*Draft for Deliberative Purposes Only*

# PM2.5 Wildland Fire Exceptional Events Tiering Document

*Draft for Deliberative Purposes Only*

EPA-457/D-24-001
January 2024

# PM2.5 Wildland Fire Exceptional Events Tiering Document

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Research Triangle Park, NC

# $PM_{2.5}$ Wildland Fire Exceptional Events Tiering Document

January 2024

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina

*Draft for Deliberative Purposes Only*

# Contents

# 1. Purpose of the Document

This document supplements the EPA's September 2016 document titled, *Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations* and focuses on preparing and reviewing exceptional events demonstrations associated with wildfire and prescribed fire events for both the 24-hour and annual fine particulate matter ($PM_{2.5}$) standards. This document is relevant for events that may be associated with initial area designations for the revised annual $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS) and other actions of regulatory significance.

The EPA is providing this information to assist air agencies in preparing exceptional events demonstrations for wildland fire influences on $PM_{2.5}$ concentrations that meet the requirements of Clean Air Act (CAA) section 319(b) and the Exceptional Events Rule. Where there are differences between the information in this document and statute or regulatory requirements, the statute and regulations take precedence. Further, the EPA's decision regarding a submitted exceptional events demonstration does not constitute final Agency action until the demonstration and the EPA's decision are included in notice-and-comment rulemaking.

The EPA has previously released the following exceptional events implementation resources related to fire-related events:

- *Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations* (Wildfire Ozone Guidance)[1] - outlines and clarifies EPA's expectations specifically for wildfire ozone demonstrations
- *Exceptional Events Guidance: Prescribed Fire on Wildland that May Influence Ozone and Particulate Matter Concentrations* (Prescribed Fire Guidance)[2] - outlines EPA's expectations for prescribed fire demonstrations
- *Exceptional Event Demonstration for an Exceedance of the 2012 Annual $PM_{2.5}$ NAAQS at Grass Valley, California on April 20, 2021, Due to Smoke From a Prescribed Fire*[3] - an example demonstration for a prescribed fire on wildland
- *Wildfire Resource Document* - outlines potential analyses that may be useful to include in a wildfire demonstration[4]

[1] The EPA's September 2016 Wildfire Ozone Guidance (EPA-457/B-16-001) is available at *https://www.epa.gov/air-quality-analysis/final-guidance-preparation-exceptional-events-demonstrations-wildfire-events.*

[2] The EPA's August 2019 Prescribed Fire Guidance is available at *https://www.epa.gov/sites/default/files/2019-08/documents/ee_prescribed_fire_final_guidance_-_august_2019.pdf.*

[3] Exceptional Event Demonstration for an Exceedance of the 2012 Annual $PM_{2.5}$ NAAQS at Grass Valley, California on April 20, 2021, Due to Smoke From a Prescribed Fire.

[4] The EPA's *Wildfire Resource Document*, updated in August 2023, is available at *https://www.epa.gov/system/files/documents/2023-09/Wildfire%20Resource%20Document_Final_Revised.pdf.*

- *Updated Frequently Asked Questions* document[5] - contains several fire-related exceptional events questions and answers

This document supplements the *Wildfire Ozone Guidance* and further outlines the EPA's expectations for the "narrative conceptual model" and "clear causal relationship" criteria for fire-related events, including wildfires and prescribed fires on wildland, that cause monitored $PM_{2.5}$ exceedances or violations. This document also identifies three analytical "tiers" and associated levels of evidence appropriate to show the clear causal relationship criterion within an air agency's fire-related $PM_{2.5}$ exceptional events demonstration. While this document focuses on $PM_{2.5}$, the principles outlined in this document may also be appropriate to extend to demonstrations of $PM_{10}$ exceedances or violations caused by wildland fire events. Air agencies should consult with their EPA Regional offices to determine whether and how to apply the principles in this document to a specific $PM_{10}$ wildland fire exceptional events demonstration.

The technical analyses described in this document to address the clear causal relationship criterion are generally appropriate for exceptional events demonstrations for both wildfires and prescribed fires on wildland. Other criteria, including the "natural event/human activity unlikely to recur" and "not reasonably controllable or preventable" elements, require different approaches for prescribed fires versus wildfires. This document does not address those criteria. Agencies should consult either the *Wildfire Ozone Guidance* or *Prescribed Fire Guidance* previously referenced for further information on how these criteria apply for their specific event type.

One of the EPA's goals in developing this document is to establish clear expectations to enable air agencies to better manage resources as they prepare the documentation required under the Exceptional Events Rule and to avoid the preparation and submission of extraneous information. Submitters should prepare and submit the appropriate level of supporting documentation, which will vary on a case-by-case basis depending on the nature and severity of the event, as appropriate under a weight-of-evidence approach. This document identifies important analyses and language to include within an exceptional events demonstration and promotes a common understanding of these elements between the submitting air agency and the reviewing EPA Regional office. As a result, this document is expected to improve the EPA's efficiency in reviewing demonstrations prepared consistent with the guidance. While this document contains example analyses that air agencies may use in their demonstrations, air agencies can also prepare analyses or present documentation not listed or explained in this guidance, provided the information is well-documented, appropriately applied, technically sound, and supports the weight of evidence showing for the Exceptional Events Rule regulatory criteria.

The EPA acknowledges the complexity and intricacies of regional conditions prevalent across the country. The EPA is committed to continuing to provide clarification and assistance to air agencies as the Exceptional Events Rule is implemented and through communications between the Regions and the air agencies to ensure that these regional conditions are adequately

[5] The EPA's *Updated Exceptional Events Rule Frequently Asked Questions* document is available at *https://www.epa.gov/air-quality-analysis/updated-exceptional-events-rule-faqs.*

addressed. For additional context regarding this document, background information regarding some of the statutory and regulatory requirements associated with the Exceptional Events Rule is offered in the *Wildfire Ozone Guidance*. We intend to post new information and tools as they become available on the EPA's exceptional events website at: *https://www.epa.gov/air-quality-analysis/treatment-air-quality-monitoring-data-influenced-exceptional-events.*

For more detailed information on the initial notification process, regulatory significance, and EPA's review, please see the *Wildfire Ozone Guidance*. During the initial notification process, the EPA and the air agency will work together to identify the appropriate tier (**Tier 1**, **2**, or **3**) for the event demonstration. Air agencies can use the Tiering Screening Tool, which is based on the tiering methodology in Section 3, to assist in identifying the tier but, ultimately, the EPA decides the appropriate tier. An exceptional event must have regulatory significance, as defined by the Exceptional Events Rule, for the EPA to consider the demonstration. The EPA expects air agencies to include information and analyses sufficient to demonstrate the significance of specific event data for a specific regulatorily significant action. Because this document focuses only on the conceptual model and clear causal requirements for $PM_{2.5}$ and wildland fire-related events, Table 1 identifies the six elements that an air agency must include in an approvable $PM_{2.5}$ related exceptional events demonstration and identifies the location of that information in this document and other relevant documents.

