projects, the analyst should apply the non-DFAULT option in AERMOD and assume flat, level terrain. In the AERMOD input file, the FLAT option should be used in the MODELOPT keyword. This recommendation is made to avoid underestimating concentrations in two circumstances likely to occur with the low-elevation, non-buoyant emissions from transportation projects. First, in DFAULT mode, AERMOD will tend to underestimate concentrations from low-level, non-buoyant sources where there is up-sloping terrain with downwind receptors uphill since the DFAULT downwind horizontal plume will pass below the actual receptor elevation. Second, in DFAULT mode, AERMOD will tend to underestimate concentrations when a plume is terrain-following. Therefore, the FLAT option should be selected in most cases.

There may be some cases where significant concentrations result from nearby elevated sources. In these cases, interagency consultation should be used on a case-by-case basis to determine whether to include terrain effects and use the DFAULT option. In those cases, AERMAP should be used to prepare input files for AERMOD; consult the AERMOD and AERMAP user guides and the latest AERMOD Implementation Guide for information on obtaining and processing relevant terrain data.

J.6 Running AERMOD and Obtaining Results

This discussion supplements Section 7.7 of the guidance and describes in more detail how to handle data outputs in AERMOD.
AERMOD requires that users specify the type and format of output files in the main input file for each run. See Section 3.7 of the AERMOD User's Guide for details on the various output options. Output options should be specified to enable the relevant design concentration calculations required in Section 9.3. Note that many users will have multiple years of meteorological data, so multiple output files may be required (unless the meteorological files have been joined prior to running AERMOD – which is recommended for most analyses).

For the annual $PM_{2.5}$ design concentration calculations described in Section 9.3.2, averaging times should be specified that allow calculation of the annual average concentrations at each receptor. For example, when using five years of meteorological data, the ANNUAL averaging time should be specified using the AVERTIME keyword in the CO pathway. For the OU pathway, a POSTFILE keyword should be defined to obtain the annual average concentrations at each receptor.

For the 24-hour $PM_{2.5}$ design concentration calculations described in Section 9.3.3, the RECTABLE keyword should be used to obtain the average 98^{th} percentile concentration at each receptor. The eighth high value should be requested, because this would be the 98^{th} percentile concentration for the year, that is, of 365 values. In conjunction with defining PM2.5 in the POLLUTID keyword of the Control pathway, the concentrations generated in the output will be an average across N-years of meteorological data. If five years of meteorological data were used, the output will be calculated as the average 98^{th} percentile value and can be added directly to the 98^{th} percentile background concentration to determine the 24-hr PM2.5 design concentration for a first tier approach (described in Section 9 and Appendix K).

See Appendix L for information on using AERMOD for a second tier design concentration approach.

For the 24-hour PM_{10} calculations, the RECTABLE keyword may be used to obtain the sixth highest 24-hour concentrations over the entire modeling period (assuming five years of meteorological data were used). The output will be calculated as the sixth high value at each receptor and can be added directly to the appropriate background concentration (i.e., fourth-, third-, second-highest, or highest, based on Exhibit 9-6) to determine the 24-hr PM_{10} design concentration (described in Section 9 and Appendix K).

Appendix K:
Examples of Design Concentration Calculations for PM Hot-Spot Analyses

K.1 Introduction

This appendix supplements Section 9's discussion of calculating and applying design concentrations for PM hot-spot analyses. While this guidance can apply to any PM NAAQS, this appendix provides examples of how to calculate design concentrations for the PM NAAQS that apply in most areas:

- the 2012 annual $PM_{2.5}$ NAAQS,
- the 2006 and 1997 24-hour $PM_{2.5}$ NAAQS, and
- the 1987 24-hour PM_{10} NAAQS.

The design concentrations in this appendix are calculated using the steps described in Section 9.3. Readers should reference the appropriate sections of the guidance as needed for more detail on how to complete each step of these analyses.

These illustrative example calculations demonstrate the basic procedures described in the guidance and therefore are simplified in the number of receptors considered and other details that would occur in an actual PM hot-spot analysis. Where users would have to repeat steps for additional receptors, it is noted. These examples are organized according to the build/no-build analysis steps that are described in Sections 2 and 9 of this guidance.

K.2 Project Description and Context for All Examples

For the following examples, a PM hot-spot analysis is being done for an expansion of an existing highway with a significant increase in the number of diesel vehicles (40 CFR 93.123(b)(1)(i)). The highway expansion will serve an expanded freight terminal. The traffic at the terminal will increase as a result of the expanded highway project's increase in truck traffic, and therefore the freight terminal is projected to have higher emissions under the build scenario than under the no-build scenario. The freight terminal is not part of the project; however, it is a nearby source that will be included in the air quality modeling, as described further below.

The air quality monitor selected to represent background concentrations from other sources is a Federal Equivalent Method (FEM) monitor that is 300 meters upwind of the project. The monitor is on a 1-in-3 day sampling schedule. In this example, the three most recent years of monitoring data are from 2018, 2019, and 2020. For this example,

there are 121 monitored values for both 2018 and 2019 (365 days each), and 122 values in 2020 since it is a leap year (366 days).[1]

However, through interagency consultation, it is determined that the freight terminal's emissions are not already captured by this air quality monitor, so AERMOD is used to estimate PM concentrations produced by the project (the highway expansion) and the nearby source (the freight terminal). There are five years of representative off-site meteorological data being used in this analysis.

As discussed in Section 2.4, a project sponsor could consider mitigation and control measures at any point in the process. However, since the purpose of these examples is to show the design concentration calculations, in this appendix such measures are not considered until after the calculations are done.

K.3 Example: Annual $PM_{2.5}$ NAAQS

K.3.1 General

This example illustrates the approach to calculating design concentrations for comparison to the annual $PM_{2.5}$ NAAQS, as described in Section 9.3.2. The annual $PM_{2.5}$ design value is the average of three consecutive years' annual averages. The design value for comparison is rounded to the nearest tenth of a $\mu g/m^3$ (nearest 0.1 $\mu g/m^3$). For example, 12.049 rounds to 12.0, and 12.050 rounds to 12.1.[2]

Each year's annual average concentrations include contributions from the project, any nearby sources modeled, and background concentrations. For air quality monitoring purposes, the annual $PM_{2.5}$ NAAQS is met when the three-year average concentration is less than or equal to the current annual $PM_{2.5}$ NAAQS (i.e., 15.0 $\mu g/m^3$):

Annual $PM_{2.5}$ design value = ([Y1] average + [Y2] average + [Y3] average) ÷ 3

Where:
[Y1] = Average annual $PM_{2.5}$ concentration for the first year of air quality monitoring data
[Y2] = Average annual $PM_{2.5}$ concentration for the second year of air quality monitoring data

[1] Note that the number of air quality monitoring measurements may vary by year. For example, with 1-in-3 measurements, there could be 122 or 121 measurements in a year with 365 days. Or, there may be fewer actual monitored values if sampling was not conducted on some scheduled days or the measured value was invalidated due to quality assurance concerns. The actual number of samples with valid data should be used.

[2] A sufficient number of decimal places (3-4) should be retained during intermediate calculations for design values, so that there is no possibility of intermediate rounding or truncation affecting the final result. Rounding to the tenths place should only occur during final design value calculations, pursuant to Appendix N to 40 CFR Part 50.

