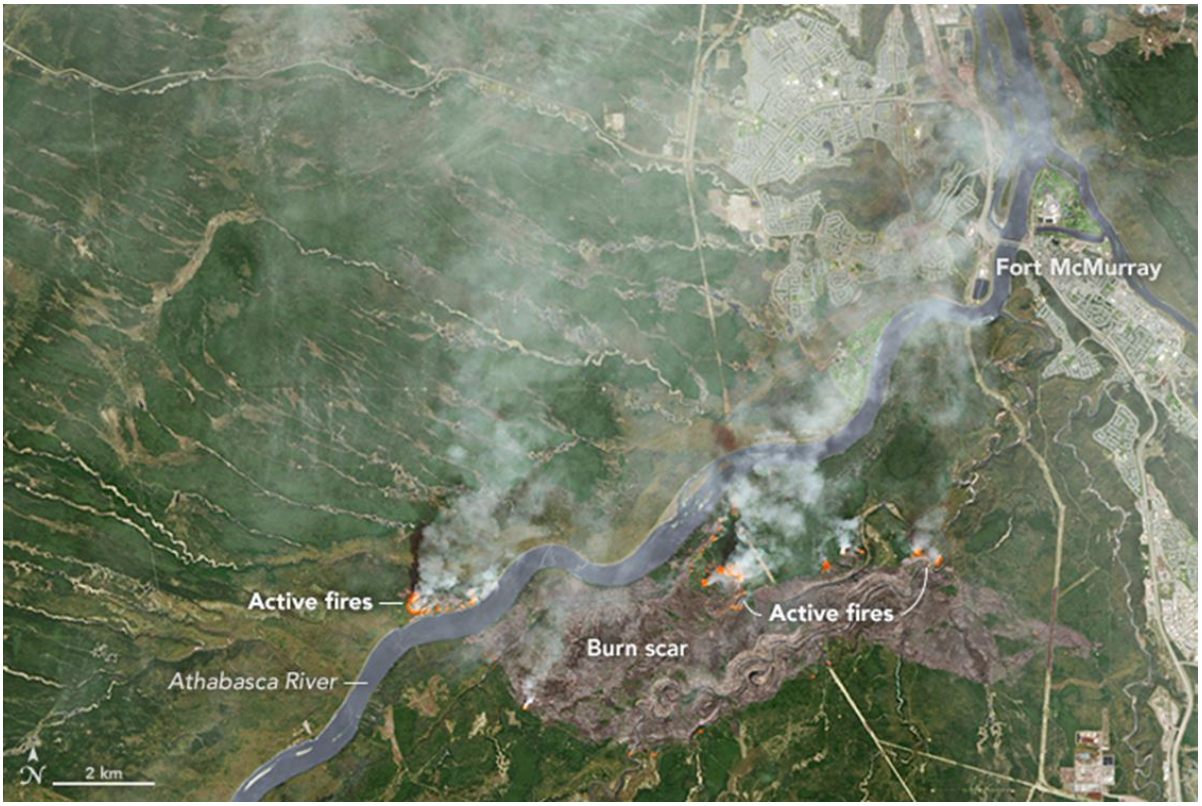
Rhode Island Department of Environmental Management

Exceptional Event Demonstration

Fort McMurray Wildfire

May 25th and 26th 2016



June 20th, 2017

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INSTRUCTIONS: This document is intended to be used side by side with the accompanying PowerPoint presentation. The PowerPoint presentation should open as a slide show through which the user can navigate. References to content in the PowerPoint presentation will be frequently made in this document, indicated by "**SLIDE#X"** in the body of the text. ***Note: There are some animations requiring the left/right arrows or mouse clicks to toggle through the animation. Those animations will be labeled accordingly. Otherwise, GIF animations will play automatically.***

I. Overview

The Rhode Island Department of Environmental Management, in conjunction with the Rhode Island Department of Health Air Pollution Laboratory, operate an air pollution monitoring network throughout the state that measures a variety of pollutants. Of particular importance is ozone, which is measured during the ozone season for three locations in the state (East Providence, West Greenwich, and Narragansett). The official EPA 2016 ozone season ran from April 1st to September 30th. Ozone data is used to gauge public health impacts real time and is also submitted to the EPA via the AQS (Air Quality System) database.