Table 1. Summary of Demonstration Elements

| Element | Location of Relevant Information |
|---|---|
| 1. A narrative conceptual model that describes the event(s) causing the exceedance or violation and a discussion of how emissions from the event(s) led to the exceedance or violation at the affected monitor(s) | Section 4 of this document, as well as the *Wildfire Ozone Guidance* or *Prescribed Fire Guidance* as appropriate and the *Wildfire Resource Document* |
| 2. A demonstration that the event affected air quality in such a way that there exists a clear causal relationship between the specific event and the monitored exceedance or violation. | Section 5 of this document |
| 3. Analyses comparing the claimed event-influenced concentration(s) to concentrations at the same monitoring site at other times. | Section 5 of this document |
| 4. A demonstration that the event was both not reasonably controllable and not reasonably preventable. | Section 4 in the *Wildfire Ozone Guidance* document or Section A.5 of the *Prescribed Fire Guidance* (depending on the type of wildland fire) |
| 5. A demonstration that the event was caused by human activity that is unlikely to recur at a particular location or was a natural event. | Section 5 in the *Wildfire Ozone Guidance* document or Section A.4 of the *Prescribed Fire Guidance* (depending on the type of wildland fire) |
| 6. Documentation that the submitting air agency followed the public comment process. | Section 6 in the *Wildfire Ozone Guidance* |

## 2. Tiered Approach for Determining the Level of Evidence Likely to be Necessary in Wildland Fire-related $PM_{2.5}$ Exceptional Events Demonstrations

Each demonstration submitted by an air agency under the Exceptional Events Rule must meet certain minimum criteria, as defined in the CAA and the EPA's implementing regulations. The EPA expects that the documentation and analyses that air agencies include in their demonstrations will vary consistent with the event characteristics, the relationship to the monitor where the exceedance or violation occurred, and the complexity of the airshed, among other points. The EPA reviews exceptional events demonstrations on a case-by-case basis using a weight of evidence approach considering the specifics of the individual event.

This document outlines a tiered approach for addressing the clear causal relationship element within a wildland fire $PM_{2.5}$ demonstration, recognizing that some causal relationships may be clearer and, therefore, require relatively fewer pieces of evidence to satisfy the rule requirements.

- **Tier 1** clear causal analyses are intended for wildland fire events that cause unambiguous $PM_{2.5}$ impacts well above historical 24-hour concentrations, thus requiring fewer pieces of evidence to establish a clear causal relationship.[6]
- **Tier 2** clear causal analyses are likely appropriate when the impacts of the wildland fire on $PM_{2.5}$ concentrations are less distinguishable from historical 24-hour concentrations, and require more pieces of evidence, than **Tier 1** analyses.
- **Tier 3** clear causal analyses should be used for events in which the relationship between the wildland fire and $PM_{2.5}$ 24-hour concentrations are more complicated than a **Tier 2** analysis, when 24-hour $PM_{2.5}$ concentrations are near or within the range of historical concentrations, and thus require more pieces of evidence to establish the clear causal relationship than **Tier 2** or **Tier 1**.

Figure 1 in Section 5 outlines the process for determining an appropriate tier for a given event. Section 3 explains the methodology by which the EPA developed the thresholds for the tiering analysis. **Tier 1** analyses are described in Section 5.3, **Tier 2** analyses are described in Section 5.4, and **Tier 3** analyses are described in Section 5.5.

Regarding the process for developing demonstrations, Figure 1 on page 6 in the *Wildfire Ozone Guidance* shows a flowchart summarizing the overall process for preparing, submitting, and reviewing wildfire ozone demonstrations, which includes the Initial Notification process and recommended review timelines. The same process applies when preparing, reviewing, and submitting wildland fire $PM_{2.5}$ demonstrations.

[6] As described in Section 3, while the tiering structure described in this document applies to both the 24-hour and annual $PM_{2.5}$ standards, the tiering thresholds were developed using monitored concentrations relative to the 24-hour NAAQS.

Various analyses could be useful for wildland fire events that influence $PM_{2.5}$ concentrations to help support the demonstration of the clear causal relationship. Some products may be more useful for situations where the fire is nearby to potentially impacted monitor(s) and might not be as appropriate for demonstrations where the transport distances are much greater. Additional guidance and details on the types of analyses useful for exceptional events demonstrations can be found on the exceptional events website, including the *Wildfire Resource Document*, *Wildfire Ozone Guidance* and the *Updated Frequently Asked Questions* document. The tiering structure and analyses described in this document apply only to $PM_{2.5}$ demonstrations. The tiering structure and supporting analyses for ozone events are outlined in the *Wildfire Ozone Guidance* and have not changed. Agencies intending to develop ozone demonstrations should follow that guidance and discuss with their EPA Regional office when determining what evidence is necessary for a particular demonstration.

Section 3 of this document provides a technical explanation of EPA's approach and methodology for establishing the tiers and the basis for the Tiering Screening Tool. Section 4 of this document discusses the conceptional model portion of an exceptional events demonstration with information relevant to $PM_{2.5}$ and wildland fire-related events. Section 5 begins the portion of this document that describes how an air agency can use the tier level approach to determine the evidence needed to establish a clear causal relationship in a wildland fire $PM_{2.5}$ exceptional events demonstration.

## 3. Overview of the EPA's Methodology to Identify Tiers

In developing the tiering approach described in this document, the EPA focused on a methodology that would provide a quantifiable metric for each tier in a manner that could be replicated nationally. As previously indicated, the EPA used monitored concentrations relative to the 24-hour NAAQS to establish the tiering thresholds, which can apply to both the 24-hour and the annual $PM_{2.5}$ standards. Generally, events are relatively short in duration, and, in some cases, a single event (particularly a **Tier 1** event) could lead to an exceedance or violation of both the 24-hour and the annual $PM_{2.5}$ standards. Additionally, the combined effects of multiple discrete events (especially **Tier 2** and **Tier 3** events), individually of inherently short duration, could lead to an exceedance or violation of the annual standard. The EPA expects that the developed tiering approach is appropriate for either scenario.

The tier thresholds are based on the lesser value of either (a) the most recent 5-year month-specific 98th percentile for 24-hour $PM_{2.5}$ data, or (b) the minimum annual 98th percentile for 24-hour $PM_{2.5}$ data for the most recent 5-year period with Informational (I) qualifiers on the monitoring data excluded. **Tier 1** demonstrations are appropriate for 24-hour $PM_{2.5}$ greater than or equal to 1.5 times the threshold determined, **Tier 2** demonstrations are appropriate for 24-hour $PM_{2.5}$ greater than or equal to the threshold but less than 1.5 times the threshold, and **Tier 3** demonstrations are appropriate for 24-hour $PM_{2.5}$ less than the threshold.

