Exceptional Events Demonstration Addressing the 2015 8-Hour Ozone (O_3) National Ambient Air Quality Standard (NAAQS)

Charlestown State Park Monitor
Clark County, Indiana

Developed By:

The Indiana Department of Environmental Management (IDEM)

July 2026

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1.0 INTRODUCTION

1.1 Background

The Clean Air Act (CAA) required National Ambient Air Quality Standards (NAAQS) to be established and routinely reviewed for six criteria pollutants; ground level ozone (O_3) is one of the six criteria pollutants. Ground-level ozone is not emitted directly into the air but instead is created by a chemical reaction between other pollutants including oxides of nitrogen (NO_x) and volatile organic compounds (VOC). NO_x and VOCs are emitted by a variety of sources such as gasoline powered engines, power plants, industrial boilers, refineries, chemical plants, and residential sources. In the atmosphere, NO_x and VOCs chemically react in the presence of sunlight to form ozone. Ozone is most likely to reach unhealthy levels on hot, sunny, non-windy days in urban environments. Once formed, ozone can be transported long distances, elevating concentrations in urban and rural areas hundreds of miles away.

Ozone occurs naturally at high altitudes to protect the earth from the sun's harmful ultraviolet rays. However, breathing ozone that forms at ground-level can cause respiratory problems for anyone. Sensitive groups, such as the very young, the elderly, or people with asthma or chronic respiratory problems, may be particularly vulnerable to ill health effects. Elevated ozone can also have secondary impacts on public welfare, harming sensitive vegetation and ecosystems, including forests, parks, wildlife refuges, and wilderness areas.

The United States Environmental Protection Agency (U.S. EPA) conducts 5-year reviews of all criteria pollutants, including ozone. These reviews include related health studies and assessments from science and health experts. The initial ozone standard was established in 1971, with revisions in 1979, 1997 (which revised the threshold and time-averaging form of the standard from 1-hour to the annual fourth highest daily maximum 8-hour average concentration averaged over three years), 2008 and 2015. U.S. EPA's 2015 review resulted in the strengthening of the 8-hour standard from 0.075 parts per million (ppm) to 0.070 ppm and an extension of Indiana's ozone monitoring season to March 1 through October 31. Air quality monitoring data is used to determine an area's compliance with the standards. When "exceptional" events influence monitoring data and cause exceedances or violations of the NAAQS, air agencies can request, and the U.S. EPA can agree, to exclude certain data influenced by the exceptional events.

1.2 Exceptional Event (EE) Rule and Guidance

U.S. EPA promulgated the Exceptional Events Rule in 2007 (73 FR 13560) to address Clean Air Act (CAA) section 319(b), which allows for the exclusion of air quality monitoring data influenced by exceptional events from use in determinations of exceedances or violations of the NAAQS, including the ozone standard. In September

2016, U.S. EPA revised the 2007 Exceptional Events Rule based on implementation experiences and issued "*Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations*" to recommend example language and analyses for demonstrations[1]. The revised Exceptional Events Rule, found at 40 CFR 50.14(c)(3), clarifies that an exceptional events demonstration must include the following elements:

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);
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;
3) Analyses comparing the claimed event-influenced concentration(s) to concentrations at the same monitoring site at other times. The Administrator shall not require a State to prove a specific percentile point in the distribution of data;
4) A demonstration that the event was both not reasonably controllable and not reasonably preventable;
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; and
6) Documentation that the submitting air agency followed the public comment process.

Emissions from wildfires are presumed to meet the standards in 40 CFR 50.14(c)(3)(iv)(D) (i.e., not reasonably controllable and not reasonably preventable), as stated in 40 CFR 50.14(b)(4): "Provided the Administrator determines there is no compelling evidence to the contrary in the record, the Administrator will determine every wildfire occurring predominantly on wildland to have met the requirements …regarding the not reasonably controllable or preventable criterion".

In accordance with the revised Exceptional Events Rule and guidance memorandum (September 2016), IDEM is providing this demonstration to request the following day be excluded as an exceptional event for the Charlestown State Park monitor in Clark County, Indiana:

- June 11, 2025

This demonstration includes maps, figures, and tables of the wildfire events that impacted Indiana, description of the ozone monitor at Charlestown State Park, examples of media coverage of the wildfire event, meteorological analysis, monitoring

[1] https://www.epa.gov/system/files/documents/2023-12/guidance-on-the-preparation-of-ee-wf-ozone.pdf

trends and smoke forecasts from the requested day to determine transport of smoke and ozone conducive conditions, and other trends and matching day analyses to confirm the impact of wildfire smoke on ozone concentrations.

1.3 Overview of the Charlestown State Park Monitor and the Louisville, KY-IN Nonattainment and Maintenance Area

The Charlestown State Park monitor is located in Clark County, Indiana, which is part of the larger Louisville, Kentucky-Indiana (KY-IN) area, along with Floyd County, Indiana, and Bullitt, Jefferson, and Oldham counties in Kentucky. Seven other ozone monitors operate in the area, including one in Floyd County and six in the Louisville area. The region covers 1,419 square miles and has an estimated 2024 population of 1.15 million people, with the majority residing in Jefferson County, Kentucky. Indiana's portion of the area lies along the Ohio River in southern Indiana's forested Knobs region.

The Louisville, KY-IN nonattainment and maintenance area consists of five counties: Bullitt, Jefferson, and Oldham counties in Kentucky, and Clark and Floyd counties in Indiana. The Indiana portion of the Louisville, KY-IN area has been redesignated from "nonattainment" to "attainment" under the 2015 8-hour ozone standard and is therefore referred to as a maintenance area; however, the Kentucky portion remains designated nonattainment, classified "moderate", under the standard.

1.4 Regulatory Significance of Exceptional Events Demonstration for the Charlestown State Park Monitor

Wildfire impacts on air quality have increased in frequency and scale since U.S. EPA issued the Exceptional Events Rule and guidance for ozone. The current form of the ozone standard is a three-year average of the annual 4th highest concentration. The first three highest values for each annual period are excluded from the design value calculation. However, in recent years it has been common for more than three days of an ozone season to be influenced by wildfire smoke, and the design value does not accommodate the increased frequency and scale of wildfire smoke impacting the U.S.

The Indiana portion of the Louisville area, consisting of Clark and Floyd counties, was redesignated to attainment on July 5, 2022 (87 FR 39750). Both Indiana area monitors continued to measure attainment until wildfire smoke elevated ozone concentrations at the Charlestown State Park monitor in 2025. The Kentucky portion of the Louisville area is designated as "moderate" nonattainment under the 2015 8-hour ozone NAAQS and is multijurisdictional, comprised of Bullitt, Jefferson, and Oldham counties. Since the Kentucky portion of the Louisville area is still designated as nonattainment, redesignation will be determined based on the most recent years' ozone data. In this case, ozone data from 2025 at area monitors will be used in determining whether the area has attained the standard.

The Cannons Lane monitor in Jefferson County, KY is the controlling monitor for the area, i.e., the monitor with the highest design value. This monitor is operated by Louisville Metro Air Pollution Control District, the agency responsible for regulating air pollution in Jefferson County, Kentucky. Prior to the 2023-2025 design value, Cannons Lane was the only area monitor that violated the 2015 8-hour NAAQS. Once 2025 ozone data was certified, two additional area monitors, including one in the Indiana portion of the area, Charlestown State Park, violated the 2015 standard with 2023-2025 design values of 0.071 ppm.

On January 29, 2026, U.S. EPA finalized a rule denying Kentucky's request to redesignate the Kentucky portion of the area to attainment (91 FR 3838). The primary reason behind the denial was that the area "does not meet the first statutory criterion for redesignation to attainment of the 2015 8-hour ozone NAAQS" due to a violating 2022-2024 design value of 0.074 ppm at the Cannons Lane monitor. Thus, excluding appropriate 2024 smoke-influenced data to reduce the 2024 and 2025 design values at all violating monitors is regulatorily significant under the Exceptional Event Rule so that Kentucky can meet the first statutory criterion for redesignation to attainment and continue to demonstrate attainment area-wide.

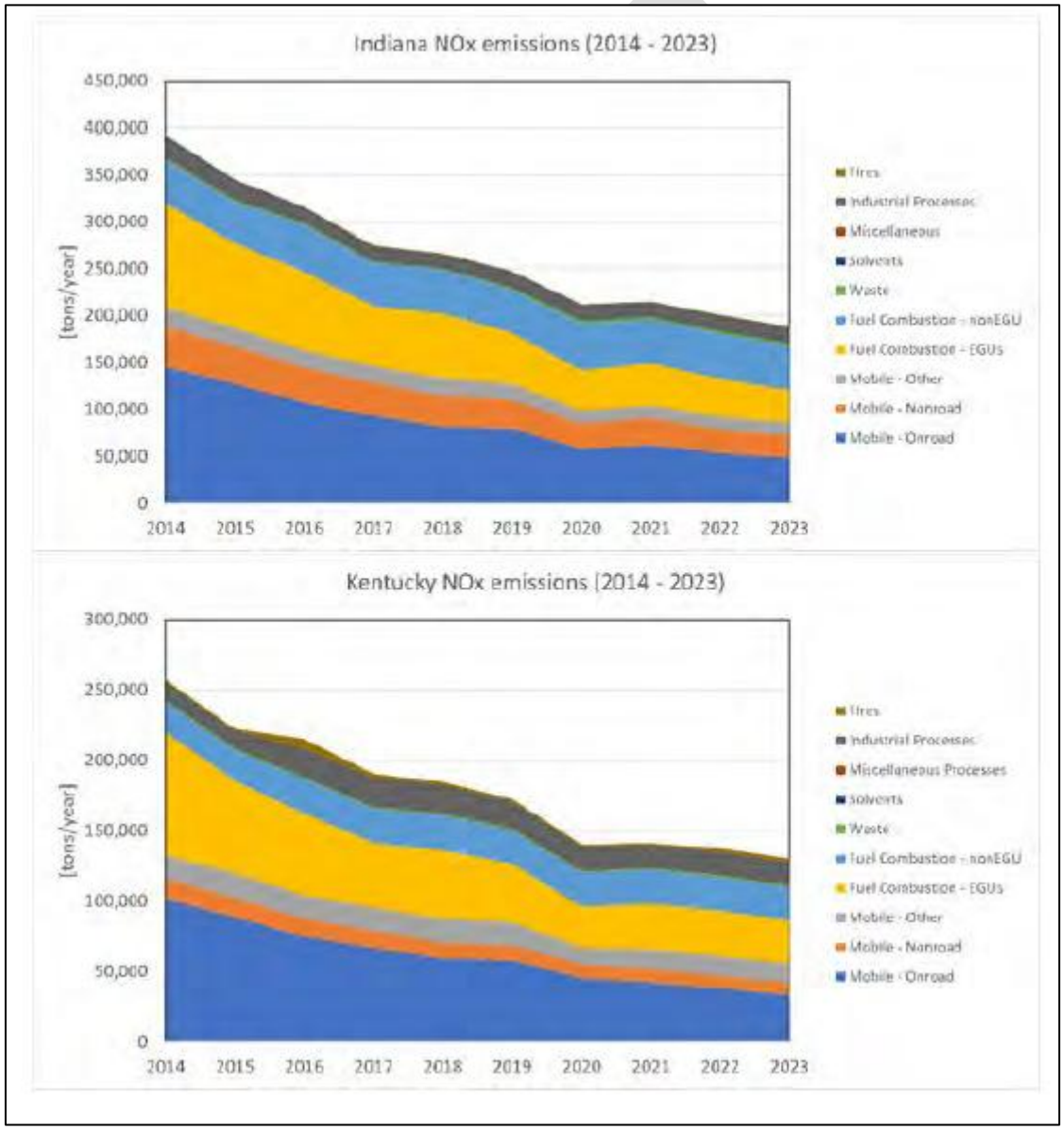
The Kentucky Division for Air Quality (KDAQ) and the Louisville Metro Air Pollution Control District (LAPCD) prepared an Exceptional Event Demonstration for wildfire-related ozone impacts experienced in 2024. The Charlestown State Park monitor is a part of the Louisville KY-IN nonattainment area and is addressed in the KDAQ/LAPCD demonstration. While IDEM agrees with the smoke day identified in 2024 that impacted the Charlestown State Park and several other ozone monitors in the Louisville area, IDEM identified June 11, 2025, as a day that was also significantly impacted by wildfire smoke that, if excluded from ozone design value calculations through 2027, would provide design values at the Charlestown State Park ozone monitor that would be at or below the NAAQS. The exclusion of the June 11, 2025, exceptional events data for the Charlestown State Park monitor therefore has regulatory significance for the Louisville, KY-IN maintenance area (Indiana portion) and nonattainment area (Kentucky portion).

2.0 Narrative Conceptual Model

2.1 Emissions and Monitoring Review

Emissions trends for ozone precursor emissions (NO_x and VOCs) have consistently decreased over the past decades in Indiana, with an approximate 50% decrease in NO_x emissions and an approximate 10% decrease in VOC emissions from 2014 – 2023. Figure 2.1 illustrates the reductions achieved in Indiana as well as similar reductions in Kentucky.

Figure 2.1 – Indiana and Kentucky NO_x and VOC Emissions Trends (2014 – 2023)