This documentation is being submitted to EPA Region I to demonstrate that the ozone data in the state of Rhode Island at the East Providence, West Greenwich, and Narragansett monitoring locations on May 25th and May 26th, 2016 should be excluded from use in regulatory determinations. This goal of this demonstration is to show that exceedances or violations of the National Ambient Air Quality Standards (NAAQS) for May 25th and May 26th are due to an exceptional event caused by extreme wildfire activity in a variety of locations, but prominently featured emissions from Fort McMurray, Alberta, Canada, as per the Revised Exceptional Events Rule (40 CFR 50.14(c)(3).

As required by the rule, this document will serve to provide the following evidence.

- A narrative conceptual model of how fire activity led to the exceedances at East Providence, West Greenwich, and Narragansett ozone monitors.
- A demonstration that the wildfires affected readings at the monitors in such a way that there exists a clear causal relationship of the elevated ozone readings.
- Comparison of the event concentrations to those of non-event.
- Evidence that the events was not reasonably controllable or preventable.
- Evidence that the event was caused by human activity and is not likely to recur.
- Documentation that RIDEM completed the public comment process.

The "Initial Notification of Potential Exceptional Event" was provided by the Rhode Island Department of Environmental Management Office of Air Resources to EPA Region I in a letter dated January 9th, 2017. See the Attachment I for copy of the letter.

The following documentation serves to meet the requirements of Clean Air Act Section 319(b), Air Quality Monitoring Data Influenced by Exceptional Events; 40 CFR Section 50.14, Treatment of Air Quality Monitoring Data Influenced by Exceptional Events; and EPA's "Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations" from the updated guidance rule promulgated on September 16th, 2016.

This documentation is intended to demonstrate that on May 25th and May 26th, 2016 the ozone monitors at East Providence, West Greenwich, and Narragansett operated jointly by the Rhode Island Department of Health and the Rhode Island Department of Environmental Management experienced elevated ozone concentrations caused by transported smoke emissions, including ozone and ozone precursors such as nitrogen oxides (NOx) and volatile organic compounds (VOCs). Below are the maximum daily 8-hour ozone concentration values for the two days.

Monitor	County	Monitor ID	Date	8-hr Concentration
Narragansett	Washington	440090007	5/25/2016	0.086 ppm
West Greenwich	Kent	440030002	5/25/2016	0.078 ppm
East Providence	Providence	40071010	5/25/2016	0.071 ppm
West Greenwich	Kent	440030002	5/26/2016	0.084 ppm
Narragansett	Washington	440090007	5/26/2016	0.081 ppm
East Providence	Providence	40071010	5/26/2016	0.078 ppm

Table 1- Daily maximum 8-hour ozone concentrations for the exceptional event.

Figure 1 – Map of RIDEM/RIDOH ozone monitoring locations

Each location monitors a variety of parameters, and meet approved EPA siting criteria and monitoring objectives. The East Providence locations performs a neighborhood measurement scale with a monitoring objective to characterize maximum precursor emissions impact and population/urban exposure. The site is designated RIDEM's National Core Monitoring Site (NCORE), which is part of a national multi-pollutant network that integrates several advanced measurement systems for particles, pollutant gases, and meteorology. East Providence also is part of the PAMS network (Photochemical Assessment Monitoring Stations). West Greenwich measures on a regional scale with an objective of characterizing upwind background and population exposure. Narragansett also monitors on a regional scale which characterizes population exposure. Table 2 below is a complete listing of parameters measured and method at each monitoring location impacted by the exceptional event.