[Y3] = Average annual $PM_{2.5}$ concentration for the third year of air quality monitoring data

For this example, the project described in Appendix K.2 is located in an annual $PM_{2.5}$ NAAQS nonattainment area. This example illustrates how an annual $PM_{2.5}$ design concentration could be calculated at the same receptor in the build and no-build scenarios, based on air quality modeling results and air quality monitoring data. In an actual PM hot-spot analysis, design concentrations would be calculated at additional receptors, as described further in Section 9.3.2.

K.3.2 Build Scenario

For the build scenario, the $PM_{2.5}$ impacts from the project and from the nearby source are estimated with AERMOD at all receptors.[3]

Steps 1. The receptor with the highest average annual concentration, using five years of meteorological data, is identified directly from the AERMOD output. This receptor's average annual concentration is 3.603 $\mu g/m^3$.

Step 2. Based on the three years of measurements at the background air quality monitor, the average monitored background concentrations in each quarter is determined. Then, for each year of background data, the four quarters are averaged to get an average annual background concentration (last column of Exhibit K-1). These three average annual background concentrations are averaged, and the resulting value is 11.582 $\mu g/m^3$, as shown in Exhibit K-1:

Exhibit K-1. Background Concentrations

Background Concentrations	Q1	Q2	Q3	Q4	Average Annual
Year 1	13.013	17.037	8.795	8.145	11.748
Year 2	14.214	14.872	7.912	7.639	11.159
Year 3	11.890	16.752	9.421	9.287	11.838
3-year average:					11.582

Step 3. The 3-year average annual background concentration (from Step 2) is added to the average annual modeled concentration from the project and nearby source (from Step 1):

11.582 + 3.603 = 15.185

[3] As noted above, there is a single nearby source that is projected to have higher emissions under the build scenario than the no-build scenario as a result of the project and its impacts are not expected to be captured by the monitor chosen to provide background concentrations. Therefore, emissions from the project and this nearby source are both included in the AERMOD modeling.

Step 4. Rounding to the nearest 0.1 $\mu g/m^3$ produces a design concentration of 15.2 $\mu g/m^3$.

In this example, the concentration at the highest receptor is estimated to exceed the 2012 annual $PM_{2.5}$ NAAQS of 12.0 $\mu g/m^3$.

Steps 5-6: Since the design concentration in Step 4 is greater than the NAAQS, design concentration calculations are then completed for all receptors in the build scenario, and receptors with design concentrations above the NAAQS are identified. After this is done, the no-build scenario is modeled for comparison.

K.3.3 No-Build Scenario

The no-build scenario (i.e., the existing highway and freight terminal without the proposed highway and freight terminal expansion), is modeled at all of the receptors in the build scenario, but design concentrations are only calculated in the no-build scenario at receptors where the design concentration for the build scenario is above the annual $PM_{2.5}$ NAAQS (from Steps 5-6 above).

Step 7. For this example, the receptor with the highest average annual concentration in the build scenario is used to illustrate the no-build scenario design concentration calculation. The average annual concentration modeled at this receptor in the no-build scenario is 3.521 $\mu g/m^3$.

Step 8. The background concentrations from the representative monitor are unchanged from the build scenario, so the average annual modeled concentration of 3.521 is added to the 3-year average annual background concentrations of 11.528 $\mu g/m^3$ from Step 3:

$$11.582 + 3.521 = 15.103$$

Step 9. Rounding to the nearest 0.1 $\mu g/m^3$ produces a design concentration of 15.1 $\mu g/m^3$.

In this example, the design concentration at the receptor in the build scenario (15.2 $\mu g/m^3$) is greater than the design concentration at the same receptor in the no-build scenario (15.1 $\mu g/m^3$).[4] In an actual PM hot-spot analysis, design concentrations would also be compared between build and no-build scenarios at all receptors in the build scenario that exceeded the annual $PM_{2.5}$ NAAQS. The interagency consultation process would then be used to discuss next steps, e.g., appropriateness of receptors. Refer to Sections 9.2 and 9.4 for additional details.

If it is determined that conformity requirements are not met at all appropriate receptors, the project sponsor should then consider additional mitigation or control measures, as

[4] Values are compared after rounding. As long as the build design value is no greater than the no-build design value after rounding, the project would meet conformity requirements at a given receptor, even if the pre-rounding build design value is greater than the pre-rounding no-build design value.

discussed in Section 10. After measures are selected, a new build scenario that includes the controls should be modeled and new design concentrations calculated. Design concentrations for the no-build scenario shown above would not need to be recalculated since the no-build scenario would not change.

K.4 Example: 24-Hour $PM_{2.5}$ NAAQS

K.4.1 General

This example illustrates a first tier approach to calculating design concentrations for comparison with the 24-hour $PM_{2.5}$ NAAQS. As discussed in Section 9, while either approach is acceptable, EPA recommends beginning with a first tier approach as there are very few cases where a second tier approach would not produce a more conservative design concentration. See Appendix L for information on using a second tier approach.

The 24-hour design value is the average of three consecutive years' 98^{th} percentile $PM_{2.5}$ concentration of 24-hour values for each of those years. For air quality monitoring purposes, the NAAQS is met when that three-year average concentration is less than or equal to the currently applicable 24-hour $PM_{2.5}$ NAAQS for a given area's nonattainment designation (35 $\mu g/m^3$ for nonattainment areas for the 2006 $PM_{2.5}$ NAAQS and 65 $\mu g/m^3$ for nonattainment areas for the 1997 $PM_{2.5}$ NAAQS).[5] The design value for comparison to any 24-hour $PM_{2.5}$ NAAQS is rounded to the nearest 1 $\mu g/m^3$ (i.e., decimals 0.5 and greater are rounded up to the nearest whole number, and any decimal lower than 0.5 is rounded down to the nearest whole number). For example, 35.499 rounds to 35 $\mu g/m^3$, while 35.500 rounds to 36.[6]

For this example, the project described in Appendix K.2 is located in a nonattainment area for the 2006 24-hour $PM_{2.5}$ NAAQS. This example presents the first tier build scenario results for a single receptor to illustrate how the calculations should be made based on air quality modeling results and air quality monitoring data. In an actual PM hot-spot analysis, design concentrations would be calculated at additional receptors, as described further in Section 9.3.3.

K.4.2 Build Scenario

$PM_{2.5}$ contributions from the project and the nearby source are estimated together with AERMOD in each of four quarters using meteorological data from five consecutive years, using a 24-hour averaging time. As discussed in Appendix K.2 above, the one nearby source (the freight terminal) was included in air quality modeling.

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[5] There are only two $PM_{2.5}$ areas where conformity currently applies for both the 1997 and 2006 24-hour NAAQS. While both 24-hour NAAQS must be considered in these areas, in practice if the more stringent 2006 24-hour $PM_{2.5}$ NAAQS is met, then the 1997 24-hour $PM_{2.5}$ NAAQS is met as well.

[6] A sufficient number of decimal places (3-4) should be retained during intermediate calculations for design values, so that there is no possibility of intermediate rounding or truncation affecting the final result. Rounding should only occur during final design value calculations, pursuant to Appendix N to 40 CFR Part 50.