Table 2. $PM_{2.5}$ Exceptional Events Demonstration Tiers and Thresholds.

| Tier | Measured Concentration of Event Day vs Tiering Threshold* |
|---|---|
| Tier 1 | Measured value is greater than or equal to 1.5 times the tiering threshold |
| Tier 2 | Measured value is greater than or equal to the tiering threshold and less than 1.5 times the tiering threshold |
| Tier 3 | Measured value is less than the tiering threshold |

* The tiering threshold is defined as the lesser value of either (a) the most recent 5-year month-specific 98th percentile for 24-hour $PM_{2.5}$ data, or (b) the minimum annual 98th percentile for 24-hour $PM_{2.5}$ data for the most recent 5-year period, excluding fire-related "Informational Only" (I) qualifiers and all "Request Exclusion" (R) data qualifiers.

To determine whether a relationship exists between approved demonstrations and the 98$^{th}$ percentile tiering thresholds methodology, the EPA compiled and assessed numerous concurred-on 24-hour $PM_{2.5}$ exceptional events demonstrations due to wildland fire smoke to compare to the proposed tiers. Events from EPA Regions 5, 8, 9, and 10 were evaluated in this analysis.[7] The EPA also included in the comparison, the results from three well-documented case studies focused on eastern and western cases that are not yet approved by the EPA as exceptional events, but that the EPA independently determined would most likely be **Tier 1** events. The eastern wildland fire smoke case focused on the Canadian wildland fires in 2023 and the western wildland fire smoke case focused on the Camp Fire in 2018 and the August Complex in 2020, both in California.

The EPA chose to base the $PM_{2.5}$ tiering threshold on a 98$^{th}$ percentile statistic, since this statistic is already in use in $PM_{2.5}$ NAAQS calculations and represents a site-specific high $PM_{2.5}$ value near the top of the distribution of ambient $PM_{2.5}$ data.

To determine a 98$^{th}$ percentile that is most representative of a time period without smoke impacting air quality, the EPA calculated the 98$^{th}$ percentile in two ways and used the lesser of the two for comparison to the measured value. The first method was to calculate the 98$^{th}$ percentile for a specific month over an entire 5-year period. This approach recognizes that many monitoring sites have periods of seasonally high and low $PM_{2.5}$, and that the event concentration should be evaluated against other seasonally appropriate data. The second method was to calculate the 98$^{th}$ percentile for each year in the last 5-year period and take the lowest year out of the five. To ensure that the percentiles were better representative of smoke free air, the EPA excluded data that had been previously qualified in the EPA's Air Quality System (AQS) with

[7] Specifically, the EPA assessed events from the states of California, Maryland, Pennsylvania, Ohio, Oregon, Idaho, Utah, and Montana. A summary of these data and the related analyses are included in the Excel spreadsheet (Sites_Scenarios_Test_Tiering_Data.xlsx), included in Docket No. EPA-HQ-OAR-2023-0586.

the "informational only" (I) fire-related qualifiers IF, IG, IH, and IT and all "request exclusion" (R) data qualifiers[8] from the datasets used to calculate the 98th percentile in these analyses.

The EPA finalized the tiers by first evaluating the ratio of the tiering threshold to the measured values for $PM_{2.5}$ concurred on events and the three case studies focused on eastern and western cases. The EPA then evaluated whether each event would be a **Tier 1**, **2**, or **3** demonstrations based on the criteria discussed previously. The $PM_{2.5}$ exceptional events demonstration tiers identified in Table 2 are the result of these analyses. Most of the measured concentrations fell within the expected tier in Table 2, thus the EPA determined this is an acceptable method for determining the tiering.

In conclusion, EPA's tested various tier thresholds for $PM_{2.5}$ wildland fire exceptional events demonstrations. The analysis explains how the EPA arrived at the conclusion that it is reasonable to use a tiering threshold based on the lesser of (a) the two 98th percentiles, the 5-year month specific 98th percentile, or (b) the minimum annual 5-year 98th percentiles. This tiering approach to $PM_{2.5}$ wildland fire exceptional events demonstrations assists agencies with determining the amount of evidence necessary to demonstrate a clear causal relationship between wildland fire smoke and the concentration.

**Additional Information on EPA's Literature Review**

Fires, including both wildland fires and prescribed fires, are estimated to account for over 43 percent of the nation's primary emissions of $PM_{2.5}$.[9] In recent years, the frequency and magnitude of wildland fires have increased.[10] Fires can impact $PM_{2.5}$ concentrations by emitting direct $PM_{2.5}$ along with hundreds of gaseous compounds. The gaseous compounds include nitrogen oxides (NOx), carbon monoxide (CO), methane ($CH_4$), and hundreds of volatile organic

[8] "Qualifier" is the common terminology for a data qualifier code in AQS. Within AQS, air agencies can use two types of data qualifier codes: Informational Only qualifiers ("I") or Request Exclusion qualifiers ("R"). The EPA uses the following qualifier codes to describe fires: "IF" – Fire – Canadian (Informational Only); "IG" – Fire – Mexico/Central America (Informational Only); "IH" – Fireworks (Informational Only); "IM" – Prescribed Fire (Informational Only); "IP" – Structural Fire (Informational Only); "IT" – Wildfire – US (Informational Only); "RF" – Fire – Canadian (Request Exclusion); "RG" – Fire – Mexico/Central America (Request Exclusion); "RM" – Prescribed Fire (Request Exclusion); "RP" – Structural Fire (Request Exclusion); and "RT" – Wildfire – US (Request Exclusion). The EPA also has the qualifier codes "IF/RF" – Fire – Canadian ("IF/RF"), and "IG/RG" – Fire – Mexico/Central America ("IG/RG"), because these qualifiers indicate the jurisdictional origin of the fire (i.e., outside of the submitting state/outside of the United States). Please note that the EPA did not exclude all qualified data, only those identified as wildfires.

[9] U.S. EPA (2021b). 2017 National Emissions Inventory: January 2021 Updated Release, Technical Support Document. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, NC. U.S. EPA. February 2021. Available at *https://www.epa.gov/sites/production/files/2021-02/documents/nei2017_tsd_full_jan2021.pdf*.

[10] U.S. EPA (2019). Integrated Science Assessment (ISA) for Particulate Matter (Final Report). U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment. Washington, DC. U.S. EPA. EPA/600/R-19/188. December 2019. Available at *https://www.epa.gov/naaqs/particulate-matter-pm-standards-integrated-science-assessments-current-review*.

compounds (VOCs), including many oxygenated VOCs (OVOCs).[11] This chemical complexity makes wildland fire smoke very different from typical industrial pollution. A key challenge for understanding fire impacts on air quality is the large variability from fire to fire in both the quantity and composition of emissions. Emissions can vary as a function of the amount and type of fuel, meteorology, and burning conditions. These variations give rise to large uncertainties in the emissions from individual fires. Once emitted, wildland fire smoke undergoes chemical transformations in the atmosphere, which alters the mix of compounds and generates secondary pollutants, such as ozone and secondary organic aerosol. Fire emissions can affect both nearby and distant geographic areas, well beyond the actual wildland fires. Most smoke in the United States is associated with wildland fires in the United States, but fires outside the country can also impact air quality in the United States. In 2017, high $PM_{2.5}$ in the Pacific Northwest was associated with large fires in British Columbia. These same fires were associated with smoke transport to Europe and strong thunderstorm-pyrocumulonimbus activity, which injected smoke into the stratosphere. Large fires in Quebec have affected air quality in the northeast United States, fires from Mexico and Central America can impact Texas.