Site	Address	Parameter Measured	Method of Sampling
East Providence	Francis School	Oxides of Nitrogen	Chemiluminescence (low range)
	64 Bourne Avenue	Nitrogen Dioxide	
		NO/NOy	Chemiluminescence (low range)
		Carbon Monoxide	Gas Filter Correlation (low range)
		Sulfur Dioxide	Pulsed Fluorescence (low range)
		Ozone	U.V. Photometric
		PM 2.5	Lo Vol
		PM 2.5	Beta Attentuation/Cont
		Speciated PM 2.5	Speciation Monitor
		Course PM (PM 10-2.5)	Lo Vols (PM 10 & PM 2.5)
		Black Carbon	Aethalometer
		VOC	Canisters, GC/FID/MS
		Carbonyls	HPLC Cartridges
		Wind Speed	Anemometer
		Wind Direction	Wind Vane
		Barometric Pressure	Barometer
		Temperature	Spot Reading
		Relative Humidity	Plastic Film
		Solar Radiation	Pyranometric
		UV Radiation	UV Photometric
		Precipitation	Bucket/Continuous
West Greenwich	Alton Jones Campus	Ozone	U.V. Photometric
	Victory Highway	Oxides of Nitrogen	Chemiluminescence (low range)
		Nitrogen Dioxide	
		VOC	Canisters, GC/FID/MS
		PM 10	Hi Vol
		PM 2.5	Lo Vol
		PM 2.5	Beta Attentuation/Cont
		Wind Speed	Anemometer
		Wind Direction	Wind Vane
		Barometric Pressure	Barometer
		Temperature	Spot Reading
		Relative Humidity	Plastic Film
		Solar Radiation	Pyranometric
Narragansett	USEPA Laboratory	Ozone	U.V. Photometric
	27 Tarzwell Drive	PM 2.5	Beta Attentuation/Cont
		Wind Speed	Anemometer
		Wind Direction	Wind Vane
		Temperature	Spot Reading

Table 2 - Complete listing of all parameters measured at the locations being considered in this exceptional event demonstration.

The EPA Guidance document outlines a 3-tiered approach in preparing exceptional event demonstrations. A Tier 1 demonstration is one in which a wildfire clearly influenced monitored values, either outside of the ozone season, with concentrations higher than typical that were deemed as event related, or the wildfire was in very close proximity to the monitor. These demonstrations require the least amount of evidence and documentation. The May 25th and May 26th events occurred during the Rhode Island ozone season, and although statistically above normal for that time of year, they are not unprecedented, and therefore a Tier 1 approach is not applicable.

A Tier 2 analysis is necessary when the wildfire impacts are less clear, and more evidence is required in a weight of evidence approach to demonstrate a causal relationship. Due to the great distance traveled with this smoke event, a minimum Tier 2 analysis is required. Tier 3 demonstrations are used when the relationship between the wildfire and ozone concentrations are the most complex, requiring the highest level of documentation. RIDEM is making this more complex Tier 3 type demonstration.

As part of a Tier 2 analysis, the guidance document lists 2 factors for providing a clear causal relationship, with (Q) being the quantity of wildfire emissions over (d), the distance of the impacted monitors. A Q/d ratio that is over 100 tons/day/km is the threshold listed as providing a clear causal relationship. The 2nd factor is providing analysis that the ozone concentrations when compared to non-event concentrations are in the 99th percentile for the year and past 5 years. Some of the exceedances from May 25th and May 26th were in the 99th percentile, but not all three locations were in the 99th percentile on both days of the event. While the Q/d ratio submitted as part of this demonstration is less than 100 tons/day/km for the Ft. McMurray fire, analysis of the past six years reveals some of the ozone concentrations were in the 99th percentile for historic levels for this event.

RIDEM relied on a Q/d analysis performed by the Connecticut Department of Energy and Environmental Protection (CT DEEP) to determine a causal effect of the Fort McMurray wildfire on some of their monitors. The CTDEEP Q/d was calculated based on the distance from Fort McMurray to the most distant point in the state of Stonington, CT at 3286 km. The distances of the East Providence monitor (3279 km), West Greenwich monitor (3276 km), and Narragansett monitor (3302 km) are deemed similar enough to that of North Stonington, CT to make the CT to make the CT DEEP analysis applicable. Based on that distance, emissions from the geographical area that burned, the scale of the fire, and EPA AP-42 emission factors, all approached yielded Q/d values significantly below the 100 tons/day/km value established by EPA to display clear causal effect. As Q/d method does not generally satisfy the expectation of a clear causal impact, RIDEM is presenting other evidence demonstrating that the plume from the Fort McMurray fire caused elevated ozone levels in Rhode Island in Tier 2 and Tier 3 approaches. Therefore, this document will attempt to show a clear causal relationship that (1) the wildfire emissions were transported to the monitor and (2) that the wildfire emissions impacted ozone concentrations. The full CT DEEP Q/d analysis is located at the end of this document as Attachment II.