Under a first tier analysis, the average 98th percentile modeled 24-hour concentrations at a given receptor are added to the average 98th percentile 24-hour background concentrations, regardless of the quarter in which they occur. The average 98th percentile modeled 24-hour concentrations are produced by AERMOD, using five years of meteorological data in one run.

Step 1. The receptor with the highest average 98th percentile modeled 24-hour concentration is identified from the AERMOD output. For this example, the data from this receptor is shown in Exhibit K-2. Exhibit K-2 shows the 98th percentile 24-hour concentration for each year of meteorological data used. The average concentration of these outcomes, 3.710 $\mu g/m^3$ (highlighted in Exhibit K-2), is the highest, compared to the averages at all of the other receptors.

Exhibit K-2. Modeled 98th Percentile $PM_{2.5}$ Concentrations from Project and Nearby Source

Year	98th Percentile $PM_{2.5}$ Concentration
Met Year 1	3.413
Met Year 2	2.846
Met Year 3	3.671
Met Year 4	4.951
Met Year 5	3.667
Average	3.710

Step 2. The average 98th percentile 24-hour background concentration for a first tier analysis is calculated using the 98th percentile 24-hour concentrations of the three most recent years of monitoring data from the representative air quality monitor selected (see Appendix K.2). Since the background monitor is on a 1-in-3 day sampling schedule, it made either 122 or 121 measurements per year during the three most recent years. According to Exhibit 9-5, with this number of monitored values per year, the 98th percentile is the third highest concentration. Exhibit K-3 depicts the top eight monitored concentrations (in $\mu g/m^3$) of the monitor throughout the years employed for estimating background concentrations.

Exhibit K-3. Top Eight Monitored Concentrations in the Three Most Recent Years

Rank	Year 1	Year 2	Year 3
1	34.123	33.537	35.417
2	31.749	32.405	31.579
3	31.443	31.126	31.173
4	30.809	30.819	31.095
5	30.219	30.487	30.425
6	30.134	29.998	30.329
7	30.099	29.872	30.193
8	28.481	28.937	28.751

The third-ranked concentration of each year (highlighted in Exhibit K-3) is the 98th percentile value. These are averaged:

(31.443 + 31.126 + 31.173) ÷ 3 = 31.247 μg/m^3.

Step 3. Then, the 98th percentile average 24-hour modeled concentration for this receptor (from Step 1) is added to the average 98th percentile 24-hour background concentration (from Step 2):

3.710 + 31.247 = 34.957 μg/m^3.

Rounding to the nearest whole number results in a 24-hour $PM_{2.5}$ design concentration of 35 μg/m^3.

This concentration is equal to the 2006 24-hour $PM_{2.5}$ NAAQS (35 μg/m^3), and therefore this analysis demonstrates that conformity is met.

If the project had not passed the initial build comparison, the project sponsor has two options:

1. Repeat the first tier analysis for the no-build scenario at all receptors that exceeded the NAAQS in the build scenario. If the calculated design concentration for the build scenario is less than or equal to the design concentration for the no-build scenario at all of these receptors, then the project conforms; or
2. Conduct a second tier approach – See Appendix L.

K.5 Example: 24-Hour PM_{10} NAAQS

K.5.1 General

This example illustrates calculating design concentrations for comparison with the 24-hour PM_{10} NAAQS, as described in Section 9.3.4. The 24-hour PM_{10} NAAQS is based on the expected number of 24-hour exceedances of 150 $\mu g/m^3$, averaged over three consecutive years. For air quality monitoring purposes, the NAAQS is met when the expected number of days per calendar year with a 24-hour concentration above 150 $\mu g/m^3$ is less than or equal to 1.0. The 24-hour PM_{10} daily value is rounded to the nearest 10 $\mu g/m^3$. For example, 155.500 rounds to 160, and 154.999 rounds to 150.[7]

The 24-hour PM_{10} design concentration is calculated at each air quality modeling receptor by directly adding the sixth-highest modeled 24-hour concentration (if using five years of meteorological data) to the appropriate monitor value for the 24-hour background concentration (from three years of monitored data), based on Exhibit 9-6.

For this example, the project described in Appendix K.2 is located in a nonattainment area for the 24-hour PM_{10} NAAQS. This example presents build scenario results for a single receptor to illustrate how the calculations should be made based on air quality modeling results and air quality monitoring data.

K.5.2 Build Scenario

Step 1. From the air quality modeling results from the build scenario, the sixth-highest 24-hour concentration is identified at each receptor. These sixth-highest concentrations are the sixth highest that are modeled at each receptor, regardless of year of meteorological data used.[8] AERMOD was configured to produce these values.

Step 2. The sixth-highest modeled concentrations (i.e., the concentrations at Rank 6) are compared across receptors, and the receptor with the highest value at Rank 6 is identified. For this example, the highest sixth-highest 24-hour concentration at any receptor is 15.218 $\mu g/m^3$. (That is, at all other receptors, the sixth-highest concentration is less than 15.218 $\mu g/m^3$.) Exhibit K-4 shows the six highest 24-hour concentrations at this receptor.

[7] This rounding convention comes from Appendix K to 40 CFR Part 50. A sufficient number of decimal places (3-4) in modeling results should be retained during intermediate calculations for design values, so that there is no possibility of intermediate rounding or truncation affecting the final result. Rounding to the nearest 10 ug/m^3 should only occur during final design value calculations, pursuant to Appendix K to 40 CFR Part 50. Monitoring values typically are reported with only one decimal place.

[8] The six highest concentrations could occur anytime during the five years of meteorological data. They may be clustered in one or two years, or they may be spread out over several, or even all five, years of the meteorological data.

Exhibit K-4. Receptor with the Highest Sixth-Highest 24-Hour Concentration (Build Scenario)

Rank	Highest 24-Hour Concentrations
1	17.012
2	16.709
3	15.880
4	15.491
5	15.400
6	15.218

Step 3. In this example, the background monitor collects data every third day (1-in-3 sampling) and has a total of 360 daily readings in the most recent three year period. The appropriate 24-hour background concentration from the three most recent years of monitoring data is identified based on Exhibit 9-6. The information in Exhibit 9-6 has been repeated in Exhibit K-5 below, along with the highest four values from the background monitor:

Exhibit K-5: Highest Values from the Chosen Background Monitor (360 Readings in the Most Recent Three-Year Period)

Number of Background Concentration Values from the Monitor	Monitor Value Used for Design Concentration Calculation	Highest Values from the Chosen Background Monitor
< 347	Highest Monitor Value	112.490
348 - 695	Second Highest Value	86.251
696 - 1042	Third Highest Value	75.821
1043 - 1096	Fourth Highest Value	75.217

Because the monitor has 360 readings in the most recent three-year period, the second-highest 24-hour background concentration is used for the design concentration calculation. The second-highest value is 86.251 $\mu g/m^3$.

Step 4. The sixth-highest 24-hour modeled concentration of 15.218 $\mu g/m^3$ from the highest receptor (from Step 2) is added to the second-highest 24-hour background concentration of 86.251 $\mu g/m^3$ (from Step 3):

15.218 + 86.251 = 101.469

Step 5. This sum is rounded to the nearest 10 $\mu g/m^3$, which results in a design concentration of 100 $\mu g/m^3$.