## 4. Conceptual Model of an Event

The Exceptional Events Rule requires that demonstrations include a narrative conceptual model describing the event.[12] To be meaningful and clearly interpreted, air agencies should tie all supporting technical analyses to this simple narrative describing how emissions from a specific fire (or group of fires) caused $PM_{2.5}$ exceedances or violations at a particular location and how these event-related emissions and resulting exceedances or violations differ from typical high $PM_{2.5}$ episodes in the area resulting from other natural and anthropogenic sources of emissions. This narrative description of the cause of the exceedance and the supporting data and technical analyses will provide a consistent framework by which the EPA can evaluate the evidence in a demonstration. Because this narrative should appear at or near the beginning of a demonstration, it will help readers and the reviewing EPA Regional office understand the event formation and the event's influence on monitored pollutant concentrations before the reader reaches the portion of the demonstration that contains the technical evidence to support the requested data exclusion. The EPA expects that much of the information the air agency discussed with or submitted to the EPA during the Initial Notification process would also be useful in the narrative conceptual model section of a demonstration. The narrative conceptual model should describe the principal features of the interaction of the event and how direct $PM_{2.5}$ from the event was transported to the monitor(s) that measured the exceedance or violation.

The EPA expects that, in most cases, the conceptual model of the event will be a brief narrative of the *specific* facts leading up to, and directly relevant to, the exceedance or violation date(s). For example, a description of what is known about the specific fire (or group of fires) whose

[11] Jaffe, D., O'Neill, S., Larkin, N., Holder, A., Peterson, D., Halofsky, J., Rappold, A., 2020. Wildfire and prescribed burning impacts on air quality in the United States. Journal of the Air & Waste Management Association 70, 583-615.
[12] 40 CFR 50.14(c)(3)(iv)(A).

emissions impacted the monitor, the meteorological conditions leading to emissions being transported from the fire to the monitor, the monitored value, and the typical levels of $PM_{2.5}$ impacting the monitor in non-event conditions. Extensive presentations comparing patterns not directly linked to the specific event (*e.g.*, drought conditions, climate analyses) are not typically needed.

# 5. Clear Causal Relationship between the Specific Event and the Monitored Concentration

## 5.1 Overview and Exceptional Events Rule Provisions

The Exceptional Events Rule requires that demonstrations address the technical element that "the event affected air quality in such a way that there exists a clear causal relationship between the specific event and the monitored exceedance or violation"[13] supported, in part, by the comparison to historical concentrations and other analyses. Air agencies must support the clear causal relationship with a comparison of the $PM_{2.5}$ data requested for exclusion with historical concentrations at the air quality monitor.[14] In addition to providing this information on the historical context for the event-influenced data, air agencies must further support the clear causal relationship criterion by demonstrating that the fire's emissions were transported to the monitor, and that the emissions from the fire influenced the monitored concentrations.

The three analytical tiers described in this document, and summarized in Table 3, are intended to assist air agencies in determining the appropriate analyses to include in an exceptional events demonstration submission. Air agencies are encouraged to work with their reviewing EPA Regional office to verify the appropriate tier and to identify sufficient information to support an exceptional events demonstration.

**Tier 1** analyses for the clear causal relationship are likely appropriate for wildland fire events that cause extreme $PM_{2.5}$ impacts resulting in 24-hour average concentrations well above historical concentrations, thus requiring fewer pieces of evidence. **Tier 2** clear causal analyses are appropriate when the impacts of the wildland fires on $PM_{2.5}$ concentrations are less extreme in comparison to historical 24-hour concentrations and require more pieces of evidence than **Tier 1** analyses. **Tier 3** clear causal analyses should be used for events in which 24-hour $PM_{2.5}$ concentrations are near or within the range of historical concentrations, and thus require more evidence of the clear causal relationship between the fire and the measured exceedance or violation than **Tiers 1** or **2**. Figure 1 provides a simplified process diagram of the event demonstration tiering process for $PM_{2.5}$.

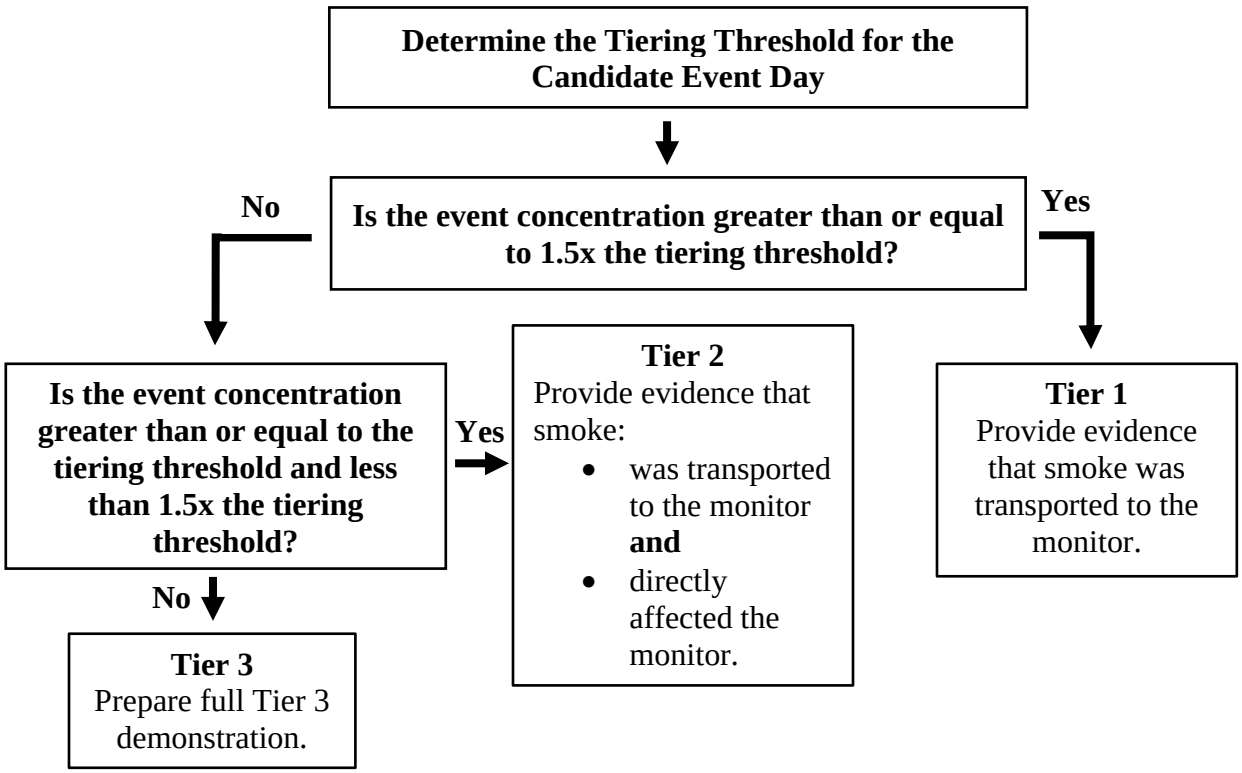
Section 5.3 discusses **Tier 1** analyses; Section 5.4 discusses **Tier 2** analyses and Section 5.5 discusses **Tier 3** analyses.