II. Design Value and Regulatory Significance

A site is in violation of the NAAQS eight-hour standard if the monitored design value for that site is in exceedance of 70 parts per billion (ppb). The design value is calculated by averaging the fourth highest maximum daily eight-hour ozone concentrations measured at each site in three consecutive years. For the most recent certified data, 2013-2015, the design value for the Narragansett monitor is 73 ppb, while West Greenwich and East Providence both have design values of 70 ppb. Refer to the Rhode Island attainment designation letter sent to EPA on 9/27/16 at the end of this document as Attachment III. Table 3 below (**SLIDE** #1) reveals the design value for the 2014-2016 seasons, and how those values are impacted when exceptional event values for 5/25/16 and 5/26/16 are excluded from the design value for that period, which drops the design value 2 ppb for all three ozone monitors. *Note that the 2013-2016 design values are in attainment of the standard even when including the exceptional event values.*

Looking towards the 2017 season, the critical value of the 4th highest maximum 8-hr average will be impacted if the events of May 25th and 26th are removed, allowing for a *higher* 4th highest to achieve attainment. Refer to Table 3 (**SLIDE** #1) with the listed critical values for 2017 for each location below. Currently for East Providence, a 4th highest in 2017 of 0.071 ppm will result in nonattainment, while removing the data from the exceptional event, a 0.078 ppm will result in nonattainment. For West Greenwich, currently a 4th high of 0.068 ppm will result in nonattainment, while removing May 25th and 26th, an 4th high 8-hr of 0.078 ppm would result in nonattainment. For Narragansett, currently a 4th high of 0.065 ppm will result in nonattainment, while removing May 25th and 26th, nonattainment would occur at a 4th highest 8-hr of 0.070 ppm. By removing May 25th and 26th from consideration for the 2016 ozone season design values, there is a considerable jump in the 2017 critical 4th high values.

East Providence Top 8-hr			Year	4th Highest		Design Value 2014-2016 (ppb)		
7/22/2016	0.082		2014	0.064				
5/26/2016	0.078		2015	0.071		0.068	Current	
7/6/2016	0.073		2016	0.071		**0.066**	Remove May 25-26	
5/25/2016	**0.071**	4th Highest	2016 (EE)	0.064				
7/21/2016	0.067					2017 Critical Value		
4/22/2016	**0.064**	4th Highest removing				Current		0.071
		May 25-26				Remove May 25-26		0.078
West Greenwich Top 8-hr			Year	4th Highest		Design Value 2014-2016 (ppb)		
5/26/2016	0.084		2014	0.067				
7/22/2016	0.08		2015	0.07		0.070	Current	
5/25/2016	0.078		2016	0.075		**0.069**	Remove May 25-26	
6/7/2016	**0.075**	4th Highest	2016 (EE)	0.07				
7/6/2016	0.075					2017 Critical Value		
9/14/2016	**0.070**	4th Highest removing				Current		0.068
		May 25-26				Remove May 25-26		0.075
Narragansett Top 8-hr			Year	4th Highest		Design Value 2014-2016 (ppb)		
5/25/2016	0.086		2014	0.063				
5/26/2016	0.081		2015	0.077		0.070	Current	
7/6/2016	0.072		2016	0.071		**0.068**	Remove May 25-26	
7/15/2016	**0.071**	4th Highest	2016 (EE)	0.066				
7/16/2016	0.067					2017 Critical Value		
8/24/2016	**0.066**	4th Highest removing				Current		0.065
		May 25-26				Remove May 25-26		0.070

Table 3 - Listing of top maximum daily 8-hour ozone concentrations, design value impacts, and 2017 critical value impacts.