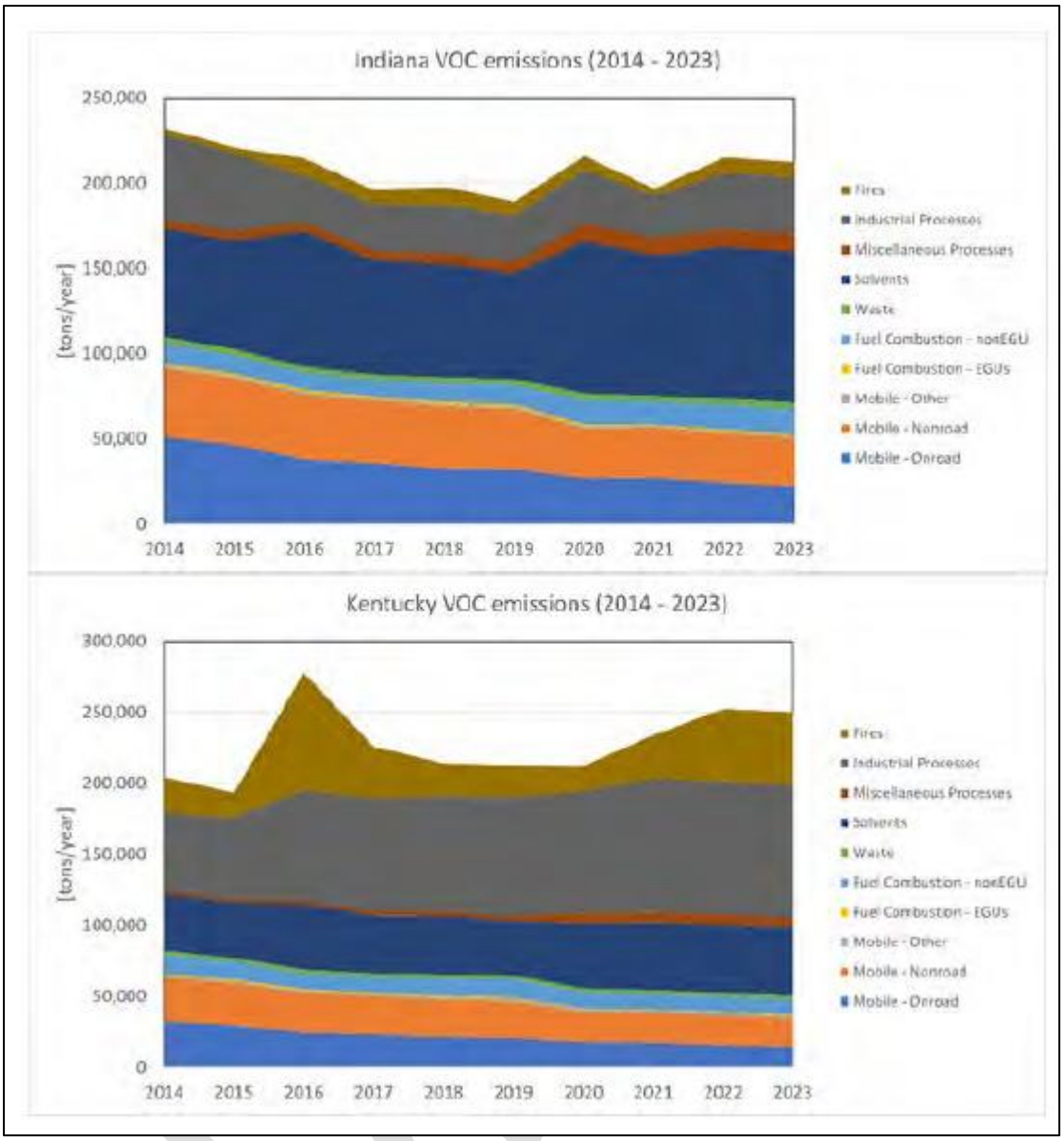
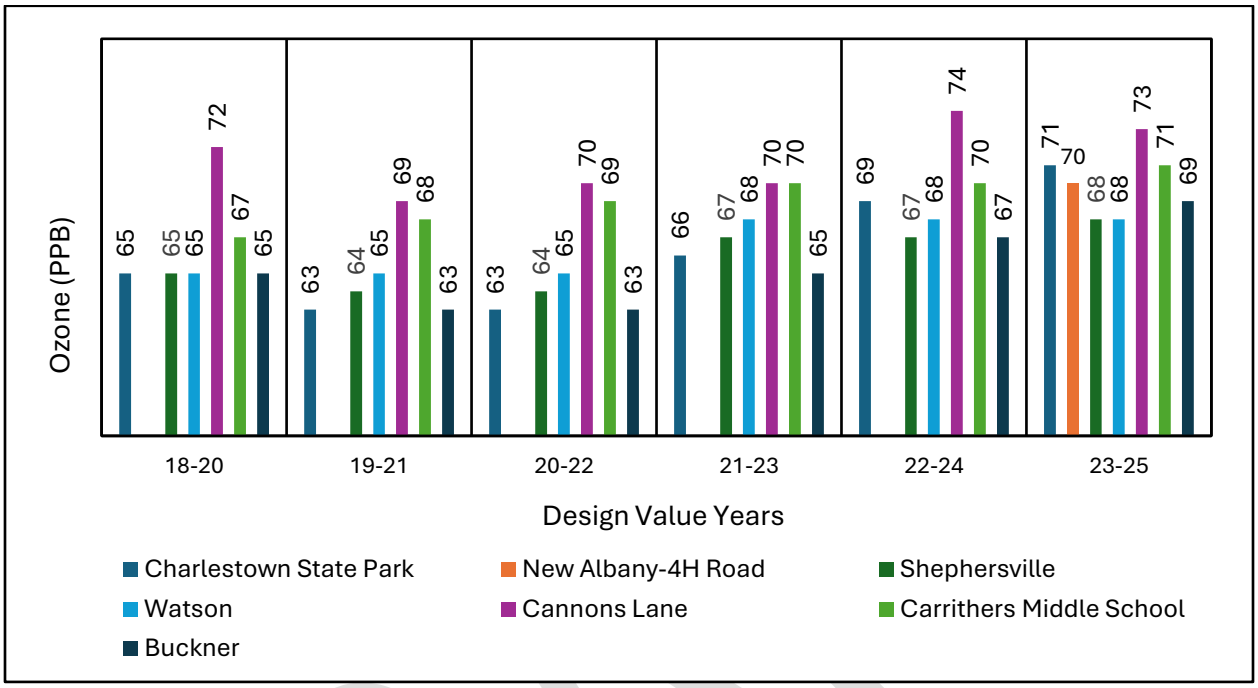


Figure 2.2 shows ozone design value trends from 2018-2020 through 2023-2025 for monitors in the Louisville, KY-IN area (excluding the Algonquin Parkway monitor which recently began operation). The Cannons Lane monitor in Louisville has historically recorded the area's highest ozone concentrations and remains the area's "controlling monitor." Design values for the other monitors displayed, including the Charlestown State Park monitor in Clark County, IN, consistently attained the standard until the 2023-2025 timeframe, when wildfire smoke elevated ozone concentrations.

Indiana notes the 2023-2025 DVs for the Carithers Middle School monitor and the Cannons Lane monitor in Louisville also violated the 2015 ozone standard. As discussed in Section 1.4 above, Kentucky is conducting separate analyses into the impacts of wildfire smoke on monitors in the Louisville portion of the area. Section 2.3,

below, discusses the Charlestown State Park, Cannons Lane, and Carithers Middle School monitors in greater detail.

Figure 2.2 – Louisville Area Ozone Design Value Trends



2.2 Wildfire Smoke Impacts

Uncontrolled wildfire smoke has played a major role in higher ozone concentrations observed throughout the Midwest and, more recently, the Indiana portion of the Louisville, KY-IN area. Frequency of wildfires in Canada and the United States have remained fairly consistent over the past several decades, however the acreage burned per year has trended upward with extreme spikes in acreage burned during more recent fire seasons. The resulting wildfire smoke has impacted both ozone and $PM_{2.5}$ concentrations throughout the Midwest. These naturally occurring precursor emissions from wildfire smoke have contributed to the formation of ozone under certain conditions and elevated ozone concentrations beyond what would be expected in 2025.

The daily total intensity, indicated by Fire Radiative Power (FRP) values, in Saskatchewan, Manitoba, and Ontario, have been significantly above the 23-year average throughout June and July, with correspondingly high estimated wildfire emissions in the three provinces. In Saskatchewan and Manitoba, cumulative wildfire carbon emissions since the start of the year are already at their highest level on record at just over 66 megatons and around 44 megatons respectively, contributing to the

cumulative total for Canada of around 180 megatons.[2] The solid red line in Figure 2.3 shows increasing cumulative daily total wildfire carbon emissions throughout June 2025.

Figure 2.3 – Cumulative Daily Total Wildfire Carbon Emissions

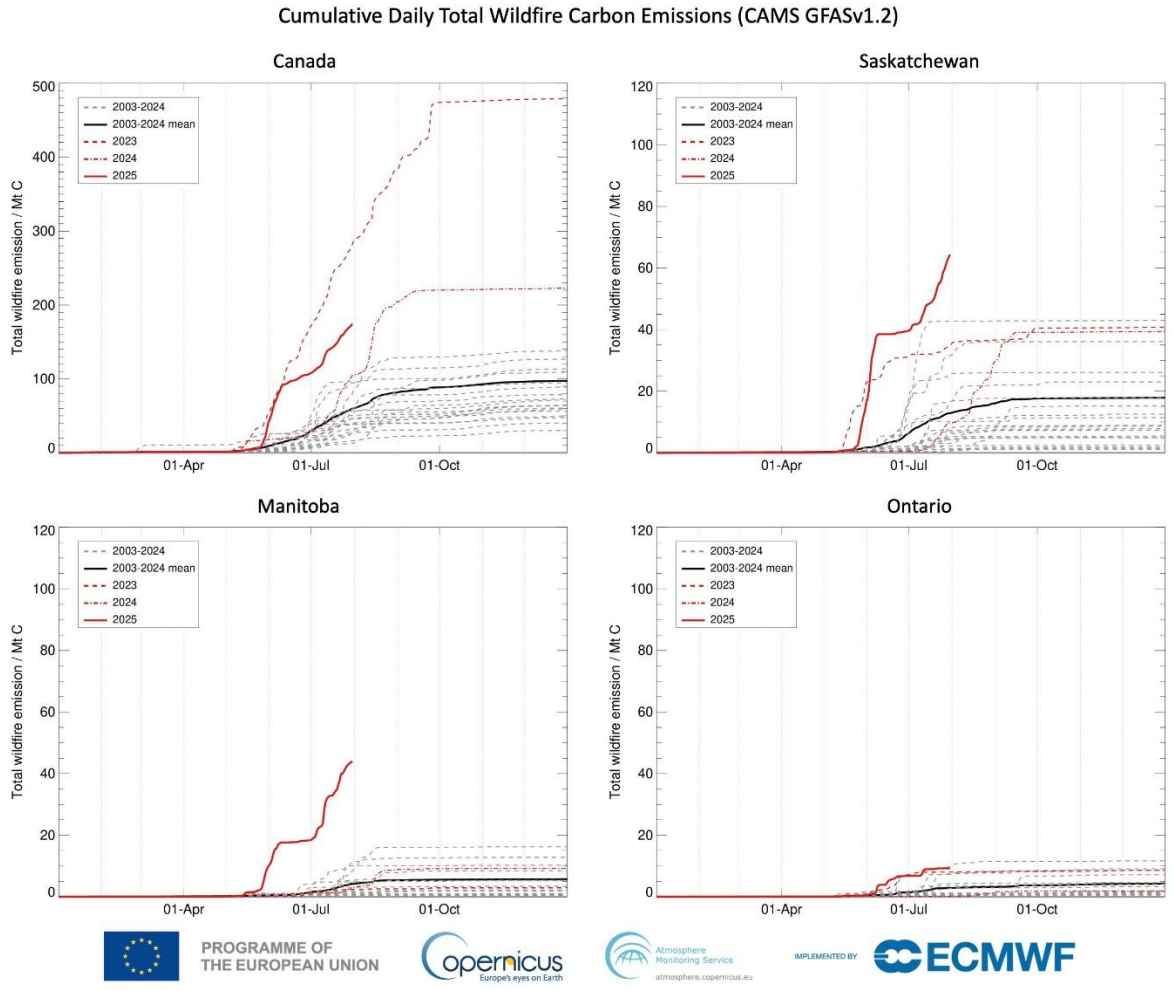
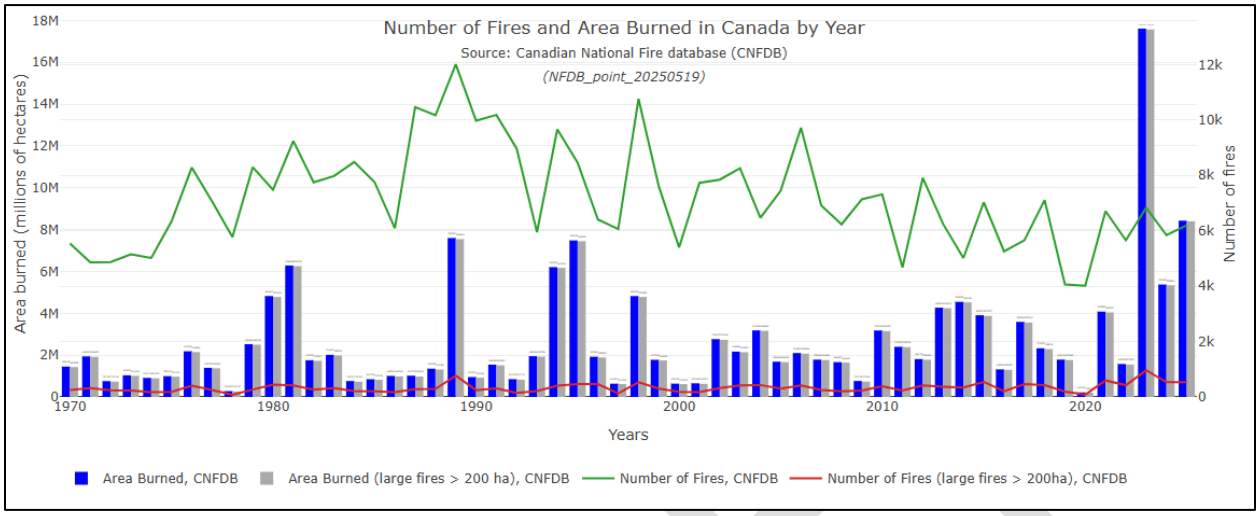


Figure 2.4 depicts the number of wildfires and acreage burned in Canada from 1970 through 2025. As can be noted, 2023 was by far the highest hectares burned in the past 55 years. While this chart has not been updated to include 2025 data, the Canadian National Fire Database (CNFDB) indicates there were nearly 9 million hectares burned in 2025, making it the second most hectares burned in Canada since 1970. Smoke from wildfires from 2025 severely impacted air quality in Indiana and the Midwest.

[2] https://atmosphere.copernicus.eu/cams-tracks-extreme-july-wildfire-activity-both-sides-atlantic

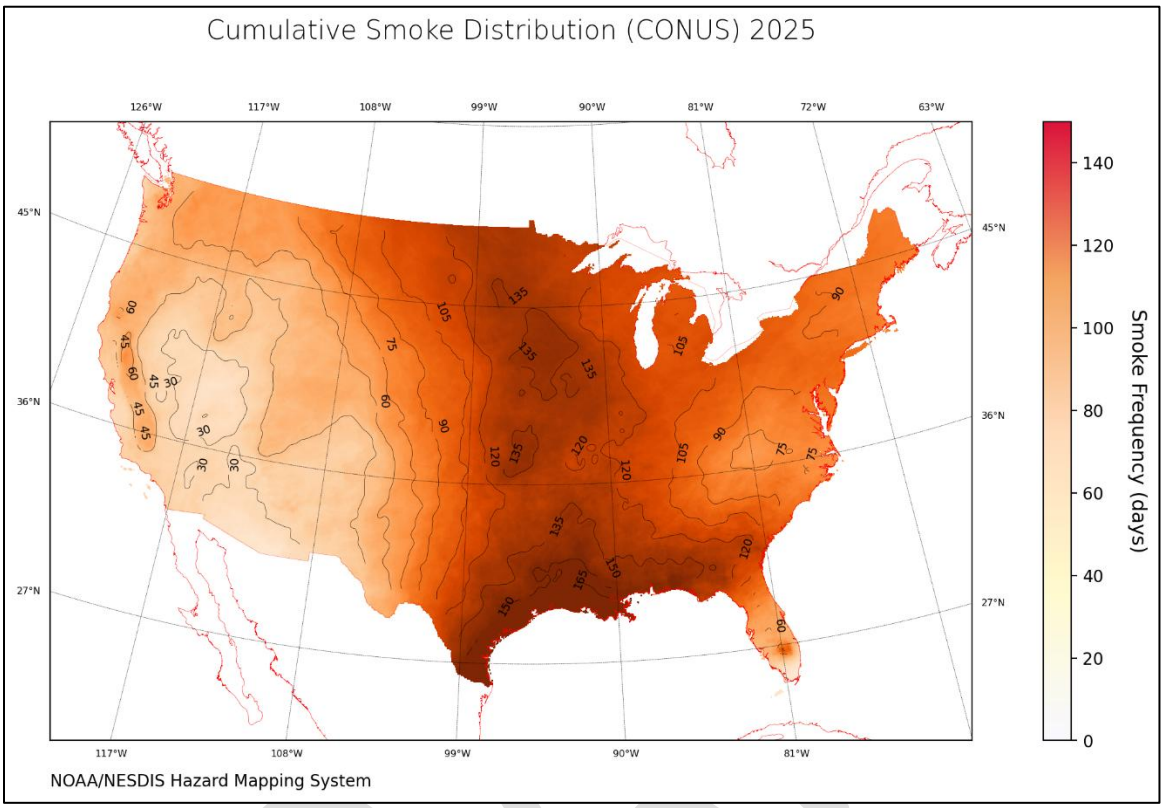
Figure 2.4 – Canadian Wildfire and Areas (Hectares) Burned (1970 – 2025)



The cumulative smoke distribution maps, taken from the NOAA Hazard Mapping[3] system fire point analysis, shows southern Indiana had between 105 and 120 smoke frequency days in 2025. Figure 2.5 represents the smoke day distribution for the entire country for 2025, with the majority of smoke days concentrated over the Central Plains and Mississippi Valley during Canada's severe wildfire season in 2025.

[3] https://www.ospo.noaa.gov/products/land/hms.html#stats-smoke

Figure 2.5 – Cumulative Smoke Frequency Days for 2025



2.3 Indiana and Louisville, KY-IN Area Ozone Monitoring Networks

Indiana has a total of thirty-eight ozone monitoring sites within the state, collecting hourly data primarily from March 1 through October 31. Figure 2.6 shows the ozone monitor locations throughout the state of Indiana with the Charlestown State Park ozone monitor highlighted. Figure 2.7 shows the ozone monitors in the Louisville, KY-IN area. Each monitor is a State or Local Air Monitoring Station (SLAMS) monitor with a scale set for neighborhood or urban to determine population exposure or the highest concentrations.