This result is then compared to the 24-hour PM_{10} NAAQS. In this case, the concentration calculated at all receptors is less than the 24-hour PM_{10} NAAQS of 150 $\mu g/m^3$, therefore

the analysis shows that the project conforms. However, if the design concentration for this receptor had been greater than 150 $\mu g/m^3$, the remainder of the steps in Section 9.3.4 would be completed. That is, build scenario design concentrations for each receptor would be calculated (Steps 6-7 in Section 9.3.4) and, for all those that exceed the NAAQS, the no-build design concentrations would also be calculated (Steps 8-10 in Section 9.3.4). The build and no-build design concentrations would then be compared.[9]

[9] Values are compared after rounding. As long as the build design value is no greater than the no-build design value after rounding, the project would meet conformity requirements at a given receptor, even if the pre-rounding build design value is greater than the pre-rounding no-build design value.

Appendix L:
Calculating 24-hour $PM_{2.5}$ Design Concentrations Using a Second Tier Approach

L.1 Introduction

As described in Section 9, design concentrations for the 24-hr $PM_{2.5}$ NAAQS may be calculated using either a first tier or second tier approach. Generally, the first tier approach involves adding the 98th percentile monitored data directly to each receptor's 98th percentile modeled concentrations. The second tier approach requires developing a 98th percentile background concentration for each quarter. Those values are then read into the AERMOD input file and used to calculate an appropriate 98th percentile design concentration for each receptor – done entirely within the model. EPA believes that most analyses should be done with a first tier approach, as described in Section 9 and illustrated in Appendix K. The first tier approach requires much less processing of monitoring data and modeled concentrations. However, users may choose to follow the second tier approach to meet conformity requirements if through interagency consultation it is determined that a first tier approach is overly conservative. The second tier process includes the following general steps:

1) Calculate quarterly 98th percentile values from the monitoring data
2) Add quarterly background concentrations to AERMOD input file
3) Run AERMOD to generate 98th percentile concentrations at each receptor

This process differs from the methodology described for the first tier approach, as well as $PM_{2.5}$ annual and PM_{10} design concentration calculations. Notably, background is handled first, then added into the AERMOD input file. AERMOD will automatically generate the appropriate 98th percentile design concentration.

The remainder of Appendix L describes an example of a second tier design concentration approach, as well as the steps involved with adding background concentrations to an AERMOD input file.

L.2 Preparing Monitoring Data

This appendix provides an illustrative example of the calculations and data sorting recommendations for the background monitoring data to be used in a second tier modeling approach.[1] In this example, it was determined through interagency consultation that the impacts from the project's $PM_{2.5}$ emissions were most prominent during the cool season and were not temporally correlated with background $PM_{2.5}$ levels that were typical highest during the warm season. So, combining the modeled and

[1] This example has been adapted from the 2014 Guidance for $PM_{2.5}$ Permit Modeling, available at: http://www.epa.gov/ttn/scram/guidance/guide/Guidance_for_PM25_Permit_Modeling.pdf.

monitored contributions through a first tier approach was determined to be potentially overly conservative.

The example provided is from an idealized Federal Reference Method (FRM) $PM_{2.5}$ monitoring site that operates on a daily (1-in-1 day) frequency with 100% data completeness. In this case, the annual 98^{th} percentile concentration is the 8^{th} highest concentration of the year. In most cases, the FRM monitoring site will likely operate on a 1-and-3 day frequency and will also likely have missing data due to monitor maintenance or collected data not meeting all of the quality assurance criteria. Please reference Section 9 (Exhibit 9.5) and Appendix N to 40 CFR Part 50 to determine the appropriate 98^{th} percentile rank of the monitored data based on the monitor sampling frequency and valid number of days sampled during each year. The appropriate seasonal (or quarterly) background concentrations to be included as input to the AERMOD model per a second tier approach are as follows:

Step 1 – Start with the most recent three years of representative background $PM_{2.5}$ ambient monitoring data that are being used to develop the monitored background $PM_{2.5}$ concentration. In this example, the three years are labeled Year 1, Year 2, and Year 3.

Step 2 – For each year, determine the appropriate rank for the daily 98^{th} percentile $PM_{2.5}$ concentration. Again, this idealized example is from a 1-in-1 day monitor with 100% data completeness. So, the 8^{th} highest concentration of each year is the 98^{th} percentile $PM_{2.5}$ concentration. The 98^{th} percentile $PM_{2.5}$ concentration for Year 1 is highlighted in Exhibit L-1. The full concentration data from Year 2 and Year 3 are not shown across the steps in this Appendix for simplicity but would be similar to that of Year 1.

Step 3 – Remove from further consideration in this analysis the $PM_{2.5}$ concentrations from each year that are greater than the 98^{th} percentile $PM_{2.5}$ concentration. In the case presented for a 1-in-1 day monitor, the top 7 concentrations are removed. If the monitor were a 1-in-3 day monitor, only the top 2 concentrations would be removed. The resultant dataset after the top 7 concentrations have been removed from further consideration in this analysis for Year 1 is presented in Exhibit L-2.

Step 4 – For each year, divide the resultant annual dataset of the monitored data equal to or less than the 98^{th} percentile $PM_{2.5}$ concentration into each season (or quarter). For Year 1, the seasonal subsets are presented in Exhibit L-3.

Step 5 – Determine the maximum $PM_{2.5}$ concentration from each of the seasonal (or quarterly) subsets created in Step 4 for each year. The maximum $PM_{2.5}$ concentration from each season for Year 1 is highlighted in both Exhibits L-3 and L-4.

Step 6 – Average the seasonal (or quarterly) maximums from Step 5 across the three years of monitoring data to create the four seasonal background $PM_{2.5}$ concentrations to be included as inputs to the AERMOD model. These averages for the Year 1, Year 2, and Year 3 dataset used in this example are presented in Exhibit L-4. As noted above, the full concentration data only from Year 1 is shown in the exhibits in this appendix for

simplicity, but the seasonal maximums from Years 2 and 3 presented in Exhibit L-4 were determined by following the previous five steps, similar to that of Year 1.