III. Statistical Examination of Exceptional Event with Non Events

With the arrival of the plume on May 25th, all three of the ozone monitors in Rhode Island experienced exceedances on both days. Additionally, widespread exceedances were recorded in New Jersey (16/17 monitors), New York (29/30 monitors), and Connecticut (11/12) monitors. Massachusetts experienced exceedances with 9/15 monitors, with three additional monitors reaching the standard.

Table 4 below examines the historical context for the 3 monitors in question for the previous 6 years, 2011-2016, for the months of May and June only. For May 25th, Narragansett (0.086 parts per million (ppm)) exceeded 99th percentile for the period. West Greenwich was below 99th percentile but tied 98th percentile (0.078 ppm), while East Providence (0.071 ppm) was below 99th and 98th percentile. For May 26th, West Greenwich (0.084 ppm) and East Providence (0.078 ppm) both exceeded 99th percentile. Narragansett (0.081 ppm) was below 99th percentile, but tied 98th percentile. Sites colored blue are tied with or exceed the 99th percentile for the period.

Monitor	Date	Daily Max 8-hr Average Concentration	2011-2016 99th Percentile	2011-2016 98th Percentile
Narragansett	**5/25/2016**	**0.086 ppm**	**0.084 ppm**	**0.081 ppm**
West Greenwich	5/25/2016	0.078 ppm	0.082 ppm	0.078 ppm
East Providence	5/25/2016	0.071 ppm	0.076 ppm	0.076 ppm
West Greenwich	**5/26/2016**	**0.084 ppm**	**0.082 ppm**	**0.078 ppm**
Narragansett	5/26/2016	0.081 ppm	0.084 ppm	0.081 ppm
East Providence	**5/26/2016**	**0.078 ppm**	**0.076 ppm**	**0.076 ppm**

Table 4 - Exceptional event maximum daily 8-hour averages as compared to all May-June 2011-2016 percentile data.

Table 5 below examines the historical context for the 3 monitors in question for the entire ozone season, April to September, for the years 2011-2016. On May 25th, Narragansett (0.086 ppm) exceeded 99th percentile for the period, while West Greenwich tied the 99th percentile (0.078 ppm). East Providence (0.071 ppm) was lower than the 99th percentile, but exceeded 98th percentile. For May 26th, West Greenwich (0.084 ppm) eclipsed 99th percentile, while East Providence (0.078 ppm) tied 98th percentile. Narragansett (0.081 ppm) tied 99th percentile.

Monitor	Date	Daily Max 8-hr Average Concentration	2011-2016 99th Percentile	2011-2016 98th Percentile
Narragansett	**5/25/2016**	**0.086 ppm**	**0.081 ppm**	**0.075 ppm**
West Greenwich	**5/25/2016**	**0.078 ppm**	**0.078 ppm**	**0.072 ppm**
East Providence	5/25/2016	0.071 ppm	0.078 ppm	0.070 ppm
West Greenwich	**5/26/2016**	**0.084 ppm**	**0.078 ppm**	**0.072 ppm**
Narragansett	**5/26/2016**	**0.081 ppm**	**0.081 ppm**	**0.075 ppm**
East Providence	**5/26/2016**	**0.078 ppm**	**0.078 ppm**	0.070 ppm

Table 5 - Exceptional event maximum daily 8-hour averages as compared to April-September 2011-2016 percentile data.

Table six below lists the top 10 highest daily maxiumum 8-hour ozone values for the previous 6 years.

SITE	Date	Daily Max 8-hour Ozone
6/29/2012	Narragansett	0.097
7/18/2013	Narragansett	0.093
6/11/2015	West Greenwich	0.092
8/31/2012	East Providence	0.092
6/11/2015	East Providence	0.089
6/30/2012	Narragansett	0.086
5/25/2016	**Narragansett**	**0.086**
9/11/2013	East Providence	0.085
7/6/2011	West Greenwich	0.084
5/26/2016	**West Greenwich**	**0.084**

Table 6- Top 10 Highest Daily Maximum 8-hour Ozone Averages for past 6 years

West Greenwich

5/25/16 8-hr ozone is tied for 2nd highest for entire ozone season (2011-2016)
8-hr ozone tied for 7th highest for May/June (2011-2016)