Figure 2.6 – Indiana's Ozone Air Monitoring Network

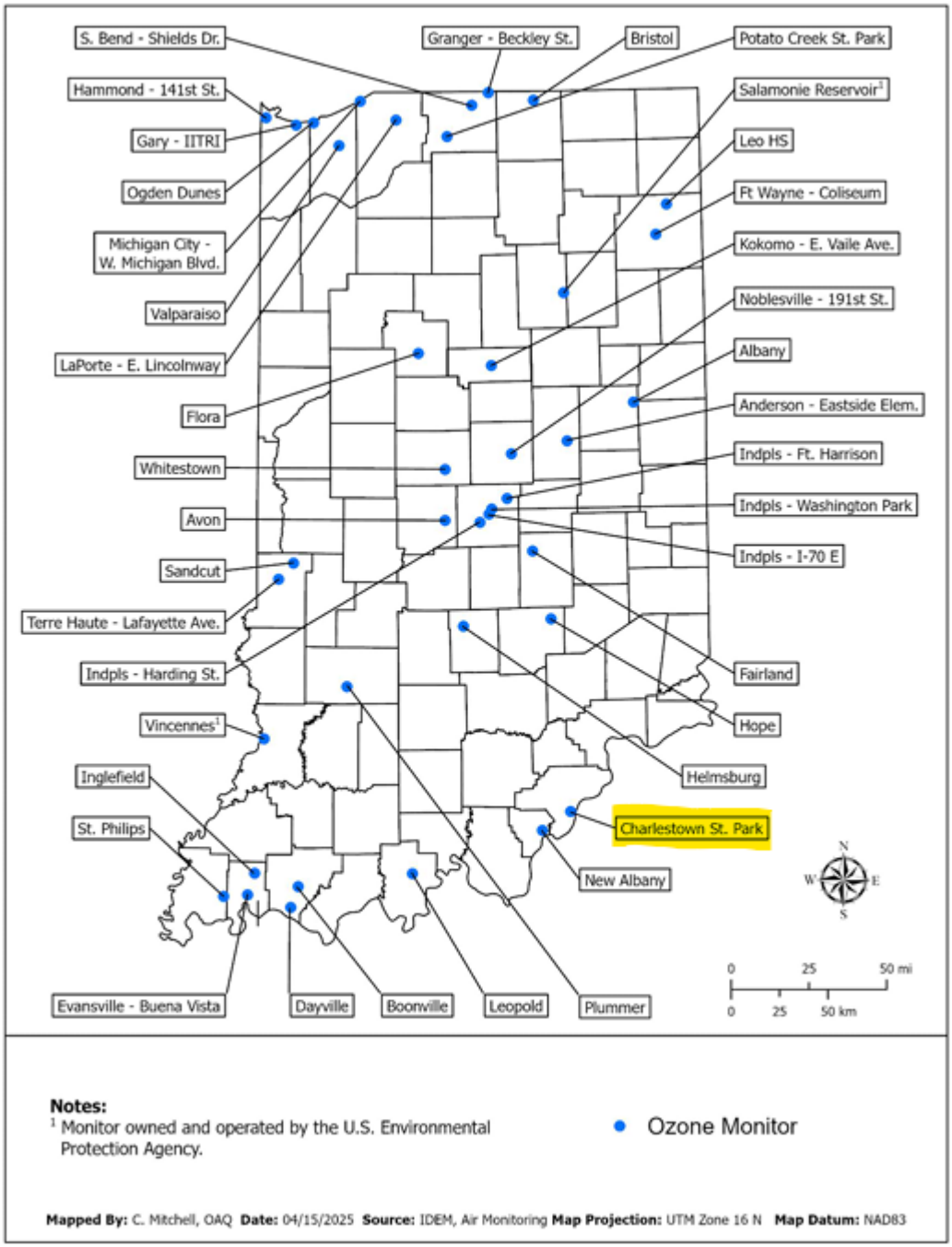
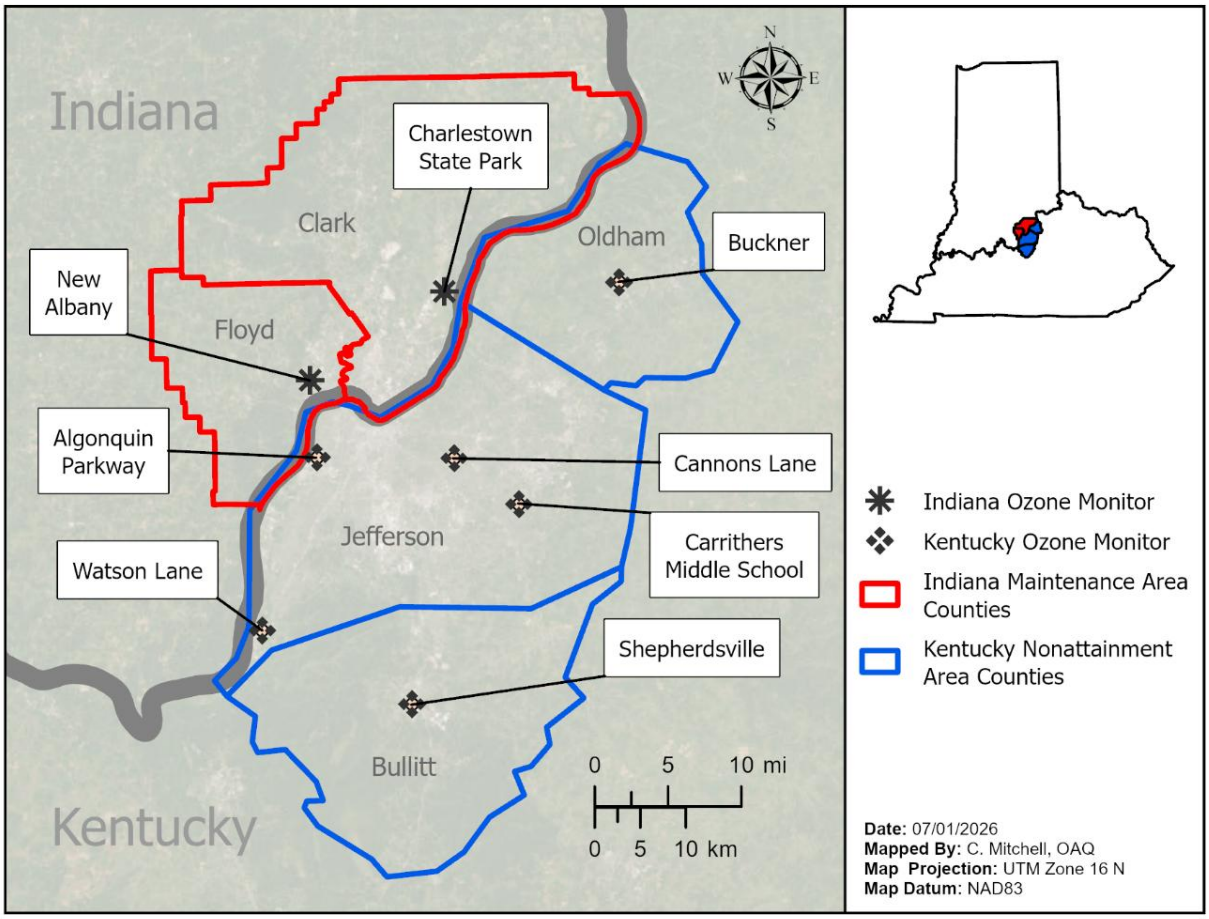


Figure 2.7 – Louisville Area Ozone Monitors



The Charlestown State Park monitor is located in Clark County, IN, as shown in Figures 2.8 and 2.9. It is the only ozone monitor in Clark County, and ozone is the only pollutant measured at the site. It is located in between a large, forested park and a large industrial/warehouse area. This monitor is typically downwind of the urban emissions from city activity and usually sees similar trends but lower actual measurements when compared to the Cannons Lane monitor. The monitoring objective of the Charlestown site is to measure ozone and meteorological conditions downwind of Louisville, Kentucky.

The Cannons Lane monitor (AQS ID# 21-111-0067), in Jefferson County, KY, is the controlling monitor in the area, as it has the highest three-year ozone design value. It is located 11.1 miles south of the Charlestown State Park monitor.

The Carrithers Middle School monitor (AQS ID# 21-111-0067), in Jefferson County, KY, is located 15.5 miles south-southeast of the Charlestown State Park monitor in a dense suburban setting. It is the easternmost monitor in Jefferson County. This monitor tends to show a similar trend in ozone formation to the Cannons Lane monitor.

Figure 2.8 – Overview of Charlestown State Park Ozone Monitor Location

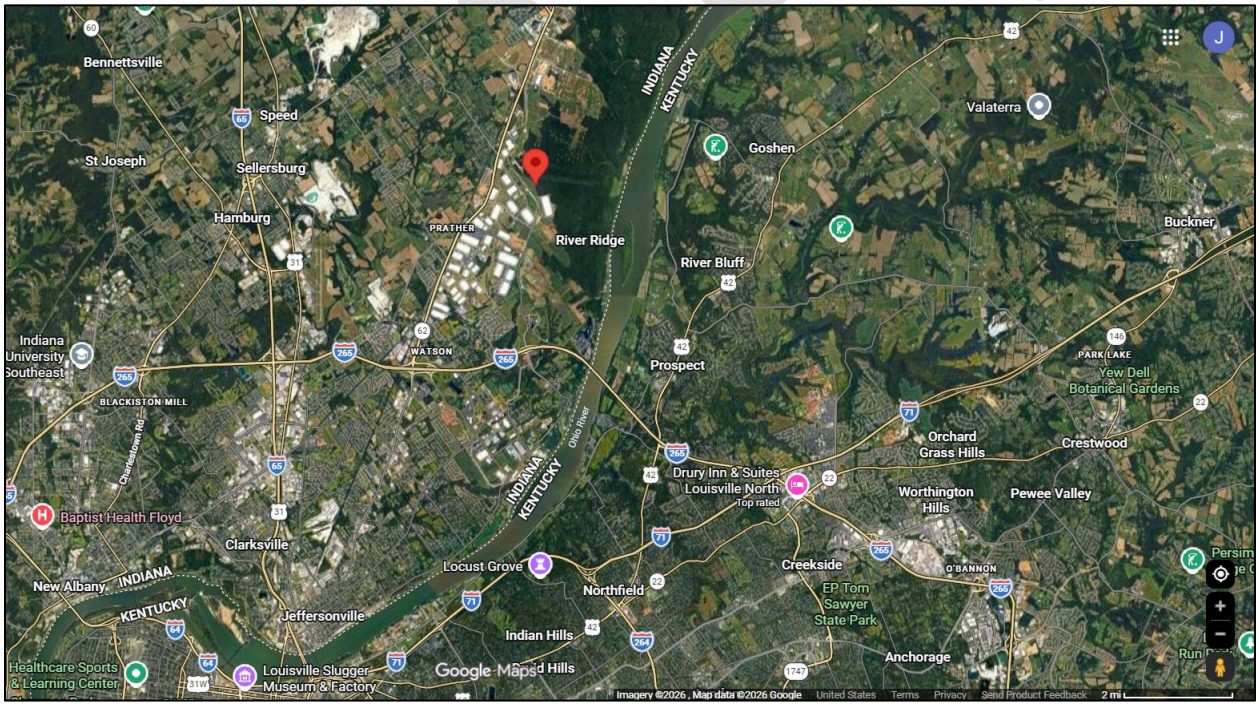


Figure 2.9 – Map of Charlestown State Park Ozone Monitor

The Charlestown State Park monitor exceeded the 2015 ozone standard for 2023-2025, as shown in Table 2.1.

Table 2.1 – 2023-2025 Ozone Maximum Daily 8-hour Averages (MDA8) and Design Value for the Charlestown State Park Monitor

Monitor	2023 Fourth Highest MDA8 Ozone Value (ppb)	2024 Fourth Highest MDA8 Ozone Value (ppb)	2025 Fourth Highest MDA8 Ozone Value (ppb)	2023-2025 8-Hour Ozone Design Value (ppb)
Charlestown State Park	72	73	70	71

Table 2.2 shows the top five highest ranked 8-hour ozone concentrations for the Charlestown State Park monitor for 2025, with the highest measurement occurring June 11, 2025.

Table 2.2 – 2025 Highest MDA8 Ozone Concentrations for the Charlestown State Park Monitor

Annual Rank	Date	MDA8 Ozone Concentration (ppb)
1st	6/11/2025	80
2nd	9/19/2025	72
3rd	9/18/2025	71
4th	9/20/2025	70
5th	9/12/2025	63

To determine the regulatory significance for making the exceptional events request, the data for June 11, 2025, was removed from the 2025 daily ozone monitoring data. Using U.S. EPA's Exceptional Events Analysis and Visualization Tools[4], a revised 2023-2025 design value was calculated for the Charlestown State Park monitor. Table 2.3 shows the updated 4th high value for 2025 and the corresponding 2023-2025 design value for the Charlestown State Park monitor with the requested smoke-impacted day excluded.

Table 2.3 – 2023-2025 MDA8s and Design Value for the Charlestown State Park Monitor After Removing the Wildfire Smoke-Influenced Day

Monitor	2023 Fourth Highest MDA8 Ozone Value (ppb)	2024 Fourth Highest MDA8 Ozone Value (ppb)	2025 Fourth Highest MDA8 Ozone Value (ppb)	2023-2025 8-Hour Ozone Design Value (ppb)
Charlestown State Park	72	73	63	69

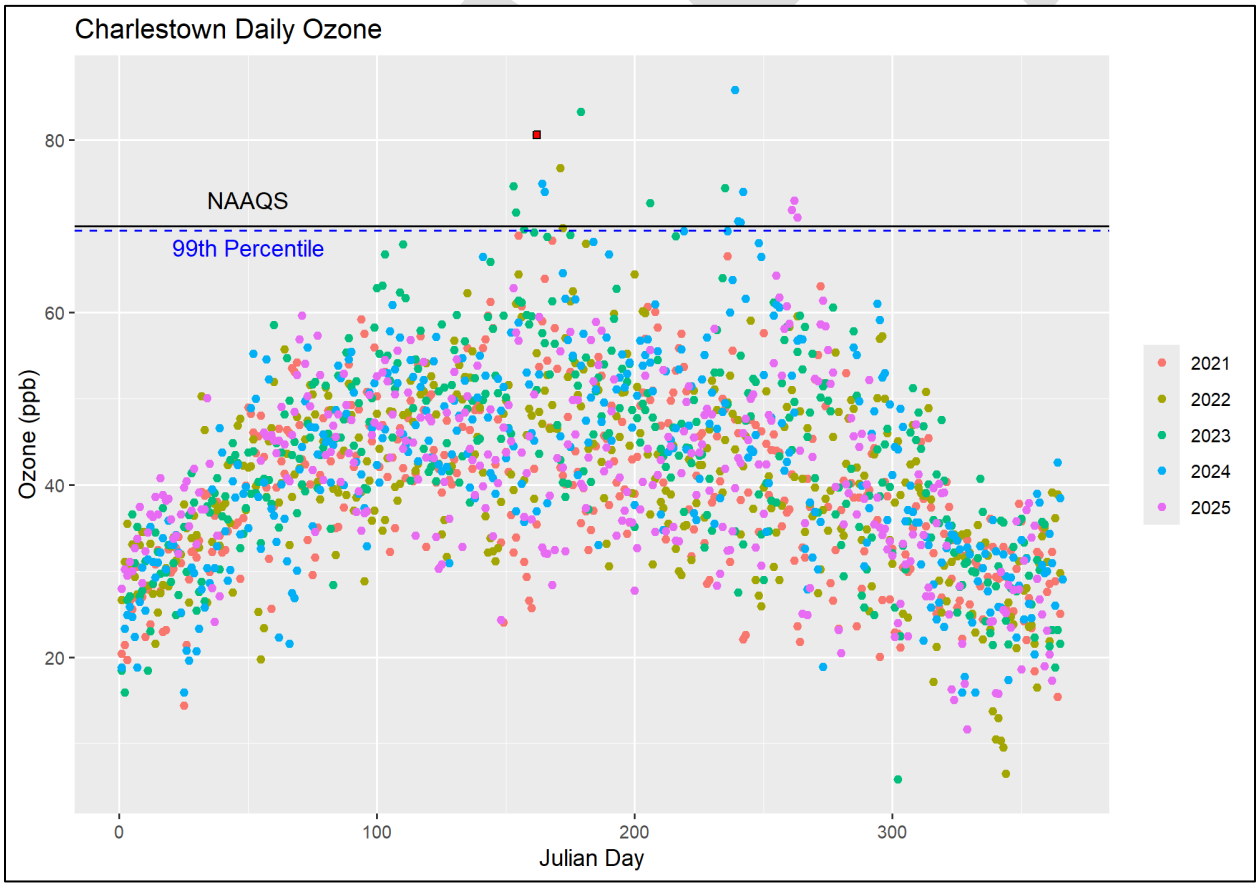
[4] https://www.epa.gov/air-quality-analysis/exceptional-events-analysis-and-visualization-tools

3.0 Clear Causal Relationship between Event and Monitored Data

3.1 Summary of Spatial/Temporal Ozone Patterns

Figure 3.1 presents a summary of maximum daily 8-hour ozone values from 2021-2025 for the Charlestown State Park ozone monitor. As can be seen, ozone is most prevalent during the spring, summer and early fall. The values are compared to the NAAQS of 70 ppb and the 99th percentile for all five years of data. The June 11, 2025 (Julian Day 162), date, displayed with a dark red square in the graph, is the requested day for exclusion due to wildfire smoke with a maximum concentration well above the NAAQS and the 99th percentile of highest ozone values during the 5-year period. Research on the ozone data for the years 2021 through 2025 indicates the vast majority of the highest ozone values correspond to wildfire smoke.