Exhibit L-1. Year 1 Daily $PM_{2.5}$ Concentrations

Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.
1-Jan	10.4	16-Feb	15.1	2-Apr	10.5	18-May	11.1	3-Jul	17.1	18-Aug	18.7	3-Oct	12.3	18-Nov	4.4
2-Jan	5.4	17-Feb	11.8	3-Apr	8.2	19-May	7.7	4-Jul	19.8	19-Aug	21.5	4-Oct	19.5	19-Nov	8.2
3-Jan	10.0	18-Feb	3.4	4-Apr	9.7	20-May	13.6	5-Jul	14.3	20-Aug	20.1	5-Oct	23.7	20-Nov	11.1
4-Jan	16.4	19-Feb	4.5	5-Apr	6.9	21-May	12.1	6-Jul	11.5	21-Aug	18.4	6-Oct	19.8	21-Nov	5.3
5-Jan	11.2	20-Feb	4.8	6-Apr	6.3	22-May	10.0	7-Jul	14.3	22-Aug	16.7	7-Oct	21.7	22-Nov	8.9
6-Jan	11.1	21-Feb	11.9	7-Apr	7.9	23-May	13.3	8-Jul	12.2	23-Aug	13.8	8-Oct	12.2	23-Nov	14.0
7-Jan	10.2	22-Feb	20.1	8-Apr	9.8	24-May	11.2	9-Jul	11.1	24-Aug	19.0	9-Oct	5.1	24-Nov	12.7
8-Jan	11.4	23-Feb	11.4	9-Apr	16.5	25-May	17.7	10-Jul	9.7	25-Aug	17.6	10-Oct	10.2	25-Nov	9.7
9-Jan	8.1	24-Feb	19.3	10-Apr	13.3	26-May	14.2	11-Jul	16.4	26-Aug	15.4	11-Oct	10.7	26-Nov	12.8
10-Jan	9.4	25-Feb	18.2	11-Apr	11.0	27-May	15.4	12-Jul	21.5	27-Aug	12.6	12-Oct	5.6	27-Nov	16.6
11-Jan	5.7	26-Feb	12.8	12-Apr	8.8	28-May	13.9	13-Jul	25.1	28-Aug	12.1	13-Oct	5.9	28-Nov	17.2
12-Jan	8.9	27-Feb	5.5	13-Apr	6.3	29-May	9.3	14-Jul	11.7	29-Aug	10.1	14-Oct	9.7	29-Nov	16.6
13-Jan	18.1	28-Feb	9.7	14-Apr	5.1	30-May	14.5	15-Jul	18.9	30-Aug	17.2	15-Oct	12.8	30-Nov	4.5
14-Jan	11.0	29-Feb	12.1	15-Apr	7.9	31-May	20.5	16-Jul	28.9	31-Aug	19.9	16-Oct	16.4	1-Dec	7.5
15-Jan	11.8	1-Mar	9.6	16-Apr	8.2	1-Jun	15.3	17-Jul	27.6	1-Sep	19.4	17-Oct	12.0	2-Dec	10.6
16-Jan	10.7	2-Mar	5.6	17-Apr	14.7	2-Jun	11.5	18-Jul	12.8	2-Sep	18.2	18-Oct	7.9	3-Dec	16.7
17-Jan	10.0	3-Mar	12.5	18-Apr	22.5	3-Jun	17.9	19-Jul	6.2	3-Sep	24.0	19-Oct	6.6	4-Dec	12.5
18-Jan	15.6	4-Mar	7.1	19-Apr	12.8	4-Jun	21.1	20-Jul	20.1	4-Sep	15.4	20-Oct	8.1	5-Dec	7.3
19-Jan	18.0	5-Mar	4.9	20-Apr	6.9	5-Jun	17.9	21-Jul	26.5	5-Sep	12.4	21-Oct	12.2	6-Dec	10.4
20-Jan	6.6	6-Mar	9.9	21-Apr	7.5	6-Jun	17.6	22-Jul	16.9	6-Sep	12.5	22-Oct	4.6	7-Dec	13.4
21-Jan	7.4	7-Mar	11.2	22-Apr	6.0	7-Jun	15.0	23-Jul	12.8	7-Sep	15.8	23-Oct	6.1	8-Dec	10.5
22-Jan	13.5	8-Mar	5.5	23-Apr	9.1	8-Jun	22.3	24-Jul	7.9	8-Sep	23.4	24-Oct	4.6	9-Dec	9.3
23-Jan	16.0	9-Mar	8.8	24-Apr	10.3	9-Jun	27.9	25-Jul	15.7	9-Sep	11.5	25-Oct	4.5	10-Dec	6.5
24-Jan	9.4	10-Mar	11.0	25-Apr	12.0	10-Jun	21.6	26-Jul	24.9	10-Sep	6.0	26-Oct	10.5	11-Dec	3.0
25-Jan	12.6	11-Mar	12.1	26-Apr	12.5	11-Jun	19.4	27-Jul	22.2	11-Sep	11.8	27-Oct	6.4	12-Dec	3.5
26-Jan	13.6	12-Mar	9.7	27-Apr	11.3	12-Jun	21.2	28-Jul	17.5	12-Sep	10.7	28-Oct	4.6	13-Dec	10.2
27-Jan	16.1	13-Mar	15.1	28-Apr	7.6	13-Jun	29.1	29-Jul	19.1	13-Sep	7.6	29-Oct	5.6	14-Dec	17.6
28-Jan	10.0	14-Mar	21.6	29-Apr	7.4	14-Jun	15.6	30-Jul	21.1	14-Sep	7.5	30-Oct	7.6	15-Dec	12.4
29-Jan	10.4	15-Mar	16.6	30-Apr	11.4	15-Jun	14.8	31-Jul	18.0	15-Sep	7.1	31-Oct	11.2	16-Dec	9.7
30-Jan	6.9	16-Mar	7.9	1-May	12.6	16-Jun	17.8	1-Aug	16.3	16-Sep	7.7	1-Nov	16.2	17-Dec	7.0
31-Jan	4.9	17-Mar	9.6	2-May	10.0	17-Jun	12.6	2-Aug	19.3	17-Sep	11.3	2-Nov	17.3	18-Dec	7.9
1-Feb	5.4	18-Mar	10.3	3-May	11.2	18-Jun	10.5	3-Aug	17.9	18-Sep	16.8	3-Nov	18.3	19-Dec	6.9
2-Feb	7.1	19-Mar	8.4	4-May	10.4	19-Jun	15.0	4-Aug	25.1	19-Sep	14.8	4-Nov	8.9	20-Dec	8.1
3-Feb	10.9	20-Mar	4.9	5-May	15.7	20-Jun	22.7	5-Aug	29.3	20-Sep	8.0	5-Nov	5.8	21-Dec	4.9
4-Feb	12.1	21-Mar	8.7	6-May	16.1	21-Jun	18.7	6-Aug	19.1	21-Sep	10.8	6-Nov	8.6	22-Dec	7.7
5-Feb	17.1	22-Mar	13.3	7-May	16.8	22-Jun	15.2	7-Aug	14.0	22-Sep	14.5	7-Nov	15.0	23-Dec	7.7
6-Feb	10.3	23-Mar	12.2	8-May	14.5	23-Jun	16.8	8-Aug	10.8	23-Sep	21.2	8-Nov	8.3	24-Dec	10.5
7-Feb	4.0	24-Mar	10.3	9-May	11.7	24-Jun	15.1	9-Aug	15.0	24-Sep	8.6	9-Nov	10.0	25-Dec	6.5
8-Feb	9.7	25-Mar	11.9	10-May	9.0	25-Jun	20.7	10-Aug	21.7	25-Sep	1.2	10-Nov	12.8	26-Dec	7.6
9-Feb	11.5	26-Mar	20.1	11-May	6.7	26-Jun	23.0	11-Aug	14.3	26-Sep	16.0	11-Nov	11.8	27-Dec	13.3
10-Feb	3.0	27-Mar	22.5	12-May	7.9	27-Jun	17.8	12-Aug	14.7	27-Sep	12.1	12-Nov	14.8	28-Dec	6.4
11-Feb	5.5	28-Mar	18.2	13-May	8.3	28-Jun	12.4	13-Aug	13.0	28-Sep	18.0	13-Nov	14.5	29-Dec	3.7
12-Feb	18.9	29-Mar	10.8	14-May	12.2	29-Jun	12.7	14-Aug	13.5	29-Sep	17.8	14-Nov	7.7	30-Dec	4.7
13-Feb	17.6	30-Mar	6.4	15-May	13.1	30-Jun	8.9	15-Aug	17.5	30-Sep	16.4	15-Nov	3.6	31-Dec	4.4
14-Feb	11.2	31-Mar	3.3	16-May	8.8	1-Jul	7.1	16-Aug	23.9	1-Oct	12.3	16-Nov	4.6		
15-Feb	14.4	1-Apr	7.8	17-May	8.2	2-Jul	13.8	17-Aug	18.4	2-Oct	8.2	17-Nov	7.8		