5/26/16 8-hr ozone is tied for 8th highest for entire ozone season (2011-2016)
8-hr ozone is 2nd highest for May/June (2011-2016)

Narragansett

5/25/16 8-hr ozone is tied for 3rd highest for entire ozone season (2011-2016)
8-hr ozone is tied for 2nd highest for May/June (2011-2016)

5/26/16 8-hr ozone is tied for 7th highest for entire ozone season (2011-2016)
8-hr ozone is tied for 6th highest for May/June 2011-2016

East Providence

5/25/16 8-hr ozone is 14th highest for entire ozone season (2011-2016)
8-hr ozone is 6th highest for May/June (2011-2016)

5/26/16 8-hr ozone is tied for 8th highest for entire ozone season (2011-2016)
8-hr ozone is tied for 3rd highest for May/June (2011-2016)

The following plots are daily maximum 8-hour ozone averages for May-June only for 2011-2016, followed by the entire ozone season, April-September 2011-2016 for all three ozone monitoring sites.

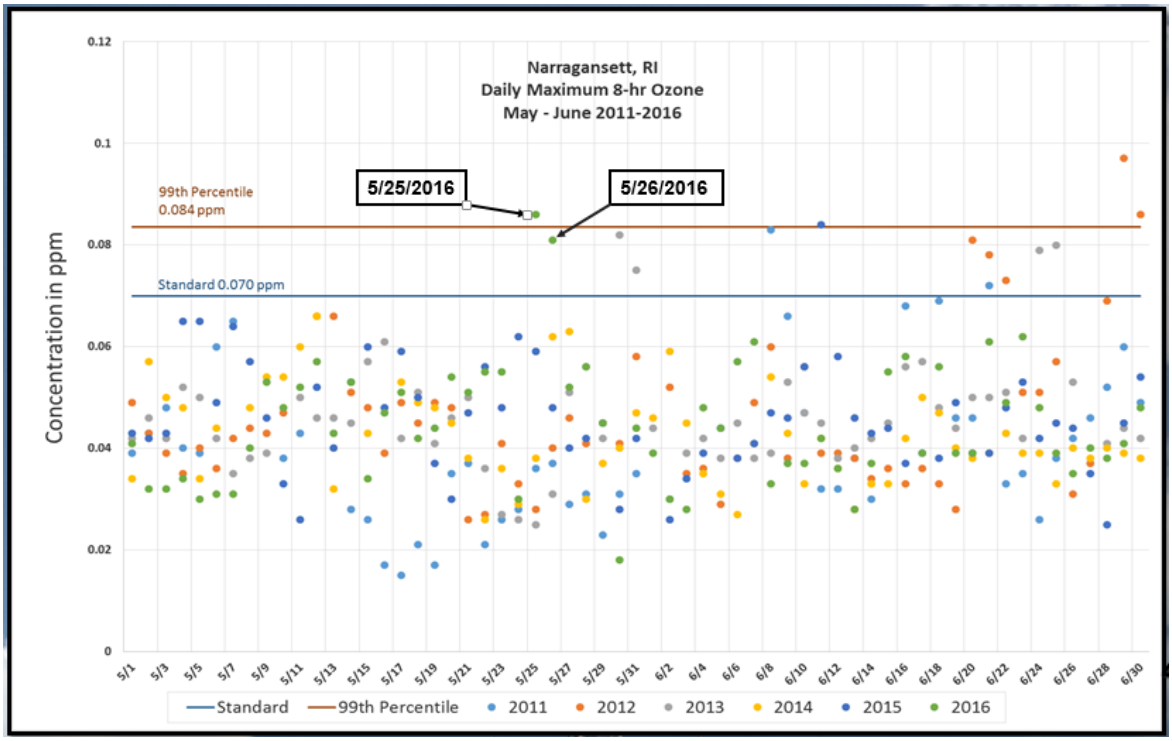


Figure 2 - Plots of 2011-2016 daily maximum 8-hr ozone averages for the months of May and June. The blue Standard line represents the 0.070 ppm 8-hr NAAQS. The orange line represents the 99th percentile. Exceptional event dates are labeled.