[13] 40 CFR 50.14(c)(3)(iv)(B).
[14] 40 CFR 50.14(c)(3)(iv)(C).

Table 3. Summary of Tiered Analyses.

| **Tier 1: Section 5.3** | **Tier 2: Section 5.4** | **Tier 3: Section 5.5** |
|---|---|---|
| The event clearly influences monitored $PM_{2.5}$ exceedances or violations when they occur in an area that typically experiences lower $PM_{2.5}$ concentrations. This tier is associated with a $PM_{2.5}$ concentration that is clearly higher than non-event related concentrations (greater than or equal to 1.5x the tiering threshold) for the historical month or annual period, as appropriate. | The event's $PM_{2.5}$ influences are higher than most or all non-event related concentrations (between 1 to 1.5x the tiering threshold), and the weight of evidence shows a clear causal relationship. | The event does not fall into the specific scenarios that qualify for **Tier 1** or **Tier 2**, but the clear causal relationship criterion can still be satisfied by a weight of evidence showing. |

Figure 1. Process to Determine the Appropriate Tier for the Clear Causal Relationship Criterion



## 5.2 Comparison of Candidate Event Data to Tiering Thresholds

As discussed in more detail in Section 3 of this document, the determination of the appropriate tiering level begins with an analysis of the measured $PM_{2.5}$ air quality associated with the candidate event in relation to historical concentrations. Air agencies should compare the concentration in question to the lesser of (a) the most recent 5-year month-specific 98th percentile for 24-hour $PM_{2.5}$ data, or (b) the minimum annual 98th percentile for 24-hour $PM_{2.5}$ data for the most recent 5-year period with the "informational only" (I) fire-related data qualifiers and all "request exclusion" (R) data qualifiers on the monitoring data *excluded*.

As an initial screening, air agencies may generate an AMP480 report (also known as the Design Value Report) from AQS, which *includes* all I qualifiers. If an event day's measured concentration is above or equal to 1.5 times the tiering threshold calculated with only R qualifiers excluded (as is the case with the AMP480), analyzing the data with I qualifiers would not be necessary to determine if the candidate event demonstration is **Tier 1**. Please consult with your EPA Regional office to ensure data are appropriately qualified in AQS.[15]
The EPA acknowledges that there may be unusual circumstances or anomalies in air agencies' data that may affect tiering as proposed. For example, air agencies may not have removed other instances of wildfire smoke impacts at the event site. Through discussions with the appropriate EPA Regional office, the agency may be able to show through additional analysis that there is a more appropriate tiering threshold for the event day than was determined by the default methodology.

Air agencies are encouraged to evaluate their data carefully and consult with their EPA Regional office about any data anomalies on a case-by-case basis. The EPA also retains its authority and discretion to evaluate data anomalies in submitted data and determine what tier is applicable for a candidate event.

The following simplified example illustrates the tier level calculations. More thorough treatment of the tiering threshold assessment is presented in sections 5.3 and 5.4.

[15] "Qualifier" is the common terminology for a data qualifier code in AQS. Within AQS, air agencies can use two types of data qualifier codes: Informational Only qualifiers ("I") or Request Exclusion qualifiers ("R"). Agencies should use the "I" series qualifiers when identifying potential event-influenced data and the "R" series qualifiers to identify data points for which the agency is requesting EPA's concurrence on an exceptional event exclusion. States are required as part of the initial notification process to identify (or qualify with a data qualifier) event-associated air quality data and create an initial event description in EPA's AQS. Attaching the "I" data qualifier is intended to promote communication between air agencies and EPA Regional offices when air agencies begin to consider developing an exceptional events demonstration. The "R" qualifier is added when the air agency submits a formal request to the EPA to exclude data under the Exceptional Events Rule. "R" qualifiers are the only AQS qualifiers that satisfy Exceptional Events Rule data qualifying as part of the required Initial Notification Process. The EPA can act/concur only on data with "R" qualifiers.

Simplified Example:

> Candidate Event Day, July 20, 2023, 24-hr $PM_{2.5}$ concentration = 72 µg/$m^3$
> Tier Threshold (a): 98$^{th}$ percentile of all 24-hr $PM_{2.5}$ concentrations from the month of July in 2019-2023 = 54 µg/$m^3$
> Tier Threshold (b): minimum annual 98$^{th}$ percentile 24-hr $PM_{2.5}$ concentration from years 2019-2023 = {35, 29, 34, 32, 42} = 29 µg/$m^3$
> Lesser Value of Tier Threshold (a) and (b) = 29 µg/$m^3$
>
> Tier 1 Threshold: 1.5 x 29 µg/$m^3$ = 43.5 µg/$m^3$
> Tier 2 Threshold: 1 x 29 µg/$m^3$ = 29 µg/$m^3$

In this simplified example, since the Candidate Event Day concentration of 72 µg/$m^3$ exceeds the **Tier 1** Threshold of 43.5 µg/$m^3$, the Candidate Event Day could involve a **Tier 1** demonstration.

### 5.3 The Key Factor and Suggested Evidence to Include in Tier 1 Analyses

This section and Section 5.4 are intended to indicate that if a wildland fire-caused $PM_{2.5}$ event satisfies the key factors for either **Tier 1** or **Tier 2** clear causal analyses, then the additional evidence described for each tier should be sufficient to support the clear causal relationship criterion within an air agency's exceptional events demonstration for that particular event.
*Key Factor – Distinct high levels of monitored 24-hour $PM_{2.5}$ concentrations when compared to historical monthly or annual 24-hour levels of $PM_{2.5}$.* The key factor that delineates event-related monitored $PM_{2.5}$ concentrations for **Tier 1** analyses is the uniqueness of the concentration when compared to the typical levels of $PM_{2.5}$. For example, if an event-related exceedance occurs during a time of year that typically has no exceedances, then that event-related exceedance may be more clearly attributable to a fire than event-related concentrations that occur during the same month or season as typical high $PM_{2.5}$ concentrations. If the event-related exceedance occurs during a time of year in which other exceedances have been measured, the magnitude of the event-related exceedance should be clearly larger than any of the other measured exceedances that are not attributable to other EPA concurred upon or otherwise documented exceptional events. The EPA expects that **Tier 1** analyses supporting the clear causal relationship criterion may be appropriate for wildland fires that clearly influence monitored $PM_{2.5}$ exceedances or violations resulting in event concentrations that are clearly higher than non-event related concentrations. Many "extreme" wildfire events may be suitable for **Tier 1** analyses. In these situations, PM impacts should be accompanied by clear evidence that the wildland fire's emissions were transported to the location of the monitor.

*Criteria:* The EPA has determined that event-related exceedances should be greater than or equal to 1.5 times the tiering threshold as described for that candidate event day to be clearly distinguishable from non-event related concentrations.