Annual 98th Percentile Concentration (highlighted green value) = 25.1

Exhibit L-2: Year 1 Daily $PM_{2.5}$ Concentrations Less Than or Equal to the 98th Percentile

Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.
1-Jan	10.4	16-Feb	15.1	2-Apr	10.5	18-May	11.1	3-Jul	17.1	18-Aug	18.7	3-Oct	12.3	18-Nov	4.4
2-Jan	5.4	17-Feb	11.8	3-Apr	8.2	19-May	7.7	4-Jul	19.8	19-Aug	21.5	4-Oct	19.5	19-Nov	8.2
3-Jan	10.0	18-Feb	3.4	4-Apr	9.7	20-May	13.6	5-Jul	14.3	20-Aug	20.1	5-Oct	23.7	20-Nov	11.1
4-Jan	16.4	19-Feb	4.5	5-Apr	6.9	21-May	12.1	6-Jul	11.5	21-Aug	18.4	6-Oct	19.8	21-Nov	5.3
5-Jan	11.2	20-Feb	4.8	6-Apr	6.3	22-May	10.0	7-Jul	14.3	22-Aug	16.7	7-Oct	21.7	22-Nov	8.9
6-Jan	11.1	21-Feb	11.9	7-Apr	7.9	23-May	13.3	8-Jul	12.2	23-Aug	13.8	8-Oct	12.2	23-Nov	14.0
7-Jan	10.2	22-Feb	20.1	8-Apr	9.8	24-May	11.2	9-Jul	11.1	24-Aug	19.0	9-Oct	5.1	24-Nov	12.7
8-Jan	11.4	23-Feb	11.4	9-Apr	16.5	25-May	17.7	10-Jul	9.7	25-Aug	17.6	10-Oct	10.2	25-Nov	9.7
9-Jan	8.1	24-Feb	19.3	10-Apr	13.3	26-May	14.2	11-Jul	16.4	26-Aug	15.4	11-Oct	10.7	26-Nov	12.8
10-Jan	9.4	25-Feb	18.2	11-Apr	11.0	27-May	15.4	12-Jul	21.5	27-Aug	12.6	12-Oct	5.6	27-Nov	16.6
11-Jan	5.7	26-Feb	12.8	12-Apr	8.8	28-May	13.9	13-Jul	RC	28-Aug	12.1	13-Oct	5.9	28-Nov	17.2
12-Jan	8.9	27-Feb	5.5	13-Apr	6.3	29-May	9.3	14-Jul	11.7	29-Aug	10.1	14-Oct	9.7	29-Nov	16.6
13-Jan	18.1	28-Feb	9.7	14-Apr	5.1	30-May	14.5	15-Jul	18.9	30-Aug	17.2	15-Oct	12.8	30-Nov	4.5
14-Jan	11.0	29-Feb	12.1	15-Apr	7.9	31-May	20.5	16-Jul	RC	31-Aug	19.9	16-Oct	16.4	1-Dec	7.5
15-Jan	11.8	1-Mar	9.6	16-Apr	8.2	1-Jun	15.3	17-Jul	RC	1-Sep	19.4	17-Oct	12.0	2-Dec	10.6
16-Jan	10.7	2-Mar	5.6	17-Apr	14.7	2-Jun	11.5	18-Jul	12.8	2-Sep	18.2	18-Oct	7.9	3-Dec	16.7
17-Jan	10.0	3-Mar	12.5	18-Apr	22.5	3-Jun	17.9	19-Jul	6.2	3-Sep	24.0	19-Oct	6.6	4-Dec	12.5
18-Jan	15.6	4-Mar	7.1	19-Apr	12.8	4-Jun	21.1	20-Jul	20.1	4-Sep	15.4	20-Oct	8.1	5-Dec	7.3
19-Jan	18.0	5-Mar	4.9	20-Apr	6.9	5-Jun	17.9	21-Jul	RC	5-Sep	12.4	21-Oct	12.2	6-Dec	10.4
20-Jan	6.6	6-Mar	9.9	21-Apr	7.5	6-Jun	17.6	22-Jul	16.9	6-Sep	12.5	22-Oct	4.6	7-Dec	13.4
21-Jan	7.4	7-Mar	11.2	22-Apr	6.0	7-Jun	15.0	23-Jul	12.8	7-Sep	15.8	23-Oct	6.1	8-Dec	10.5
22-Jan	13.5	8-Mar	5.5	23-Apr	9.1	8-Jun	22.3	24-Jul	7.9	8-Sep	23.4	24-Oct	4.6	9-Dec	9.3
23-Jan	16.0	9-Mar	8.8	24-Apr	10.3	9-Jun	RC	25-Jul	15.7	9-Sep	11.5	25-Oct	4.5	10-Dec	6.5
24-Jan	9.4	10-Mar	11.0	25-Apr	12.0	10-Jun	21.6	26-Jul	24.9	10-Sep	6.0	26-Oct	10.5	11-Dec	3.0
25-Jan	12.6	11-Mar	12.1	26-Apr	12.5	11-Jun	19.4	27-Jul	22.2	11-Sep	11.8	27-Oct	6.4	12-Dec	3.5
26-Jan	13.6	12-Mar	9.7	27-Apr	11.3	12-Jun	21.2	28-Jul	17.5	12-Sep	10.7	28-Oct	4.6	13-Dec	10.2
27-Jan	16.1	13-Mar	15.1	28-Apr	7.6	13-Jun	RC	29-Jul	19.1	13-Sep	7.6	29-Oct	5.6	14-Dec	17.6
28-Jan	10.0	14-Mar	21.6	29-Apr	7.4	14-Jun	15.6	30-Jul	21.1	14-Sep	7.5	30-Oct	7.6	15-Dec	12.4
29-Jan	10.4	15-Mar	16.6	30-Apr	11.4	15-Jun	14.8	31-Jul	18.0	15-Sep	7.1	31-Oct	11.2	16-Dec	9.7
30-Jan	6.9	16-Mar	7.9	1-May	12.6	16-Jun	17.8	1-Aug	16.3	16-Sep	7.7	1-Nov	16.2	17-Dec	7.0
31-Jan	4.9	17-Mar	9.6	2-May	10.0	17-Jun	12.6	2-Aug	19.3	17-Sep	11.3	2-Nov	17.3	18-Dec	7.9
1-Feb	5.4	18-Mar	10.3	3-May	11.2	18-Jun	10.5	3-Aug	17.9	18-Sep	16.8	3-Nov	18.3	19-Dec	6.9
2-Feb	7.1	19-Mar	8.4	4-May	10.4	19-Jun	15.0	4-Aug	25.1	19-Sep	14.8	4-Nov	8.9	20-Dec	8.1
3-Feb	10.9	20-Mar	4.9	5-May	15.7	20-Jun	22.7	5-Aug	RC	20-Sep	8.0	5-Nov	5.8	21-Dec	4.9
4-Feb	12.1	21-Mar	8.7	6-May	16.1	21-Jun	18.7	6-Aug	19.1	21-Sep	10.8	6-Nov	8.6	22-Dec	7.7
5-Feb	17.1	22-Mar	13.3	7-May	16.8	22-Jun	15.2	7-Aug	14.0	22-Sep	14.5	7-Nov	15.0	23-Dec	7.7
6-Feb	10.3	23-Mar	12.2	8-May	14.5	23-Jun	16.8	8-Aug	10.8	23-Sep	21.2	8-Nov	8.3	24-Dec	10.5
7-Feb	4.0	24-Mar	10.3	9-May	11.7	24-Jun	15.1	9-Aug	15.0	24-Sep	8.6	9-Nov	10.0	25-Dec	6.5
8-Feb	9.7	25-Mar	11.9	10-May	9.0	25-Jun	20.7	10-Aug	21.7	25-Sep	1.2	10-Nov	12.8	26-Dec	7.6
9-Feb	11.5	26-Mar	20.1	11-May	6.7	26-Jun	23.0	11-Aug	14.3	26-Sep	16.0	11-Nov	11.8	27-Dec	13.3
10-Feb	3.0	27-Mar	22.5	12-May	7.9	27-Jun	17.8	12-Aug	14.7	27-Sep	12.1	12-Nov	14.8	28-Dec	6.4
11-Feb	5.5	28-Mar	18.2	13-May	8.3	28-Jun	12.4	13-Aug	13.0	28-Sep	18.0	13-Nov	14.5	29-Dec	3.7
12-Feb	18.9	29-Mar	10.8	14-May	12.2	29-Jun	12.7	14-Aug	13.5	29-Sep	17.8	14-Nov	7.7	30-Dec	4.7
13-Feb	17.6	30-Mar	6.4	15-May	13.1	30-Jun	8.9	15-Aug	17.5	30-Sep	16.4	15-Nov	3.6	31-Dec	4.4
14-Feb	11.2	31-Mar	3.3	16-May	8.8	1-Jul	7.1	16-Aug	23.9	1-Oct	12.3	16-Nov	4.6		
15-Feb	14.4	1-Apr	7.8	17-May	8.2	2-Jul	13.8	17-Aug	18.4	2-Oct	8.2	17-Nov	7.8		