Figure 3.1 – Timeseries of the Daily Maximum 8-hour Average Ozone Concentrations – Charlestown



3.2 Analysis Description for Clear Causal Evidence

IDEM used the following items to prove clear causal relation between wildfire smoke and increased ozone concentrations on the requested day for exclusion. This approach is consistent with U.S. EPA's "Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations" Tier 3 analysis to demonstrate clear causal relationship with wildfire impacts:

- **Meteorological Overview**
- **Ozone Diurnal Patterns**
- **Comparison with other pollutants**
- **MODIS AOD Satellite Imagery**
- **NOAA GOES Satellite Imagery**
- **AIRNOW Ozone and $PM_{2.5}$ daily concentrations**
- **GAM Modeling Analysis**
- **Expedited Modeling of Burn Event Results (EMBER)**
- **Meteorological Adjusted Ozone Trends**
- **Back Trajectory Analysis**
- **HRRR Model**
- **Media Mentions**

3.3 June 11, 2025 Event

Each piece of evidence demonstrates a clear causal link between transported wildfire smoke and elevated ozone levels at the Charlestown State Park monitor. The following section applies the same evidence-based framework to the specific exceedance event on June 11, 2025. The ozone event examines how these analytical methods, meteorological analysis, pollutant comparisons, satellite observations, statistical modeling, and trajectory assessments, collectively support the identification of the June 11, 2025, ozone exceedance at the Charlestown State Park monitor as an exceptional event influenced by Canadian wildfire smoke.

3.3.1 Executive Summary

On June 11, 2025, the Charlestown State Park monitor experienced an ozone value of 80 parts per billion, exceeding the 2015 8-hour ozone standard of 70 ppb. While meteorological conditions were conducive to ozone formation, they alone cannot explain this elevated concentration. Multiple lines of evidence confirm that Canadian wildfire smoke was a key contributor:

- Satellite Imagery & AOD Analysis: Dense smoke plumes from Canadian wildfires were observed over the region.
- Air Quality Indicators: AirNow maps showed elevated ozone and $PM_{2.5}$ concentrations coinciding with smoke presence.

- Modeling Support: GAM, EMBER and MAOT analyses estimate up to 41 ppb of ozone attributable to wildfire smoke.
- Trajectory Analysis: HYSPLIT back trajectories link air masses directly to Shoe/Camp Fire, Saskatchewan, and Flin Flon Fire, Manitoba.

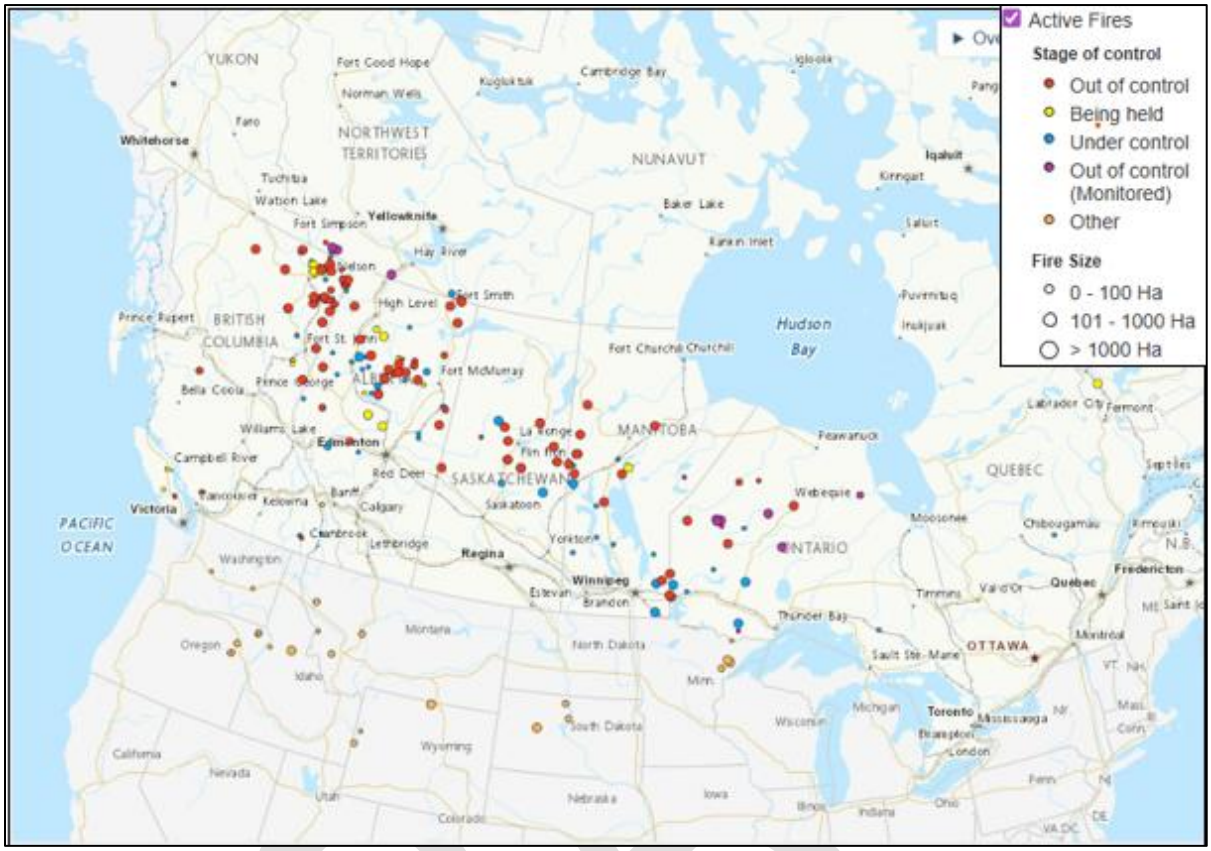
This convergence of observational data, satellite imagery, and modeling establishes a clear causal relationship between wildfire smoke and ozone exceedances. The Charlestown State Park monitor recorded an exceedance of 80 ppb on June 11, 2025, as shown in Table 3.3.1. These findings support classification of June 11, 2025, as an exceptional event under U.S. EPA guidelines.

Table 3.3.1 – June 11, 2025, Charlestown State Park MDA8 Value

Date	Monitor ID	Observed MDA8 Concentration (ppb)
June 11, 2025	180190008	80

On June 11, 2025, multiple Canadian wildfires contributed ground level smoke that caused the Charlestown State Park monitor to exceed the 2015 ozone standard of 70 ppb. Figure 3.3.1 shows the major contributors to the smoke plumes that reached the Charlestown State Park monitor on June 11, 2025.

Figure 3.3.1 – Canadian Wildfires - June 11, 2025



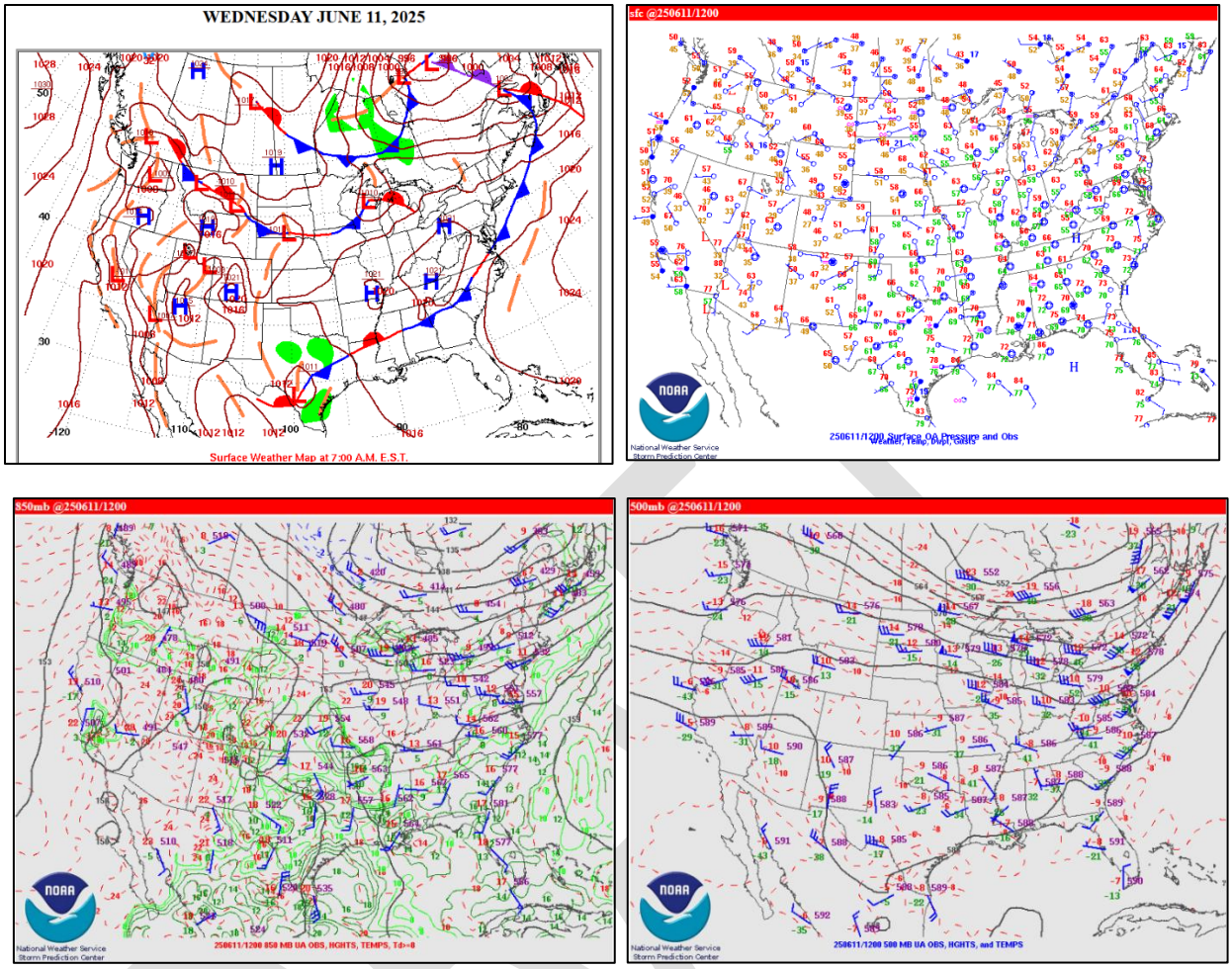
The Shoe Fire and the Camp Fire were among the largest in Canada in 2025. These fires burned from early May through mid-August, burning over 565,000 hectares (approximately 1.4 million acres) at their peak.

The "Flin Flon Fire" (WE017) originated near Creighton, Saskatchewan, and quickly crossed the border into Manitoba, growing into a massive complex that eventually scorched over 515,000 hectares.

3.3.2 Meteorological Episode Overview

For June 11, 2025, Indiana remained under northwest flow in the upper atmosphere as a broad 500 mb trough axis was centered over the Great Lakes and Ohio Valley and slowly drifted east. This set-up ushered in wildfire smoke from central and western Canada that was pulled southward along a series of cold fronts. At the surface, high pressure behind the cold front remained over the area, maintaining stable weather with light surface winds out of the west-southwest. Thus, residual smoke remained evident throughout the area. Figure 3.3.2 shows the surface, 850 mb, and 500 mb maps of the conditions on June 11.

Figure 3.3.2 – Surface, 850, and 500 mb plots from 12Z on June 11, 2025



As of June 10, 2025, 2.79 million hectares had burned based on satellite detected hotspots across Canada, according to the Canadian Wildland Fire Information System. The HRRR-NCEP Near Surface Smoke forecast from 06 UTC had a plume of smoke between 10-20 μg/m^3 impacting parts of Indiana on June 10 and 11 around the outer boundary of surface high pressure over the eastern United States, with vertically integrated values near or over 50 μg/m^3.

Wind rose (Figure 3.3.3) and pollution rose (Figure 3.3.4) analyses were taken from the Charlestown State Park meteorological station for June 11 as winds were light and southerly, beginning primarily from the southwest before shifting as a frontal boundary moved through. A surface high positioned between frontal boundaries over the Great Lakes and Ohio Valley trapped smoke across the state on June 11. Wind and pollution roses from June 11 indicate elevated ozone levels. HYSPLIT back trajectories linked air masses directly to Canadian fire regions. Hourly wind directions for June 11, 2025, are displayed in Figure 3.3.5.