One of the two types of analyses in Figures 1 and Figure 2, should be provided to support the air

agency's determination of the tiering threshold of the event, appropriate to the specific option the agency used to determine the tiering threshold. Agencies may choose to plot data with R qualified data excluded and/or R and I qualified data excluded.

1) Provide a 1-month time series plot covering the most recent 5 years of data for the month that the event day occurred in (multiple years can be overlayed on the same 1-month plot). Clearly distinguish the data for the candidate event day in each plot. An example is shown in Figure 2.

2) Provide a 1-year time series plot covering the year of the most recent 5-years of data with the lowest 98$^{th}$ percentile as shown in Figure 3. Clearly distinguish the data for the candidate event day in each plot.

Simplified Example with Corresponding Figures:

Candidate Event: 2022 Wildfire Smoke Event affecting Oakridge, OR.
- Candidate Days: September 9-11; 17-21; 23 – 27; 30, 2022
- Candidate $PM_{2.5}$ Concentrations range from 58.9 µg/m$^3$ – 298.6 µg/m$^3$

Tier Thresholds

a. 98$^{th}$ percentile of all 24-hr $PM_{2.5}$ concentrations from the month of September in 2018-2022 with all R and "informational only" (I) fire-related qualified days excluded (2$^{nd}$ maximum value of 59 total observations): = 39.1 µg/m$^3$. Tier 1 threshold = 1.5*39.1 = 58.7 µg/m$^3$. **Illustrated in Figure 2.**

**b.** Minimum annual 98$^{th}$ percentile 24-hr $PM_{2.5}$ concentration with all R and "informational only" (I) fire-related qualified days excluded from years 2018-2022 = 26.3 µg/m$^3$. Tier 1 = 1.5*26.3 = 39.5 µg/m$^3$. **Illustrated in Figure 3.** 24-hour $PM_{2.5}$ data from 2020 are graphed due to 2020's 98$^{th}$ percentile being the lowest in the 5-year period analyzed (2018-2022).

Lesser Value of Tier Threshold (a) and (b) = 39.5 µg/m$^3$

**Figure 2**: Example plot showing site $PM_{2.5}$ 24-hour average values for September for the 5-year period between 2018 and 2022. Candidate event-influenced days for 2022 are shown in salmon open squares. "R" and "I" qualified days are shown in purple and green, respectively. The dotted line shows the 98$^{th}$ percentile value for this site's dataset (39.1 µg/m$^3$). The solid line shows the Tier 1 threshold (58.7 µg/m$^3$). All candidate event-influenced days for this month qualify as Tier 1.

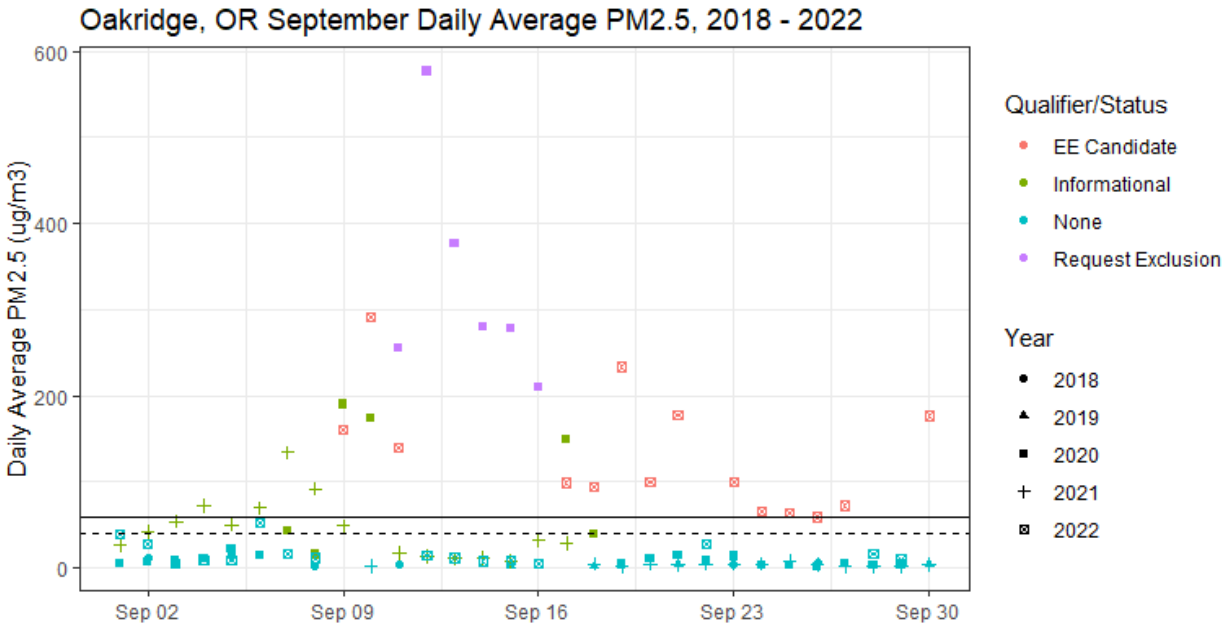
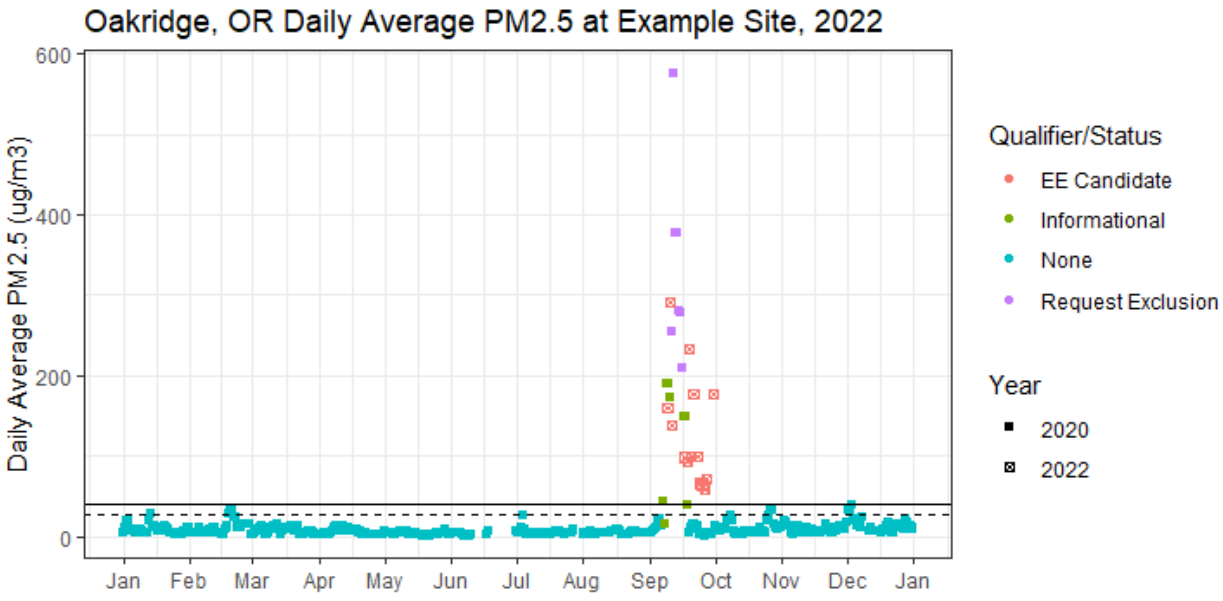



**Figure 3**: Time series plot of 24-hour $PM_{2.5}$ values for 2020 (circles), the most recent year in the last 5-years of data with the lowest 98$^{th}$ percentile. Purple and green circles indicate "R" and "I" qualified data, respectively. Candidate event-influenced days for September 2022 are shown in salmon triangles. The dotted line shows the 98$^{th}$ percentile value for 2020. The solid line shows the Tier 1 threshold. All candidate event-influenced days would qualify as Tier 1.