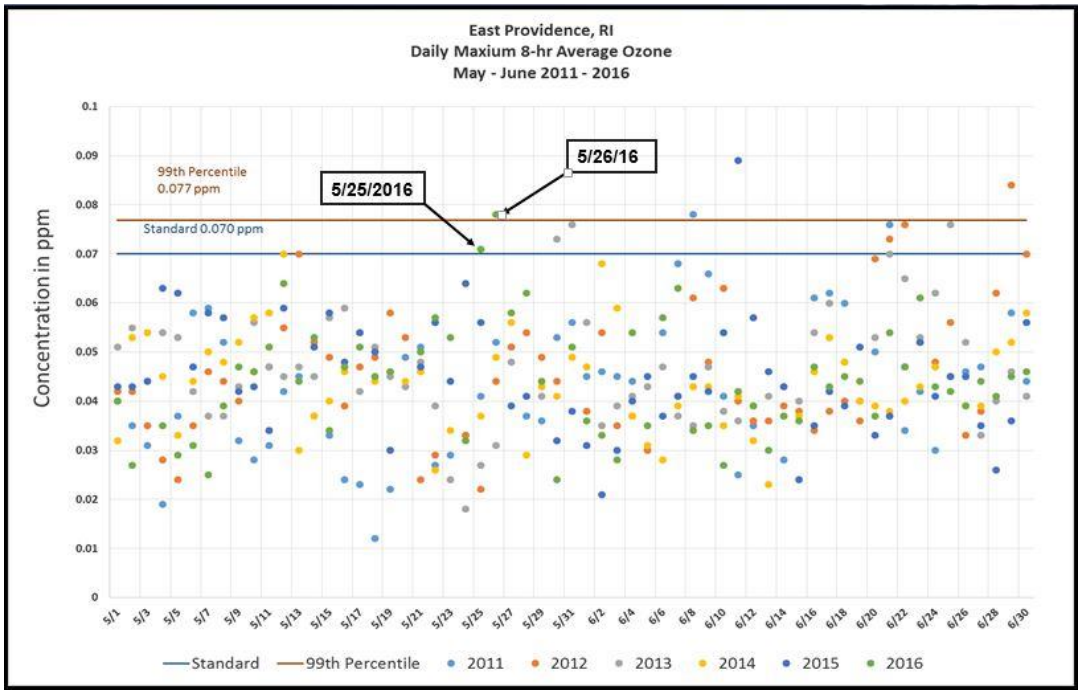


Figure 3 - Plots of 2011-2016 daily maximum 8-hr ozone averages for the months of May and June. The blue Standard line represents the 0.070 ppm 8-hr NAAQS. The orange line represents the 99th percentile. Exceptional event dates are labeled.