These conditions resemble those seen in 2023, when wildfire smoke, known to contain volatile organic compounds (VOCs), intermediate and semi-volatile organic compounds (IVOCs and SVOCs), contributed to enhanced ozone production in the lower troposphere during the summer. Reference: [Understanding Volatile Organic Compound Emissions from Wildfires in the Western US with Modeling Comparisons - Climate Program Office]

Figure 3.3.3 – Charlestown Windrose

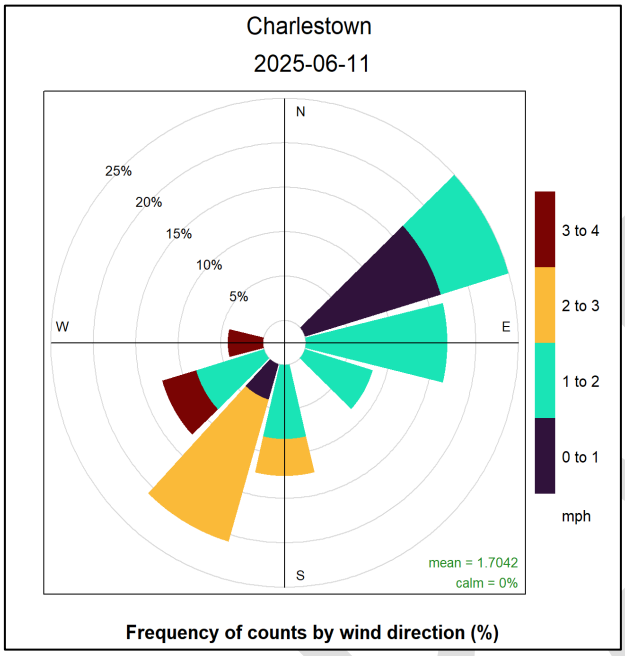


Figure 3.3.4 Charlestown Pollution Rose

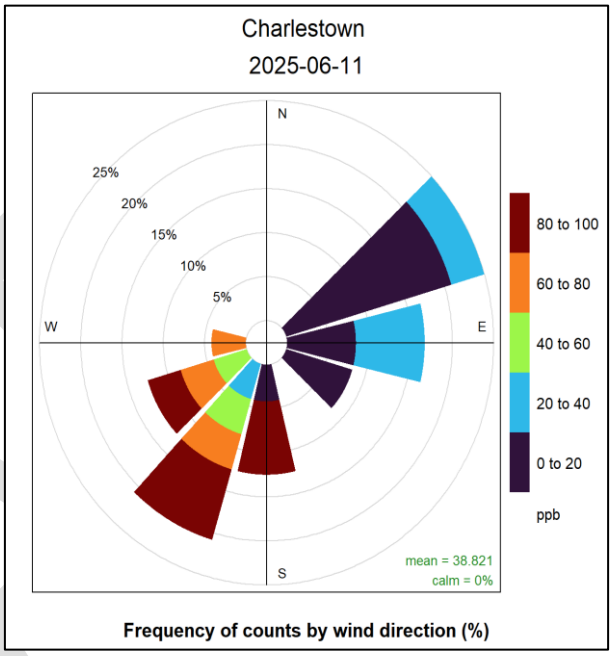
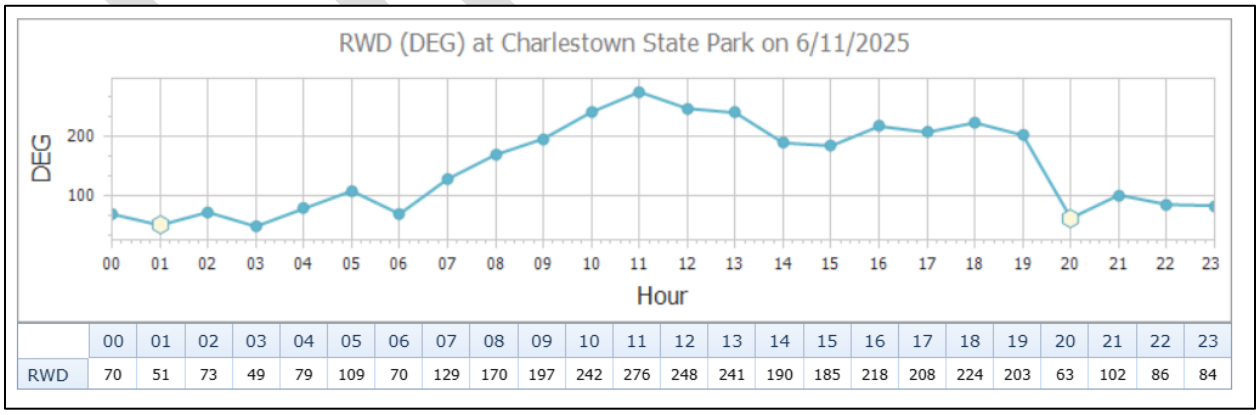


Figure 3.3.5 – Hourly Wind Directions at Charlestown for June 11, 2025



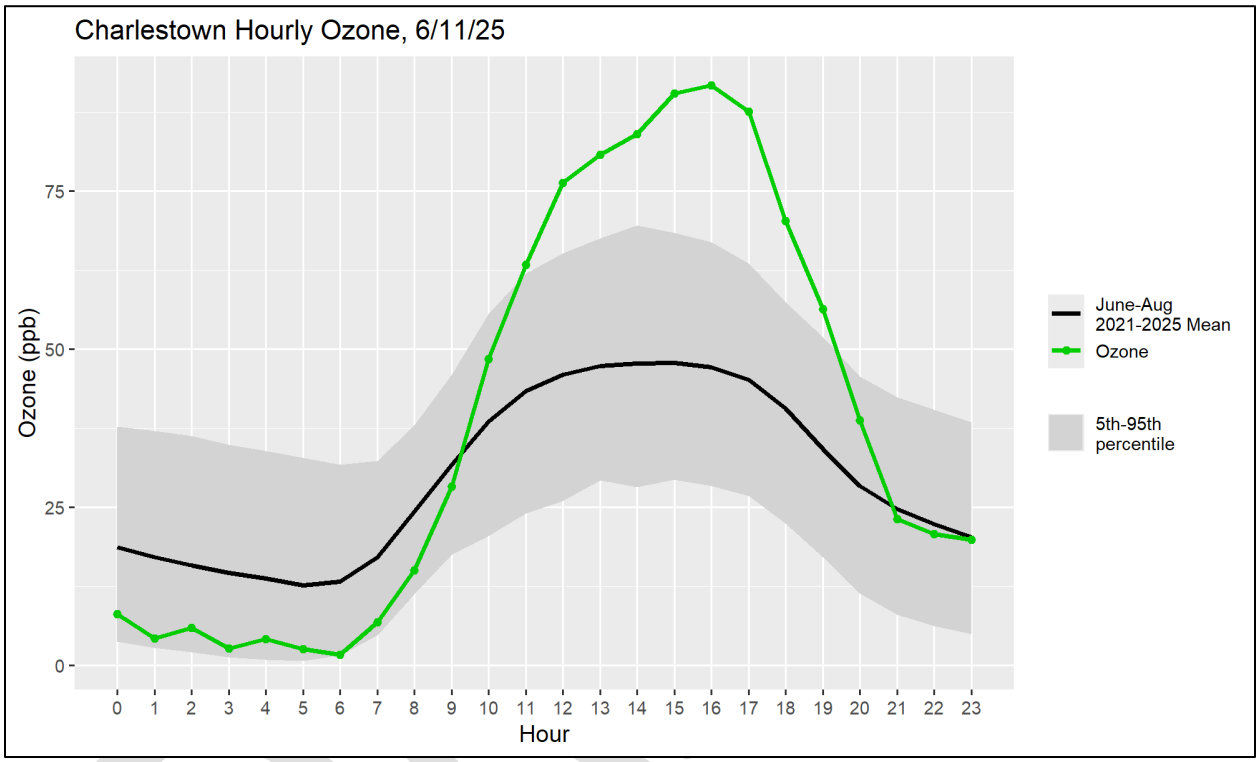
	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
RWD	70	51	73	49	79	109	70	129	170	197	242	276	248	241	190	185	218	208	224	203	63	102	86	84

3.3.3 Hourly Pollutant Analyses and Comparison

The hourly ozone readings (green line) for June 11, 2025, for the Charlestown State Park monitor were compared to the five-year ozone season mean (black line) and the

5th-95th percentile of those readings, as shown in Figure 3.3.6. For most of the day the hourly readings at the Charlestown State Park monitor exceeded the 95th percentile, only returning to below that upper percentile threshold after the wind changed from southerly to northeast at sunset.

Figure 3.3.6 – Ozone diurnal pattern for Charlestown - June 11, 2025



As shown in Table 3.3.2, hourly comparisons were completed for the Jeffersonville, Indiana $PM_{2.5}$ monitor to the 2021-2025 5-year mean for each hour from the nearest $PM_{2.5}$ monitor available for June 11, 2025. $PM_{2.5}$ makes up approximately 90% of the total particle mass emitted by wildfires.[5] All 24 hours highlighted in yellow are above statistical significance. Statistical significance was determined using a one sample T-test, to obtain the p-values for each $PM_{2.5}$ measurement on the exceptional event day. The p-values greater than 0.05 $\mu g/m^3$ were considered to be statistically significant compared to the observed values of the past five years. $PM_{2.5}$ concentrations ranged from 17-27 $\mu g/m^3$.

[5] Fiona Green. (August 14, 2025). What is wildfire smoke made of? Examining the composition of wildfire-related air pollution. Clarity Movement Company blog. https://www.clarity.io/blog/what-is-wildfire-smoke-made-of-examining-the-composition-of-wildfire-related-air-pollution

Table 3.3.2 – Jeffersonville $PM_{2.5}$ Comparison with Hourly Monthly Mean, June 11, 2025

Hour	2021-2025 June Mean Hourly $PM_{2.5}$ ($\mu g/m^3$)	Hourly Observed $PM_{2.5}$ ($\mu g/m^3$)
0	12.8	20.9
1	12.7	21
2	12.6	22
3	12.7	22.7
4	12.7	20.3
5	13	19
6	13.9	19.2
7	14.3	27.5
8	13.5	26.9
9	13	23.1
10	12.3	21.7
11	11.9	19.5
12	11.8	18.7
13	11.5	18.1
14	11.2	17.9
15	11.2	17
16	11	17.7
17	11	18
18	10.9	17.5
19	11	20
20	11.4	20.4
21	12.3	21.2
22	12.6	22.8
23	12.8	23

IDEM compared the daily average concentration with the five-year daily average for carbon monoxide (CO), nitrogen dioxide (NO_2) and black carbon (BC). Black carbon, also known as soot, is a form of particulate matter that originates from wildfires, among other sources of incomplete combustion. Table 3.3.3 shows the percentage above the five-year average. All pollutants were well above the five-year average.

Table 3.3.3 – Carbon Monoxide, Nitrogen Dioxide and Black Carbon Percentage above the Five-Year Average

Date	Percentage CO Above 5-Year Average	Percentage NO_2 Above 5-Year Average	Percentage Black Carbon Above 5-Year Average
6/11/2025	204%	143%	199%

3.3.4 AOD and Satellite Analyses

Figure 3.3.7 displays satellite imagery from Aerosol Optical Depth (AOD), from the Moderate Resolution Imaging Spectroradiometer (MODIS) combined Terra and Aqua Multi-Angle Implementation of Atmospheric Correction (MAIAC) Land Aerosol Optical Depth level 2 product. An optical thickness of less than 0.1 (palest yellow) indicates a crystal-clear sky with maximum visibility, whereas a value of 1 (reddish brown) indicates very hazy conditions. The dark red color in southern Indiana indicates the presence of smoke on June 11, 2025.

Figure 3.3.7- Aerosol Optical Depth (AOD) - June 11, 2025

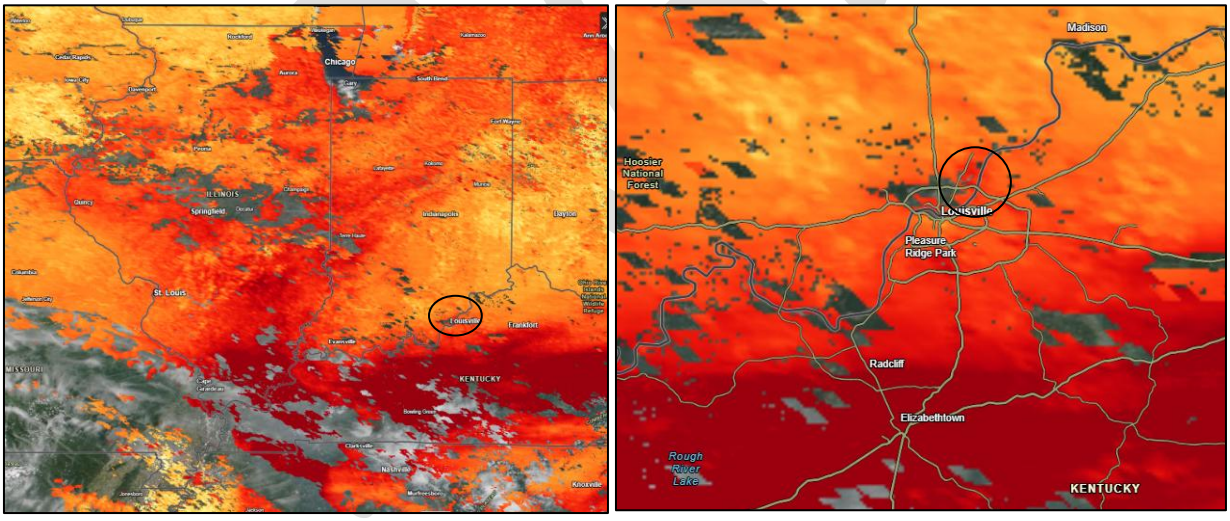
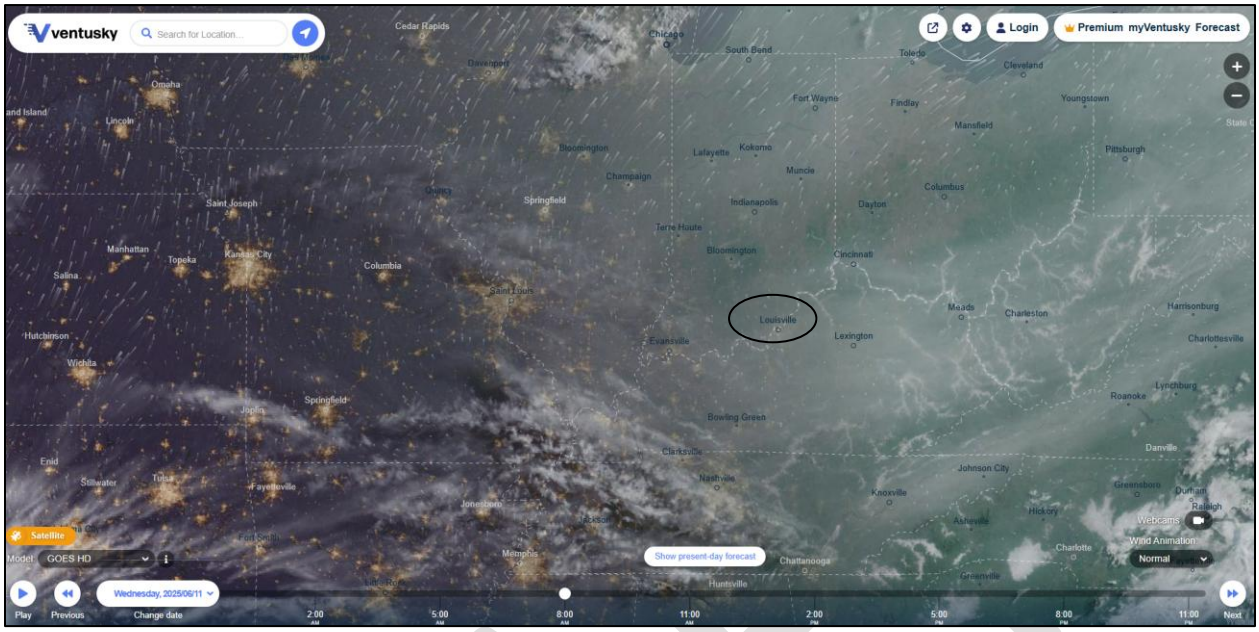


Figure 3.3.8 displays three satellite images indicating Canadian wildfire smoke coming from Manitoba, Saskatchewan and Alberta. June 11 shows heavy smoke from Kentucky being pushed by the southerly winds into the area of the Charlestown State Park monitor.

Figure 3.3.8 – Satellite Imagery - June 11, 2025



3.3.5 NOAA Smoke Narrative

DESCRIPTIVE TEXT NARRATIVE FOR SMOKE/DUST OBSERVED IN SATELLITE IMAGERY
THROUGH 1400Z June 11, 2025

SMOKE:

Canada/Central and Eastern United States/Atlantic Ocean/Europe... **Wildfire activity through Central and western Canada continues to produce moderate-to-thick smoke extending westward over Northern Yukon and Central-Eastern Alaska and east-southeastward into the Northern** Canada/Central and Eastern United States/Atlantic Ocean/Europe... **Wildfire activity through Central and western Canada continues to produce moderate-to-thick smoke extending westward over Northern Yukon and Central-Eastern Alaska and east-southeastward into the Northern Plains, Midwest, and Great Lakes, Ohio Valley and Mid-Atlantic states**, with higher concentrations found around Northeastern British Columbia and Central-Southern Alberta and Saskatchewan.

3.3.6 AirNow Smoke Maps

Figures 3.3.9 through 3.3.11 display AirNow maps for June 11, 2025, showing elevated ozone and $PM_{2.5}$ in southern Indiana and the surrounding area, indicating smoke impacts that elevated pollutant concentrations. The area of the Charlestown State Park monitor is indicated by the black circle in the maps.