Annual 98th Percentile Concentration (highlighted green value) = 25.1

RC = Above 98th Percentile and Removed from Consideration (highlighted peach values)

Exhibit L-3. Year 1 Daily $PM_{2.5}$ Concentrations Less Than or Equal to the 98th Percentile by Quarter

Season / Quarter 1			
Date	Conc.	Date	Conc.
1-Jan	10.4	16-Feb	15.1
2-Jan	5.4	17-Feb	11.8
3-Jan	10.0	18-Feb	3.4
4-Jan	16.4	19-Feb	4.5
5-Jan	11.2	20-Feb	4.8
6-Jan	11.1	21-Feb	11.9
7-Jan	10.2	22-Feb	20.1
8-Jan	11.4	23-Feb	11.4
9-Jan	8.1	24-Feb	19.3
10-Jan	9.4	25-Feb	18.2
11-Jan	5.7	26-Feb	12.8
12-Jan	8.9	27-Feb	5.5
13-Jan	18.1	28-Feb	9.7
14-Jan	11.0	29-Feb	12.1
15-Jan	11.8	1-Mar	9.6
16-Jan	10.7	2-Mar	5.6
17-Jan	10.0	3-Mar	12.5
18-Jan	15.6	4-Mar	7.1
19-Jan	18.0	5-Mar	4.9
20-Jan	6.6	6-Mar	9.9
21-Jan	7.4	7-Mar	11.2
22-Jan	13.5	8-Mar	5.5
23-Jan	16.0	9-Mar	8.8
24-Jan	9.4	10-Mar	11.0
25-Jan	12.6	11-Mar	12.1
26-Jan	13.6	12-Mar	9.7
27-Jan	16.1	13-Mar	15.1
28-Jan	10.0	14-Mar	21.6
29-Jan	10.4	15-Mar	16.6
30-Jan	6.9	16-Mar	7.9
31-Jan	4.9	17-Mar	9.6
1-Feb	5.4	18-Mar	10.3
2-Feb	7.1	19-Mar	8.4
3-Feb	10.9	20-Mar	4.9
4-Feb	12.1	21-Mar	8.7
5-Feb	17.1	22-Mar	13.3
6-Feb	10.3	23-Mar	12.2
7-Feb	4.0	24-Mar	10.3
8-Feb	9.7	25-Mar	11.9
9-Feb	11.5	26-Mar	20.1
10-Feb	3.0	27-Mar	22.5
11-Feb	5.5	28-Mar	18.2
12-Feb	18.9	29-Mar	10.8
13-Feb	17.6	30-Mar	6.4
14-Feb	11.2	31-Mar	3.3
15-Feb	14.4		
Seasonal / Quarterly Maximum			22.5

Season / Quarter 2			
Date	Conc.	Date	Conc.
1-Apr	7.8	17-May	8.2
2-Apr	10.5	18-May	11.1
3-Apr	8.2	19-May	7.7
4-Apr	9.7	20-May	13.6
5-Apr	6.9	21-May	12.1
6-Apr	6.3	22-May	10.0
7-Apr	7.9	23-May	13.3
8-Apr	9.8	24-May	11.2
9-Apr	16.5	25-May	17.7
10-Apr	13.3	26-May	14.2
11-Apr	11.0	27-May	15.4
12-Apr	8.8	28-May	13.9
13-Apr	6.3	29-May	9.3
14-Apr	5.1	30-May	14.5
15-Apr	7.9	31-May	20.5
16-Apr	8.2	1-Jun	15.3
17-Apr	14.7	2-Jun	11.5
18-Apr	22.5	3-Jun	17.9
19-Apr	12.8	4-Jun	21.1
20-Apr	6.9	5-Jun	17.9
21-Apr	7.5	6-Jun	17.6
22-Apr	6.0	7-Jun	15.0
23-Apr	9.1	8-Jun	22.3
24-Apr	10.3	9-Jun	RC
25-Apr	12.0	10-Jun	21.6
26-Apr	12.5	11-Jun	19.4
27-Apr	11.3	12-Jun	21.2
28-Apr	7.6	13-Jun	RC
29-Apr	7.4	14-Jun	15.6
30-Apr	11.4	15-Jun	14.8
1-May	12.6	16-Jun	17.8
2-May	10.0	17-Jun	12.6
3-May	11.2	18-Jun	10.5
4-May	10.4	19-Jun	15.0
5-May	15.7	20-Jun	22.7
6-May	16.1	21-Jun	18.7
7-May	16.8	22-Jun	15.2
8-May	14.5	23-Jun	16.8
9-May	11.7	24-Jun	15.1
10-May	9.0	25-Jun	20.7
11-May	6.7	26-Jun	23.0
12-May	7.9	27-Jun	17.8
13-May	8.3	28-Jun	12.4
14-May	12.2	29-Jun	12.7
15-May	13.1	30-Jun	8.9
16-May	8.8		
Seasonal / Quarterly Maximum			23.0