Evidence that the Event Emissions Were Transported to the Monitor(s)

In addition to the supporting analysis for the **Tier 1** key factor described for a **Tier 1** clear causal relationship analysis the air agency should also supply at least one piece of additional evidence to support that the emissions from the fire were transported to the monitor location (*i.e.*, the latitude and longitude). For example, this evidence could include a trajectory analysis or satellite imagery[16] of the smoke plume. The trajectory analysis or combination of satellite and surface measurements to show transport are described in more detail in Section 3.4.2 of the *Wildfire Ozone Guidance* document and its appendix. Additionally, more information on other trajectory models is included in the *Wildfire Resource Document*.

## 5.4 The Key Factor and Suggested Evidence to Include in Tier 2 Analyses

If a wildland fire event influences $PM_{2.5}$ concentrations, but this influence is not distinctly higher than or equal to non-event related concentrations as defined as 1.5 times the tiering threshold, then the event would not meet the **Tier 1** key factor and the analyses for a **Tier 1** event are not sufficient to show a clear causal relationship for the event. The air agency should then determine whether **Tier 2** analyses or **Tier 3** analyses would be appropriate.

*Key Factor – High levels of monitored 24-hour $PM_{2.5}$ concentrations, when compared to historical monthly or annual 24-hour levels of $PM_{2.5}$.* The EPA believes that it is appropriate to use a similar approach to the analysis for **Tier 1** to determine if a **Tier 2** analysis provides sufficient evidence to satisfy the clear causal relationship criteria for wildland fire $PM_{2.5}$ demonstrations. The EPA recommends a **Tier 2** analysis when event-related exceedances are greater than or equal to the tiering threshold but less than 1.5 times the tiering threshold, as previously described. Applying this key factor recognizes that an air agency will likely need more detailed information to establish a clear causal relationship between smoke transport from the event to the monitored exceedance.

Evidence that the Event Emissions Affected the Monitor(s) and reached the Ground Level

In addition to the supporting analysis for the **Tier 2** key factor, for a **Tier 2** clear causal relationship analysis, the air agency should provide evidence showing the emissions from the wildland fire were transported to the monitor location (*i.e.*, the latitude and longitude). Air agencies can use, as a technical piece of evidence, either a combination of trajectory analysis and surface measurements or satellite surface measurements to show this transport. (These recommendations are the same as for **Tier 1** demonstrations in Section 5.3 but are explained here again for completeness).

For the **Tier 2** demonstration, the air agency should also supply at least two additional pieces of evidence to support a weight of evidence conclusion that it was the emissions from the wildland

[16] *https://www.epa.gov/hesc/remote-sensing-information-gateway* and *http://arset.gsfc.nasa.gov/airquality/applications/fires-and-smoke* may be helpful resources.

fire, rather than other sources, that affected the monitored $PM_{2.5}$ concentration. Air agencies can use the following example evidence to demonstrate the fire emissions were present at the altitude of the monitor(s). This evidence could include, but is not limited to, the following:

1. Evidence of changes in hourly temporal patterns of $PM_{2.5}$ during the event, compared to typical non-event data
2. Photographic or videographic evidence of ground-level smoke at or near the monitor
3. Ground level measurements of corroborating pollutant concentrations [CO, PM (hourly mass or speciation), VOCs, or altered pollutant ratios]

    a. Plots of co-located or nearby CO, $PM_{2.5}$, $PM_{10}$, or $O_3$ and $PM_{2.5}$ precursor concentrations in the same airshed (or nonattainment/near nonattainment area) that have increases, or differences, in typical behavior that indicate the wildland fire's emissions influenced the monitor. Include an explanation of the plots.
    b. The timing and spatial distribution of NO, $NO_2$, and $O_3$, shown with data from multiple monitoring sites. These pollutant concentrations may vary when influenced by a wildland fire plume. Elevated levels that are widespread throughout a region, or are upwind of the urban area, may be due to impact of a fire plume. Peaks at locations and times different than those normally seen in an anthropogenic $O_3$ episode can indicate fire plume impact.
    c. Differences in CO: $NO_x$ and CO:$PM_{10}$ ratios: The ratio of CO and $NO_x$ emissions depends on their source; for agricultural burning it is about 10-20, for wildfire and prescribed wildland burning it is about 100,17 whereas for high-temperature fossil fuel combustion sources it is more like 4.[18] Thus, an unusually high CO/$NO_x$ ratio is consistent with wildfire impact. Similarly, the CO:$PM_{10}$ emission ratio is 8-16 in wildfires, but 200-2000 for vehicles.[19] However, changes in CO, and CO ratios, might be difficult to discern in an area dominated by vehicular CO, as the fire signal may be small in comparison.
    d. PM speciation data: $PM_{2.5}$ emissions from fires often contain elevated levels of organic carbon (OC), elemental carbon (EC), and are often enriched in water soluble potassium (K).[20] Levoglucosan, a biomass burning tracer molecule, can serve as an indicator for wildfire smoke; $PM_{10}$ from wood smoke is 14 percent or

[17] Dennis, A., Fraser, M., Anderson, S., Allen, D., 2002. Air pollutant emissions associated with forest, grassland, and agricultural burning in Texas. Atmospheric Environment, 36, 3779-3792.
[18] Chin, M., Jacob, D.J., Munger, J.W., Parrish, D.D., Doddridge, B.G., 1994. Relationship of ozone and carbon monoxide over North America. Journal of Geophysical Research, 99, 13565-14573.
[19] Phuleria, H., Fine, P., Zhu, Y., Sioutas, C., 2005. Air quality impacts of the October 2003 Southern California wildfires, Journal of Geophysical Research-Atmospheres, 110.
[20] Watson, J., Chow, J., Houck, J., 2001. $PM_{2.5}$ chemical source profiles for vehicle exhaust, vegetative burning, geological material, and coal burning in Northwestern Colorado during 1995. Chemosphere, 43, 1141-1151.

higher levoglucosan by mass.[21] Co-located or nearby particle speciation data (OC, EC, K, and/or levoglucosan) can be used to indicate fire impacts.