Figure 3.3.9 – AirNow Ozone Map - June 11, 2025

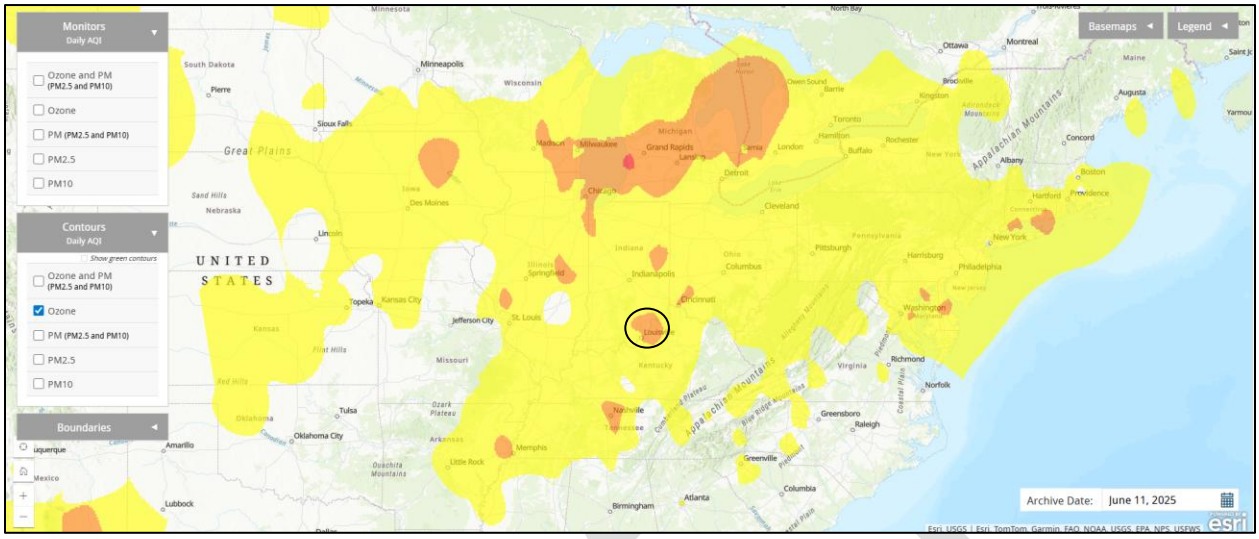


Figure 3.3.10 – AirNow $PM_{2.5}$ Map - June 11, 2025

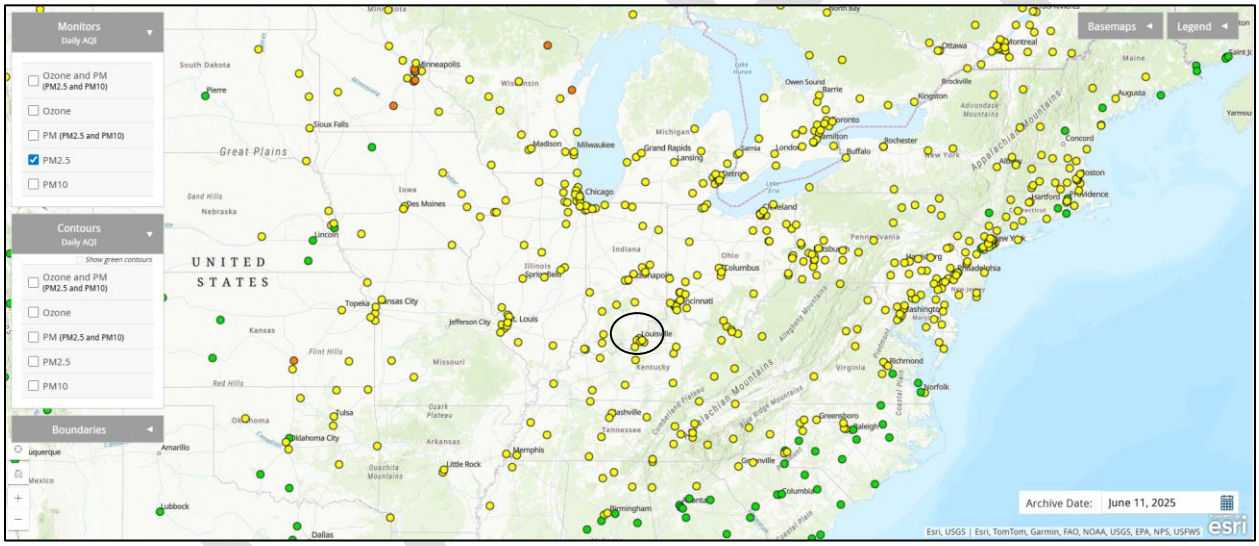
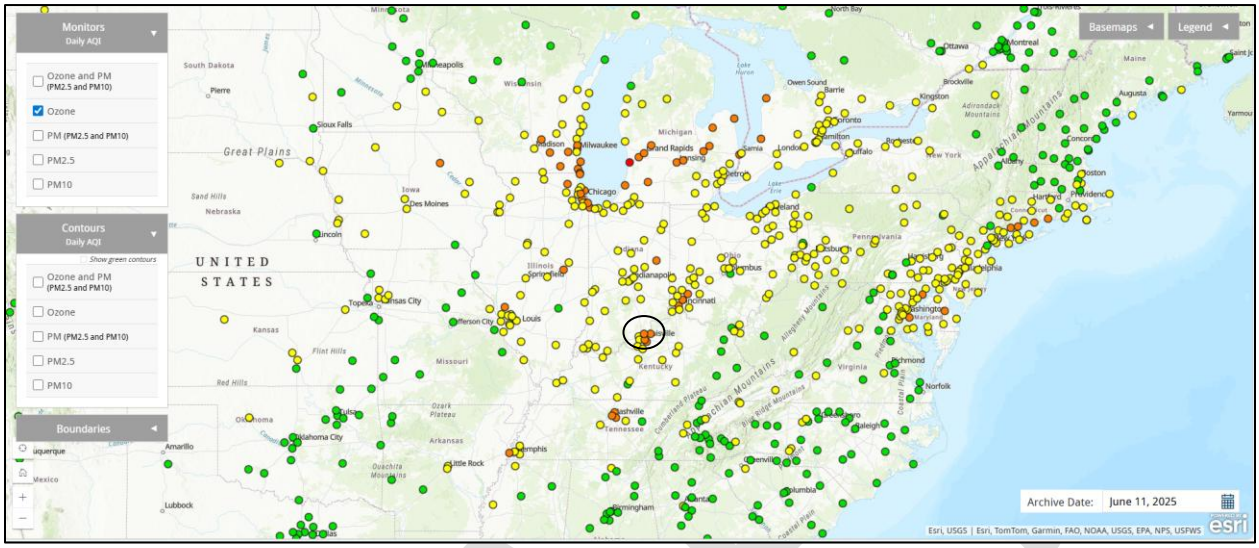


Figure 3.3.11 – AirNow Ozone Map - June 11, 2025



3.3.7 Statistical Modeling Analyses

General Additive Modeling (GAM) is a statistical or machine learning framework that provides interpretability by applying smoothing functions to individual variables. Notably, GAMs can incorporate linear, nonlinear, and categorical predictors, providing flexibility for modeling complex relationships (Wood, 2017). In particular, such statistical/machine learning models can provide an efficient tool for analyzing air quality, especially in relation to wildfire smoke. For example, ozone can be used as the response variable, modeled using meteorological data, satellite-derived measurements, and/or backward air trajectories (Lee and Jaffe, 2024). This study demonstrated the importance of wildfire smoke as contributors to exceedances of the health-based national air quality standards for $PM_{2.5}$ and O_3. GAM used an Empirical Distribution Matching (EDM) model for a more conservative estimate.[6]

Figures 3.3.12 through 3.3.14 indicate monitors influenced by wildfire smoke, with the observed ozone averages for the day at each monitor and the estimate of smoke influence from GAM.

[6] Lee, H., & Jaffe, D. A. (2025). Impact of wildfires on O3 and air quality across the United States for 2019–2024 using generalized additive models. Journal of Geophysical Research: Atmospheres, 130, e2025JD044088. https://doi.org/10.1029/2025JD044088

Figure 3.3.12 – GAM Smoke Maps Indicating Smoke Days - June 11, 2025

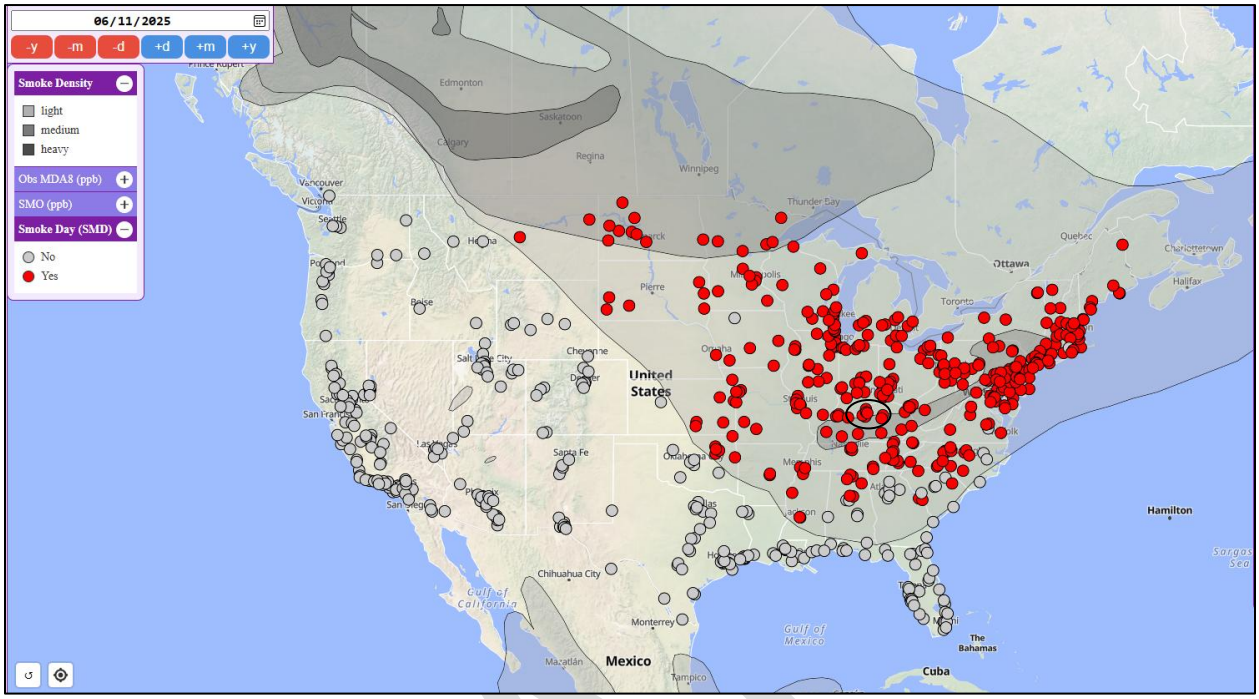


Figure 3.3.13 – GAM Observed Ozone with Smoke Days - June 11, 2025

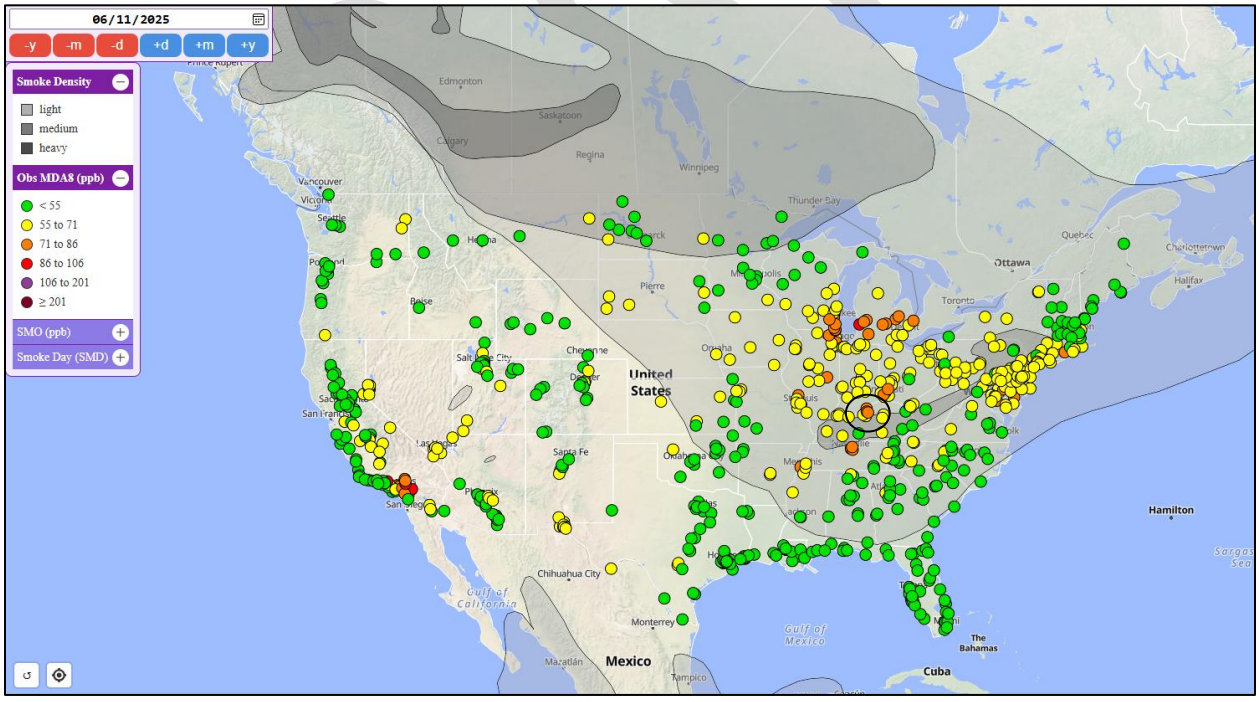
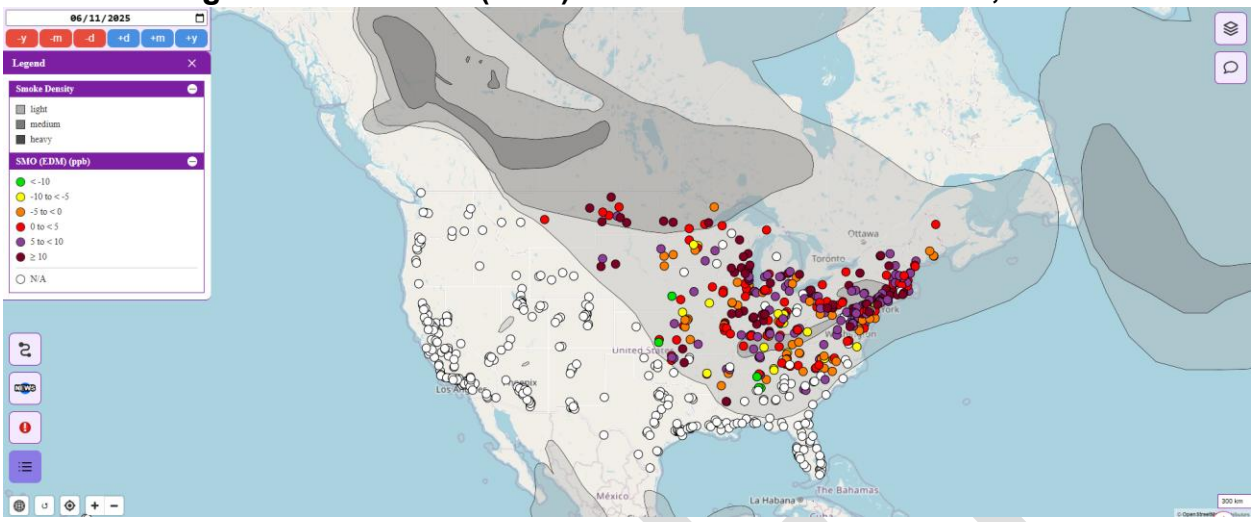


Figure 3.3.14 – GAM(EDM) Smoke Estimates - June 11, 2025



The Expedited Modeling of Burn Events Results (EMBER)[7] provides photochemical model-based estimates to help identify ozone monitoring days that may have been influenced by fire emissions, assisting in the analysis of "exceptional events" for regulatory purposes. The EMBER dataset assists in building a weight-of-evidence demonstration to show a clear causal relationship between wildland fires and monitored air quality exceedances or violations of ozone. EMBER has a base simulation and a zero fire simulation without any wildfire emissions.