Season / Quarter 3			
Date	Conc.	Date	Conc.
1-Jul	7.1	16-Aug	23.9
2-Jul	13.8	17-Aug	18.4
3-Jul	17.1	18-Aug	18.7
4-Jul	19.8	19-Aug	21.5
5-Jul	14.3	20-Aug	20.1
6-Jul	11.5	21-Aug	18.4
7-Jul	14.3	22-Aug	16.7
8-Jul	12.2	23-Aug	13.8
9-Jul	11.1	24-Aug	19.0
10-Jul	9.7	25-Aug	17.6
11-Jul	16.4	26-Aug	15.4
12-Jul	21.5	27-Aug	12.6
13-Jul	RC	28-Aug	12.1
14-Jul	11.7	29-Aug	10.1
15-Jul	18.9	30-Aug	17.2
16-Jul	RC	31-Aug	19.9
17-Jul	RC	1-Sep	19.4
18-Jul	12.8	2-Sep	18.2
19-Jul	6.2	3-Sep	24.0
20-Jul	20.1	4-Sep	15.4
21-Jul	RC	5-Sep	12.4
22-Jul	16.9	6-Sep	12.5
23-Jul	12.8	7-Sep	15.8
24-Jul	7.9	8-Sep	23.4
25-Jul	15.7	9-Sep	11.5
26-Jul	24.9	10-Sep	6.0
27-Jul	22.2	11-Sep	11.8
28-Jul	17.5	12-Sep	10.7
29-Jul	19.1	13-Sep	7.6
30-Jul	21.1	14-Sep	7.5
31-Jul	18.0	15-Sep	7.1
1-Aug	16.3	16-Sep	7.7
2-Aug	19.3	17-Sep	11.3
3-Aug	17.9	18-Sep	16.8
4-Aug	25.1	19-Sep	14.8
5-Aug	RC	20-Sep	8.0
6-Aug	19.1	21-Sep	10.8
7-Aug	14.0	22-Sep	14.5
8-Aug	10.8	23-Sep	21.2
9-Aug	15.0	24-Sep	8.6
10-Aug	21.7	25-Sep	1.2
11-Aug	14.3	26-Sep	16.0
12-Aug	14.7	27-Sep	12.1
13-Aug	13.0	28-Sep	18.0
14-Aug	13.5	29-Sep	17.8
15-Aug	17.5	30-Sep	16.4
Seasonal / Quarterly Maximum			25.1

Season / Quarter 4			
Date	Conc.	Date	Conc.
1-Oct	12.3	16-Nov	4.6
2-Oct	8.2	17-Nov	7.8
3-Oct	12.3	18-Nov	4.4
4-Oct	19.5	19-Nov	8.2
5-Oct	23.7	20-Nov	11.1
6-Oct	19.8	21-Nov	5.3
7-Oct	21.7	22-Nov	8.9
8-Oct	12.2	23-Nov	14.0
9-Oct	5.1	24-Nov	12.7
10-Oct	10.2	25-Nov	9.7
11-Oct	10.7	26-Nov	12.8
12-Oct	5.6	27-Nov	16.6
13-Oct	5.9	28-Nov	17.2
14-Oct	9.7	29-Nov	16.6
15-Oct	12.8	30-Nov	4.5
16-Oct	16.4	1-Dec	7.5
17-Oct	12.0	2-Dec	10.6
18-Oct	7.9	3-Dec	16.7
19-Oct	6.6	4-Dec	12.5
20-Oct	8.1	5-Dec	7.3
21-Oct	12.2	6-Dec	10.4
22-Oct	4.6	7-Dec	13.4
23-Oct	6.1	8-Dec	10.5
24-Oct	4.6	9-Dec	9.3
25-Oct	4.5	10-Dec	6.5
26-Oct	10.5	11-Dec	3.0
27-Oct	6.4	12-Dec	3.5
28-Oct	4.6	13-Dec	10.2
29-Oct	5.6	14-Dec	17.6
30-Oct	7.6	15-Dec	12.4
31-Oct	11.2	16-Dec	9.7
1-Nov	16.2	17-Dec	7.0
2-Nov	17.3	18-Dec	7.9
3-Nov	18.3	19-Dec	6.9
4-Nov	8.9	20-Dec	8.1
5-Nov	5.8	21-Dec	4.9
6-Nov	8.6	22-Dec	7.7
7-Nov	15.0	23-Dec	7.7
8-Nov	8.3	24-Dec	10.5
9-Nov	10.0	25-Dec	6.5
10-Nov	12.8	26-Dec	7.6
11-Nov	11.8	27-Dec	13.3
12-Nov	14.8	28-Dec	6.4
13-Nov	14.5	29-Dec	3.7
14-Nov	7.7	30-Dec	4.7
15-Nov	3.6	31-Dec	4.4
Seasonal / Quarterly Maximum			23.7

Seasonal/Quarterly Maximum Concentration (highlighted blue values)

RC = Above 98th Percentile and Removed from Consideration (highlighted peach values)

Exhibit L-4: Resulting Average of Seasonal (or Quarterly) Maximums from Year 1 for Inclusion into AERMOD

Seasonal / Quarterly Average Highest Monitored Concentration
(From Annual Datasets Equal To and Less Than the 98th Percentile)

	Q1	Q2	Q3	Q4
Year 1	22.5	23.0	25.1	23.7
Year 2	21.1	20.7	21.2	19.8
Year 3	20.7	22.6	23.5	20.7
Average	**21.433**	**22.100**	**23.267**	**21.400**

Note, the complete datasets for Year 2 and Year 3 are not shown in this appendix but would follow the same steps as for Year 1.

L.3 Running AERMOD

After calculating the seasonal 98th percentile background concentrations, the four average seasonal values (shown in the last row of Exhibit L-4) can be added to the AERMOD input file. There are four important steps to follow when creating an input file consistent with the second tier design concentration approach.

1) AERMOD must be run with five years of concatenated met data (assuming the use of an off-site monitor). This allows for the calculation of the 98th percentile value across all years of data.

2) Ensure that "PM2.5" is listed for the POLLUTID keyword in the CO pathway. This will trigger calculations in AERMOD that automatically average across five years of meteorological data to determine the 98th percentile concentration at each receptor.

3) Add a line in the SO pathway with the keyword BACKGRND, followed by SEASON. This will allow the definition of four seasonal values. For the example shown above in Appendix L.2, the appropriate line in AERMOD would be:

```
SO BACKGRND  SEASON  21.433  22.100  23.267  21.400
```

   Also, ensure that BACKGRND is added to the SRCGROUP line of the SO pathway.

4) Finally, since the 98th percentile of 365 days is the eighth highest day, use the RECTABLE keyword of the OU pathway to define the "8th" highest value to report.

After running AERMOD, the RECTABLE generated will report 98th percentile concentrations, averaged across five years of meteorological data, for each receptor. These values can be compared directly to the NAAQS, or in the case of a build/no-build analysis, the values at the same receptor in the build scenario.