4. National Weather Service reports (e.g., Area Forecast Discussions)
5. Local news reports
6. Social media reports
7. Smoke models (*e.g.*, High-Resolution Rapid Refresh, Rapid Refresh, FireWork, BlueSky)
8. Secondary (non-regulatory) data (*e.g.*, special purpose, sensors, emergency, etc. monitors)

While fires typically generate emissions of CO, NO, $NO_2$, VOCs, $PM_{10}$, and $PM_{2.5}$, anthropogenic sources, such as industrial and vehicular combustion, also emit these pollutants. Therefore, the **Tier 2** demonstration should distinguish the difference in the non-event pollutant behavior (*e.g.*, concentration, timing, ratios, and/or spatial patterns) from the behavior during the event impact to more clearly show that the emissions from the wildland fire(s) affected the monitor(s).

### 5.5 Tier 3 Analyses to Support the Clear Causal Relationship

Wildland fire-caused $PM_{2.5}$ events not meeting the tiering threshold criteria for **Tier 1** or **Tier 2** analyses, or otherwise determined by the EPA to need only a **Tier 1** or **Tier 2** analysis, will be considered by the EPA based on the **Tier 3** level of analyses. **Tier 3** is appropriate when the relationship between the wildland fire and the $PM_{2.5}$ exceedance/violation is more complicated than the relationship in a **Tier 2** analysis and thus would require more supporting documentation. **Tier 3** demonstrations are appropriate when the measured 24-hour $PM_{2.5}$ concentration is less than the tier threshold and there are not any other extenuating circumstances or data anomalies that would point to a **Tier 2** analysis being sufficient. These **Tier 3** events include areas where monitors are impacted by: multiple sources of emissions, including industrial sources; multiple event types, including dust events, volcanic events, and cultural events like fireworks during holidays or other events; and/or prescribed fires. **Tier 3** may also be appropriate when an agency believes long-range wildland fire smoke has impacted monitors that are thousands of miles away from the fire source, and the $PM_{2.5}$ concentration is closer to typical days of non-fire influenced concentrations. Additionally, **Tier 3** may be appropriate when the air agency has not identified a specific wildland fire at surface areas along the long-range transport path and/or where concentrations along the path do not demonstrate transport. When addressing the **Tier 3** clear causal relationship criterion within the demonstration, in addition to the **Tier 2** requirements, the

[21] Jordan, T., Seen, A., Jacobsen, G., 2006. Levoglucosan as an atmospheric tracer for woodsmoke. Atmospheric Environment, 40, 5316-5321. Kansas Department of Health and Environment, 2012. State of Kansas Exceptional Events Demonstration April 6, 12, 13, and 29, 2011. Department of Health and Environment, Division of Environment, Bureau of Air. November 27, 2012. http://www.epa.gov/sites/production/files/2015-05/documents/kdhe_exevents_final_042011.pdf.

air agency might compile the following additional evidence to add to the weight of evidence demonstration, or other evidence as appropriate for the event:

- backward and forward trajectories from the wildland fire to the affected monitor
- analysis of hourly PM, meteorological, or other available data
- a vertical $PM_{2.5}$ profile or model simulations

Together this information could satisfy the clear causal relationship criterion under a weight of evidence approach. More complicated relationships between the wildland fires and influenced $PM_{2.5}$ concentrations may require additional detail to satisfy the clear causal relationship element. The EPA does not expect an air agency to prepare all identified analyses but only those that add to their weight of evidence supporting the clear causal relationship. As with all exceptional events demonstrations, the submitting air agency and the EPA Regional office should discuss the appropriate level of evidence during the Initial Notification process.

In addition to the evidence suggested for a **Tier 1** or **Tier 2** demonstration, an air agency should provide additional evidence showing the emissions from the wildland fire were transported to the monitor location. The **Tier 3** clear causal relationship analyses could include multiple analyses from those examples listed in Sections 5.3 and 5.4. Each additional piece of information that supports the event's influence will strengthen the air agency's request for data exclusion under the Exceptional Events Rule. Depending on evidence supplied in other sections of the demonstration, an air agency may further support the clear causal relationship between the wildland fire and the $PM_{2.5}$ exceedance with the items listed in more detail:

1. Statistical Regression Modeling
2. Photochemical modeling
3. Emissions (maps, typical emissions)
4. Multi-pollutant corroboration
5. Ceilometer data
6. Buddy site comparisons

## 5.6 Summary of Evidence Under Three Supporting Analysis Tiers that Could be Used to Meet the Exceptional Events Rule Elements

Table 4 summarizes the technical information that air agencies can use to support the clear causal relationship under each of the three analytical tiers for wildland fire-related exceptional events demonstrations.

Table 4. Clear Causal Relationship Technical Demonstration Components Recommended for Tier 1, Tier 2, and Tier 3 Demonstrations.

| **Tier 1 Analyses Should Include** | **Tier 2 Analyses Should Include** | **Tier 3 Analyses Should Include** |
|---|---|---|
| The tiering threshold used for the event day, which calculation methodology was used, and comparison of the 24-hour PM value to the tiering threshold. | The tiering threshold used for the event day, which calculation methodology was used, and comparison of the 24-hour PM value to the tiering threshold. | The tiering threshold used for the event day, which calculation methodology was used, and comparison of the 24-hour PM value to the tiering threshold. |
| Comparison of the fire-influenced exceedance with historical concentrations, by providing two data plots appropriate to the chosen tiering threshold calculation methodology (R qualified data removed, R and I qualified data removed). | Comparison of the fire-influenced exceedance with historical concentrations, by providing two data plots appropriate to the chosen tiering threshold calculation methodology (R qualified data removed, R and I qualified data removed). | Comparison of the fire-influenced exceedance with historical concentrations, by providing two data plots appropriate to the chosen tiering threshold calculation methodology (R qualified data removed, R and I qualified data removed). |
| Evidence of transport of fire emissions from fire to the monitor (**one** of these):<br>• Trajectories linking fire with the monitor (forward and backward), considering height of trajectories, or<br>• Satellite evidence in combination with surface measurements. | Evidence of transport of fire emissions from fire to the monitor (**one** of these):<br>• Trajectories linking fire with the monitor (forward and backward), considering height of trajectories, or<br>• Satellite evidence in combination with surface measurements. | Evidence of transport of fire emissions from fire to the monitor (**one** of these):<br>• Trajectories linking fire with the monitor (forward and backward), considering height of trajectories, or<br>• Satellite evidence in combination with surface measurements. |
| | Two additional pieces of evidence demonstrating that the fire emissions affected the monitor, as identified for **Tier 2** analyses. | At least three additional pieces of evidence demonstrating that the fire emissions affected the monitor, which could include the items in the next box. |
| | | Additional evidence to add to the weight of evidence demonstration, or other evidence as appropriate for the event, including:<br>• Backward and forward trajectories from the wildland fire to the affected monitor,<br>• Analysis of hourly PM, meteorological, or other available data, and<br>• a vertical $PM_{2.5}$ profile or model simulations. |

| | | |
|---|---|---|
| United States Environmental Protection Agency | Office of Air Quality Planning and Standards<br>Air Quality Policy Division<br>Research Triangle Park, NC | Publication No. EPA-457/D-24-001<br>January 2024 |