Meteorological Adjusted Ozone Trends (MAOT) provides for the analysis of variations in weather conditions, which play an important role in determining ozone concentrations. Ozone is more readily formed on warm, sunny days when the air is stagnant. Conversely, ozone production is more limited when it is cloudy, cool, rainy, or windy. U.S. EPA uses MAOT, a statistical model to adjust for the variability in seasonal ozone concentrations due to weather, to provide a more accurate assessment of the underlying trend in ozone caused by emissions.[8]

Table 3.3.4 summarizes the observed ozone average with the GAM and MAOT predicted averages and modeled smoke influence for the Charlestown State Park monitor for June 11, 2025.

[7] https://www.epa.gov/air-quality-analysis/expedited-modeling-burn-events-results-ember

[8] https://www.epa.gov/air-trends/trends-ozone-adjusted-weather-conditions

Table 3.3.4 – Observed Versus GAM Predicted MDA 8-hour Ozone Values - June 11, 2025

Site ID	180190008
Site Name	Charlestown
Observed 8-hour MDA Ozone (ppb)	80
GAM Predicted 8-hour MDA Ozone (ppb)	58
GAM Smoke Influenced 8-hour MDA Ozone (ppb)	22
GAM(EDM) Predicted 8-hour MDA Ozone (ppb)	60
GAM(EDM) Smoke Influenced 8-hour MDA Ozone (ppb)	20
EMBER Base Simulation Predicted 8-hour MDA Ozone (ppb)	69
EMBER Zero Fire Simulation Predicted 8-hour MDA Ozone (ppb)	62
EMBER Smoke Influenced 8-hour MDA Ozone (ppb)	7
MAOT Predicted 8-hour MDA Ozone (ppb)	39
MAOT Residual Influenced 8-hour MDA Ozone (ppb)	41

3.3.8 Backward Trajectories and Smoke Map Analyses

The impact of smoke on the June 11, 2025, ozone event can be shown with HYSPLIT trajectories and Hazard Mapping System (HMS) smoke layers. The trajectories have three starting heights, 50 m (green), 100 m (red), and 500 m (orange), and higher

transport at 1000 m (green), 2000 m (yellow), and 3000 m (purple). The back trajectories start from the location of the Charlestown State Park monitor. The HMS smoke layers become less opaque as the density of smoke increases. June 11 three-day back trajectories indicate smoke from central Canada being drawn down to southern Indiana. The trajectories in Figures 3.3.15 through 3.3.18 are increased to 96 hours and 168 hours at 100 m (blue), 500 m (red), and 1000 m (green) with higher concentrations found around Manitoba and Central-Southern Alberta and Saskatchewan.

Figure 3.3.15 – Back Trajectories June 11 - 50, 100, and 500 Meters (-72 Hours)

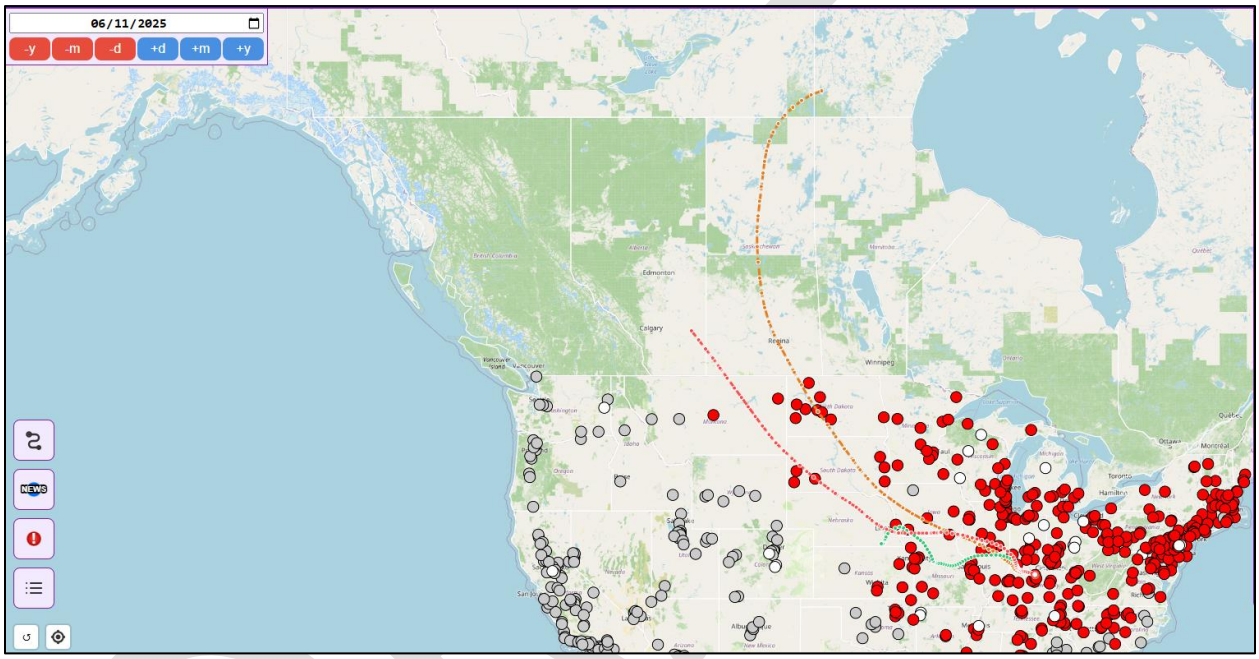


Figure 3.3.16 – Back Trajectories June 11 - 1000, 2000, and 3000 Meters (-72 Hours)

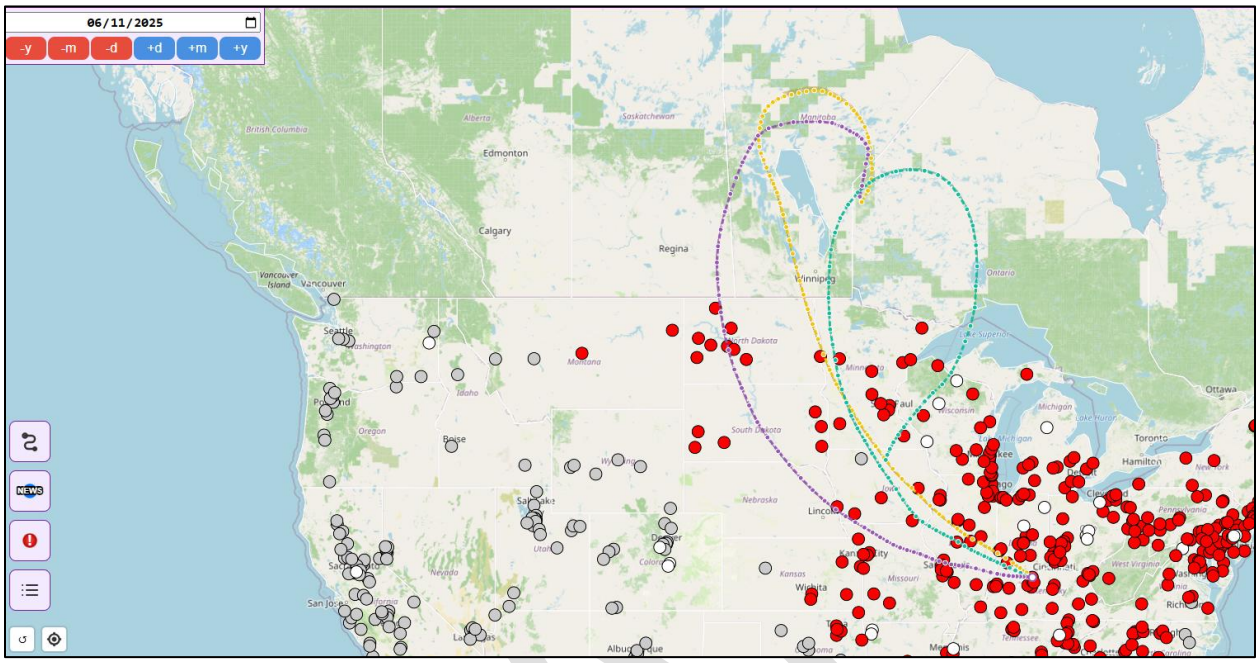


Figure 3.3.17 – Long Range Back Trajectory June 11 - 100, 500, and 1000 Meters (-96 Hours)

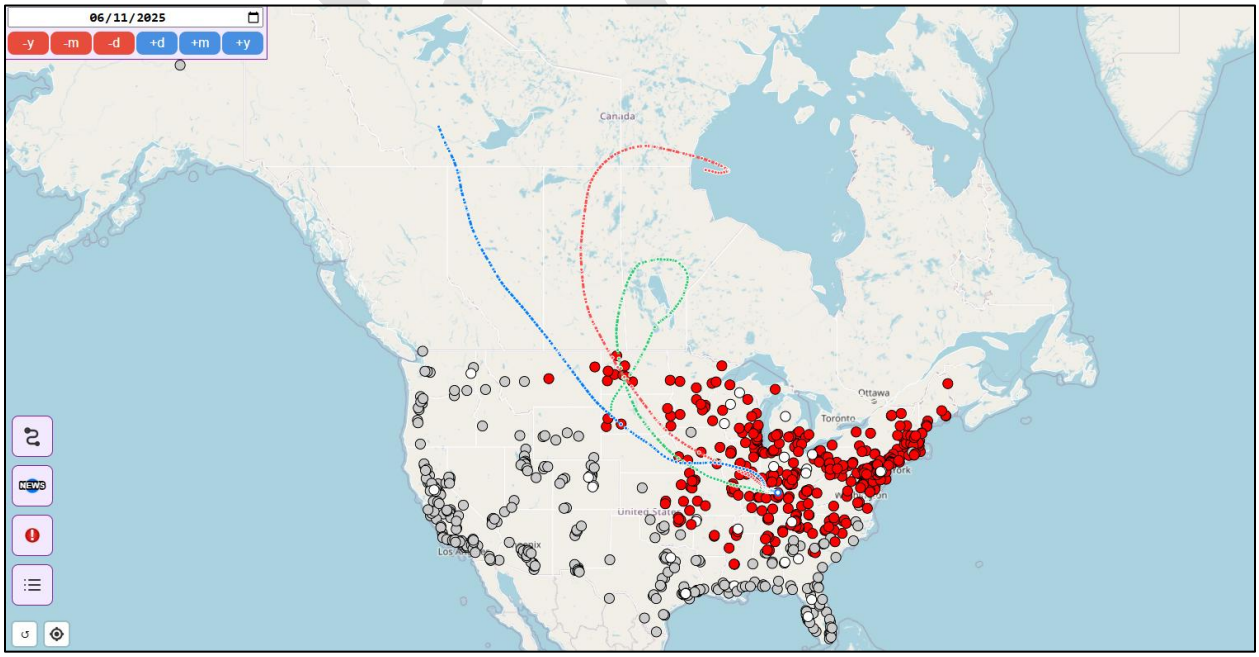
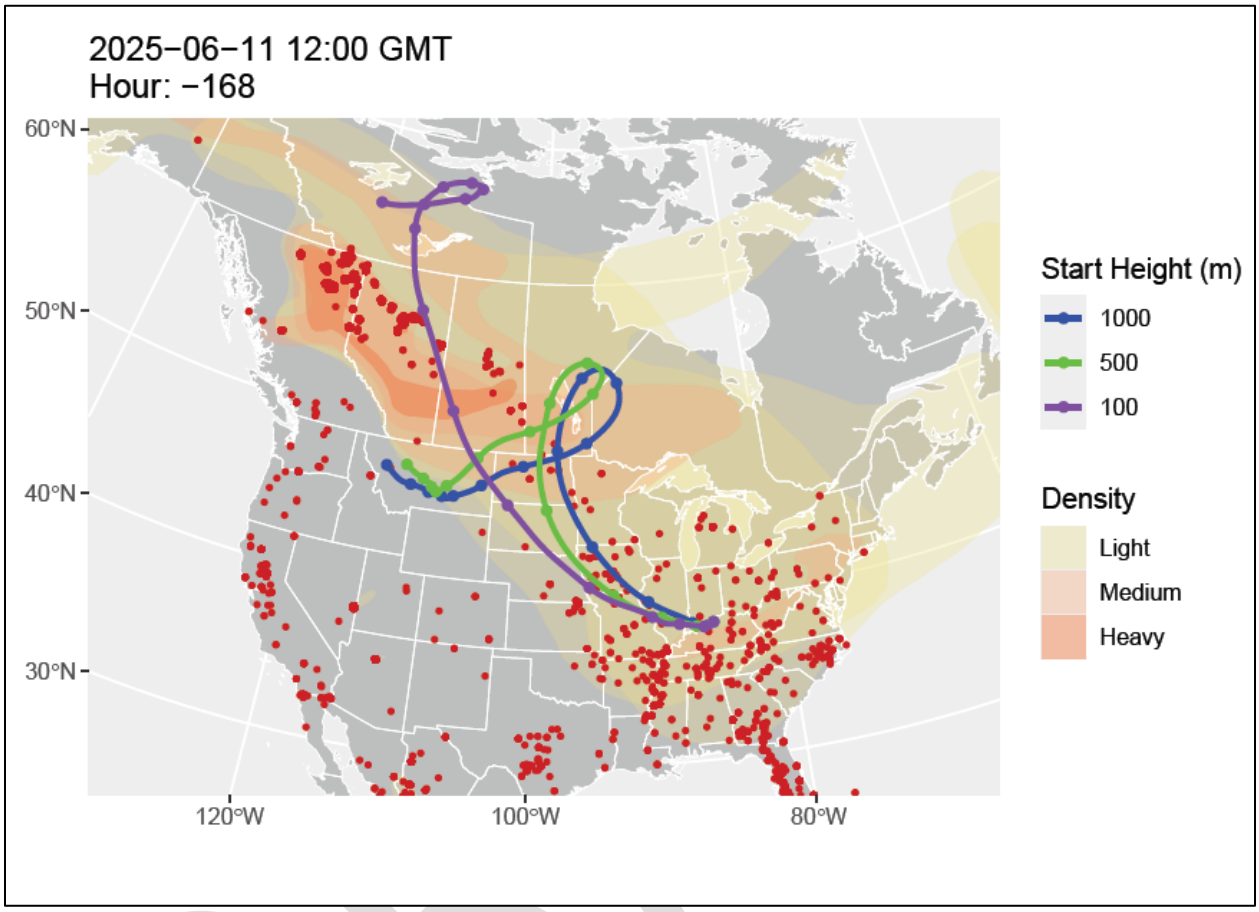


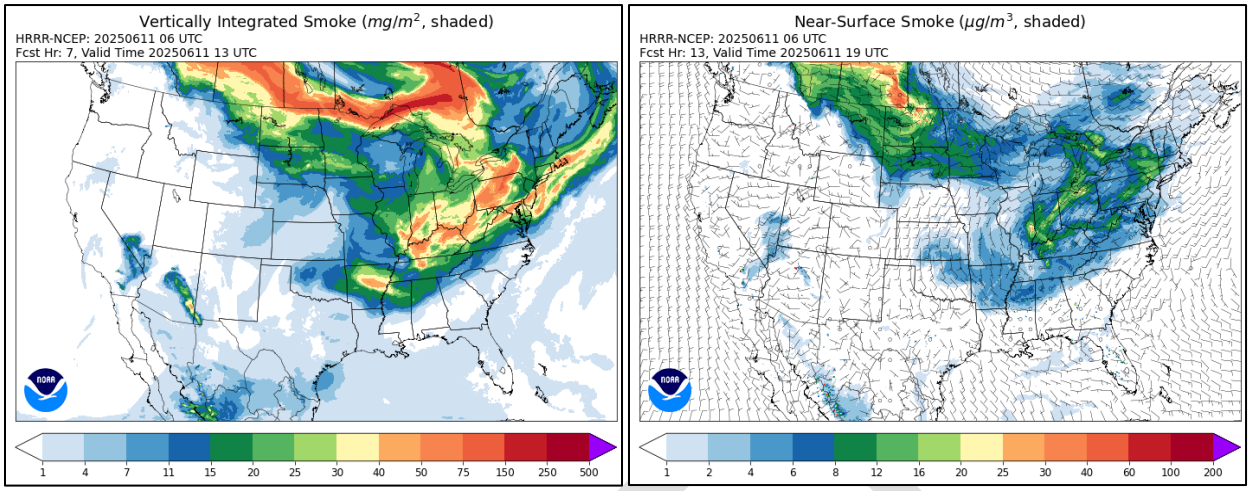
Figure 3.3.18 - Long Range Back Trajectory June 11 - 100, 500, and 1000 Meters (-168 Hours)



3.3.9 HRRR Model

The HRRR is a NOAA real-time 3-km resolution, hourly updated, cloud-resolving, convection-allowing atmospheric model, initialized by 3km grids with 3km radar assimilation. Radar data is assimilated in the HRRR every 15 min over a 1-hour period adding further detail to that provided by the hourly data assimilation from the 13km radar-enhanced Rapid Refresh. Figure 3.3.19 indicates the vertically integrated smoke column on the left and the near surface smoke on the right.

Figure 3.3.19 – HRRR Smoke Model



3.3.10 Media Mentions

(June 5, 2025). NOAA Satellites Monitor Canadian Wildfires and Smoke. *NOAA's National Environmental Satellite, Data, and Information Service (NESDIS)*. https://www.nesdis.noaa.gov/news/noaa-satellites-monitor-canadian-wildfires-and-smoke

(May 13, 2025). A Smoky Start to Saskatchewan's Fire Season. *NASA Earth Observatory*. https://science.nasa.gov/earth/earth-observatory/a-smoky-start-to-saskatchewans-fire-season-154287/

(June 11, 2025). Air Quality Alert issued for Wednesday, June 11. *LouisvilleKy.gov*. https://louisvilleky.gov/news/air-quality-alert-issued-wednesday-june-11

(June 12, 2025). Air quality concerns in Indiana for June 12, 2025. *WISH-TV*. https://www.youtube.com/watch?v=gJRdnKOBNZs

(June 10, 2025). 2025 Canada Wildfires and United States Air Quality. *United States Census Bureau*. https://www.census.gov/topics/preparedness/events/wildfires/2025-air-quality.html

(May 29, 2025). Darren Bernhardt. 'Very eerie': Evacuees describe Flin Flon sky engulfed by wildfire smoke. *CBC News*. https://www.cbc.ca/news/canada/manitoba/wildfire-evacuees-1.7546964

3.3.11 Summary

Table 3.3.5 summarizes the clear causal relationship between the June 11, 2025, exceptional event and the monitored data at the Charlestown State Park monitor.

Table 3.3.5 – Summary Table Charlestown State Park Monitor

Event Date	June 11, 2025
MDA8 Ozone Concentration (ppb)	80
Does Ozone Concentration exceed the 95th Percentile?	Yes
Are PM2.5, CO, NO2 and BC Concentrations elevated?	Yes
Does visual satellite imagery indicate smoke at Charlestown?	Yes
Do AQI maps indicate regionally elevated Ozone?	Yes
Do AQI maps indicate regionally elevated PM2.5?	Yes
Does the HMS product indicate smoke at Charlestown?	Yes
GAM predicted MDA8 ozone (ppb)	58
GAM(EDM) predicted MDA8 ozone (ppb)	60
EMBER base simulation predicted MDA8 ozone (ppb)	69
EMBER Zero fire simulation predicted MDA8 ozone (ppb)	62
MAOT predicted MDA8 ozone (ppb)	39
HYSPLIT indicated wildfire regions	Shoe/Camp Fire and Flin Flon Fire,
Do HRRR Models indicate smoke?	Yes
Media Mentions	Yes
Clear causal relationship established?	Yes

4.0 Not Reasonably Controllable or Preventable

This section addresses the “submission of demonstration” requirement (40 CFR Part 50.14(c)(3)(iv)(D)) that the event was “both not reasonably controllable and not preventable”.

According to 40 CFR Part 50.14(b)(4):

The Administrator shall exclude data from use in determinations of exceedances and violations where a State demonstrates to the Administrator's satisfaction that emissions from wildfires caused a specific air pollution concentration in excess of one or more national ambient air quality standard at a particular air quality monitoring location and otherwise satisfies the requirements of this section.

Provided the Administrator determines that there is no compelling evidence to the contrary in the record, the Administrator will determine every wildfire occurring predominantly on wildland to have met the requirements identified in paragraph (c)(3)(iv)(D) *of this section regarding the not reasonably controllable or preventable criterion.*

The 2025 Canadian wildfires burned boreal forests which meet the definition of wildlands. Therefore, there is no compelling evidence to the contrary that the 2025 Canadian wildfires burned on wildlands, affecting ozone at the Charlestown State Park monitor, qualify as natural events, and meet the criteria of being “both not reasonably controllable and not reasonably preventable”.

5.0 Natural Event or Human Event not likely to Recur

This section addresses the “submission of demonstration” requirement (40 CFR Part 50.14(c)(3)(iv)(E)) that the event “was a human activity that is unlikely to recur at a particular location or was a natural event”.

Under 40 CFR Part 50.1(k):

A natural event means an event and its resulting emissions, which may recur at the same location, in which human activity plays little or no direct causal role, anthropogenic sources that are reasonably controlled shall be considered to not play a direct role in causing emissions.

Furthermore, 40 CFR Part 50.1(n) defines:

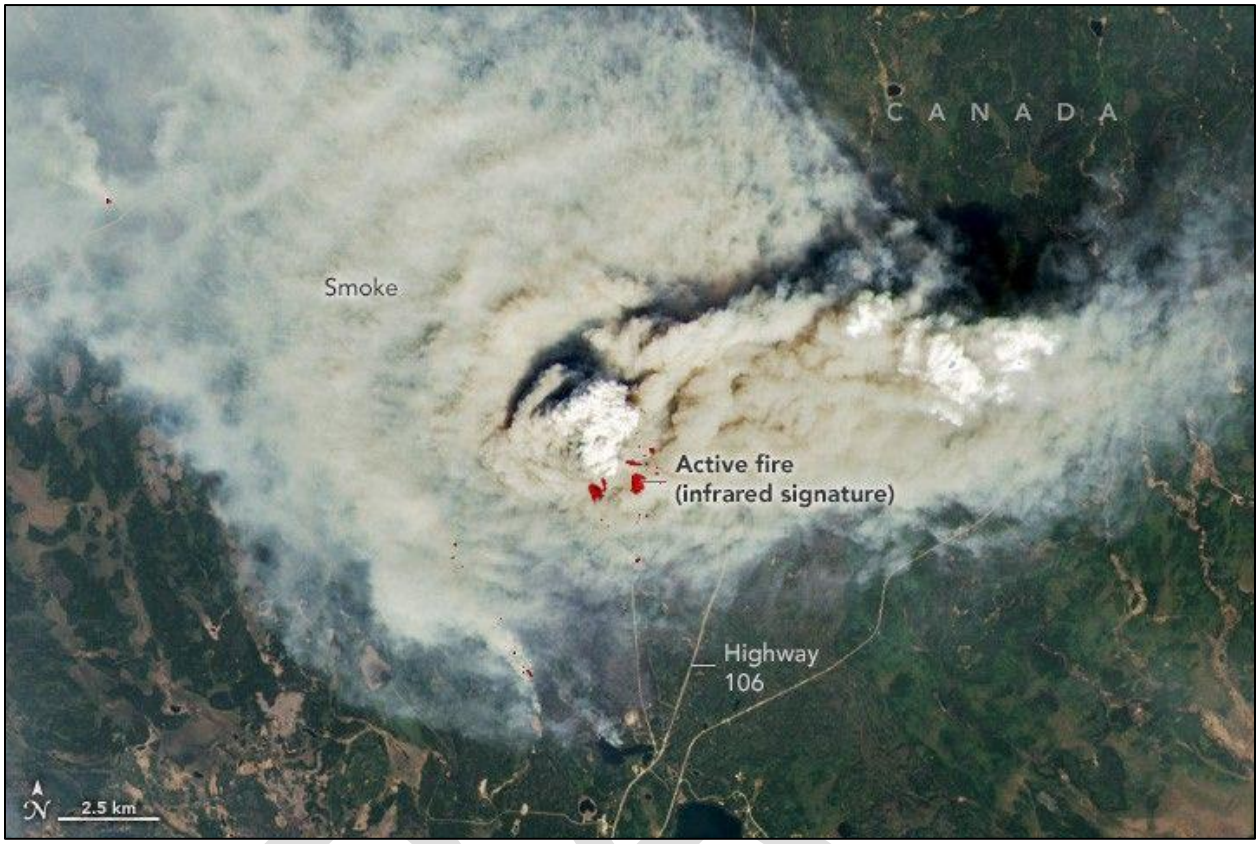
Wildfire is any fire started by an unplanned ignition caused by lightning; volcanoes; other acts of nature; unauthorized activity; or accidental, human caused actions, or prescribed fire that has developed into a wildfire. A wildfire that predominantly occurs on wildland is a natural event.

Many of Canada’s fires in 2025 had sources of ignition that were not confirmed or specified and burned for many months in remote areas. The intensity of the fires that were human-caused was increased by extreme weather conditions. Fire names and ignition sources are provided in Table 5.1, followed by discussions of the fires.

Table 5.1 – Fire Name and Source of Ignition

Fire Name	Source of Ingition
Shoe Fire	Human-caused
Camp Fire	Not confirmed (season dominated by human-caused fires)
Flin Flon Fire	Not specified (drought and wind contributed)

Shoe Fire



The Shoe Fire was discovered on May 7, 2025, near Lower Fishing Lake in Narrow Hills Provincial Park, Saskatchewan, and was classified as human-caused. Within weeks it developed into the largest wildfire in the province for 2025, eventually burning approximately 565,701 hectares and prompting evacuations around East Trout Lake, Piprell Lake, and other recreational areas. It destroyed cabins, park infrastructure, and critical administrative buildings before shifting winds and major suppression efforts slowed its progress.

Camp Fire

The Camp Fire began around May 6, 2025, north of Snowden in northern Saskatchewan. While its ignition source was not confirmed, Saskatchewan's 2025 season saw a high proportion of human-caused fires. Around May 10, NASA imagery showed its plume merging with that of the Shoe Fire, forming a combined burn area approximately 115,000 hectares by May 27. It threatened Candle Lake and nearby communities, destroyed cabins, and stretched firefighting resources already strained by multiple large fires.

Flin Flon Fire

The Flin Flon wildfire complex ignited in late May 2025, beginning in Creighton, Saskatchewan, and spreading into Flin Flon, Manitoba. Its ignition cause was not specified, though extreme drought and wind were major contributing factors. By May 28, all 5,000 residents were ordered to evacuate as the fire encircled the city. While the immediate fire near Flin Flon reached over 200 hectares, the larger fire complex burned over 516,000 hectares across both provinces.

Therefore, the Canadian wildfires qualify as natural events and meet the criteria of “was a human activity that is unlikely to recur at a particular location or was a natural event”.

6.0 PUBLIC PARTICIPATION

In accordance with 40 CFR 51.102, IDEM provided an opportunity for public participation concerning the Exceptional Events Demonstration Addressing the 2015 8-Hour Ozone (O_3) National Ambient Air Quality Standard (NAAQS) Charlestown State Park Monitor, Clark County, Indiana. Notice of availability was posted on IDEM's website under "Public Notices: Clark County" on July 13,2026 and remained posted for at least 30 days. To be completed upon completion of the 30-day comment period. See Attachment A for additional information

IDEM offers the public near real time access to the statewide air monitoring data (IDEM: Air Monitoring: Air Quality Data). Through IDEM's Data Management and Display System, anyone has access to near-real time statewide and regional air quality maps and data including:

• The Air Quality Index (AQI) for pollutants including ozone and particulate matter (PM)

• Current pollutant concentrations (including carbon monoxide, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide)

• Meteorological data (including air temperature, barometric pressure, precipitation, relative humidity, solar radiation, and wind speed and direction)

• User-generated reports for ozone and PM.

7.0 SUMMARY

This demonstration establishes that elevated ozone concentrations observed at the Charlestown State Park monitor in Clark County, Indiana on June 11, 2025, were primarily driven by long-range transport of Canadian wildfire smoke that impacted the Louisville, KY-IN area. Using a comprehensive, multi-method evidence framework, including meteorological analysis, pollutant comparisons, satellite and AOD imagery, statistical modeling, and HYSPLIT trajectory assessments, the analysis consistently links the exceedance event to substantial smoke impacts. Across the June 11 event, ozone, $PM_{2.5}$, CO, NO_2, and black carbon levels were markedly elevated, with modeling estimating wildfire smoke contributions of up to 40 ppb. Satellite data and backward trajectories confirm that air masses arrived directly from large, intense wildfire complexes in Canada, while matching day analyses show ozone levels significantly higher than comparable non-smoke days. Collectively, these findings meet U.S. EPA's Exceptional Events Rule criteria by demonstrating a clear causal relationship and supporting the exclusion of the smoke impacted day from regulatory determinations for the 2015 8-hour ozone NAAQS. See Appendix A for the Ozone Exceptional Events Initial Notification Summary Form.

Table 7.1 shows the four highest ozone concentrations in 2025 with the smoke-impacted day, June 11, 2025, included and excluded. The 4th high daily maximum 8-hour concentration in 2025 adjusts down from 70 ppb to 63 ppb.

Table 7.1 – Charlestown State Park Monitor Four Highest 8-hour Ozone Concentrations with Exceptional Event Day Included and Excluded (2025)

Smoke Impacted Day (June 11, 2025) Included			Smoke Impacted Day (June 11, 2025) Excluded		
Annual Rank	**Date**	**Daily Maximum 8-Hour Average Ozone Concentration (ppb)**	**Annual Rank**	**Date**	**Daily Maximum 8-Hour Average Ozone Concentration (ppb)**
1st	6/11/2025	80	1st	9/19/2025	72
2nd	9/19/2025	72	2nd	9/18/2025	71
3rd	9/18/2025	71	3rd	9/20/2025	70
4th	9/20/2025	70	4th	9/12/2025	63

Table 7.2 shows the 2023–2025 4th high maximum daily 8-hour average concentrations (MDA8) as well as the design value at the Charlestown State Park ozone monitor with smoke impacts, while Table 7.3 shows the 4th high daily 8-hour average concentrations and design value with the June 11, 2025, smoke day excluded.

Table 7.2 - 2023-2025 8-hour Ozone Design Values with Exceptional Event Day Included

Monitor	2023 Fourth Highest MDA8 Ozone Value (ppb)	2024 Fourth Highest MDA8 Ozone Value (ppb)	2025 Fourth Highest MDA8 Ozone Value (ppb)	2023-2025 8-Hour Ozone Design Value (ppb)
Charlestown State Park	72	73	70	71

Table 7.3 - 2023-2025 8-hour Ozone Design Values with Exceptional Event Day Excluded

Monitor	2023 Fourth Highest MDA8 Ozone Value (ppb)	2024 Fourth Highest MDA8 Ozone Value (ppb)	2025 Fourth Highest MDA8 Ozone Value (ppb)	2023-2025 8-Hour Ozone Design Value (ppb)
Charlestown State Park	72	73	63	69

Without the impacts of the wildfire smoke that influenced the data on June 11, 2025, the Charlestown State Park monitor's fourth highest ozone concentration adjusts from 70 to 63, resulting in an adjustment of the 2023-2025 DV from 71 to 69 ppb, and attainment of the 2015 ozone standard. Indiana therefore requests U.S. EPA's concurrence with this exceptional events demonstration.