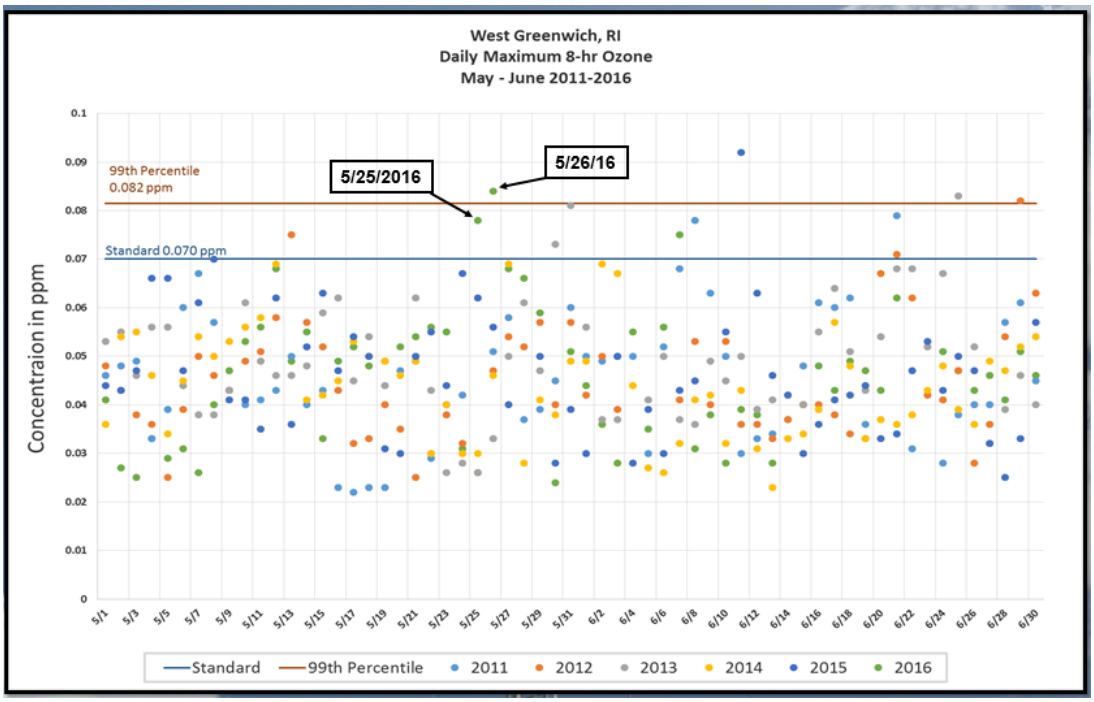


Figure 4 - Plots of 2011-2016 daily maximum 8-hr ozone averages for the months of May and June. The blue Standard line represents the 0.070 ppm 8-hr NAAQS. The orange line represents the 99th percentile. Exceptional event dates are labeled.

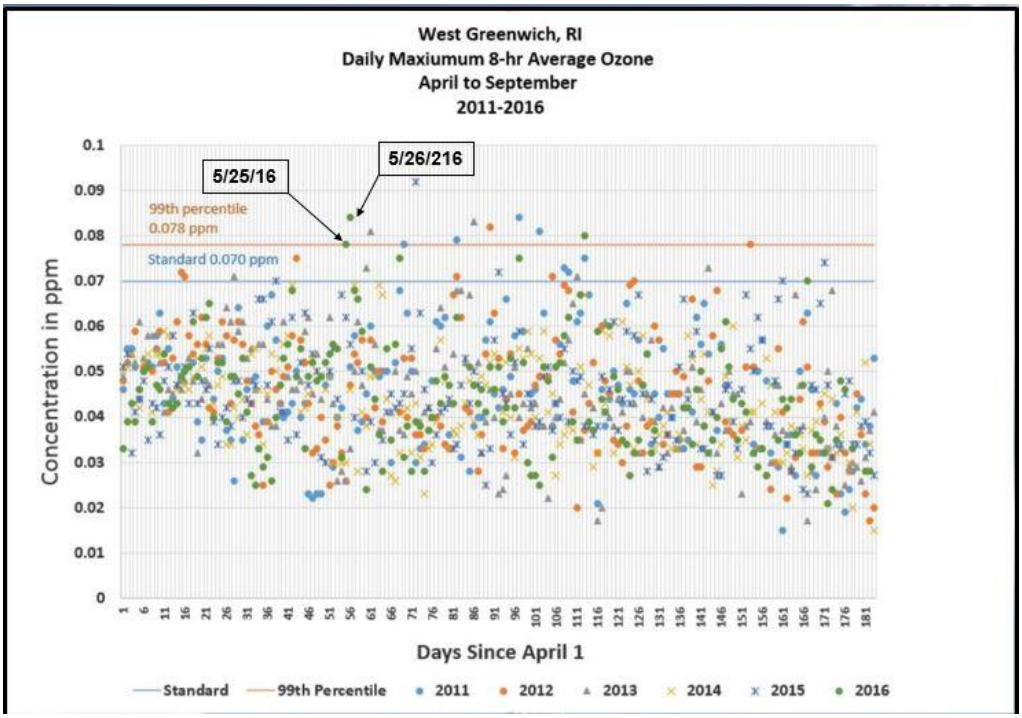


Figure 5 - Plots of 2011-2016 daily maximum 8-hr ozone averages for the entire ozone season, April-September. The blue Standard line represents the 0.070 ppm 8-hr NAAQS. The orange line represents the 99th percentile. Exceptional event dates are labeled.

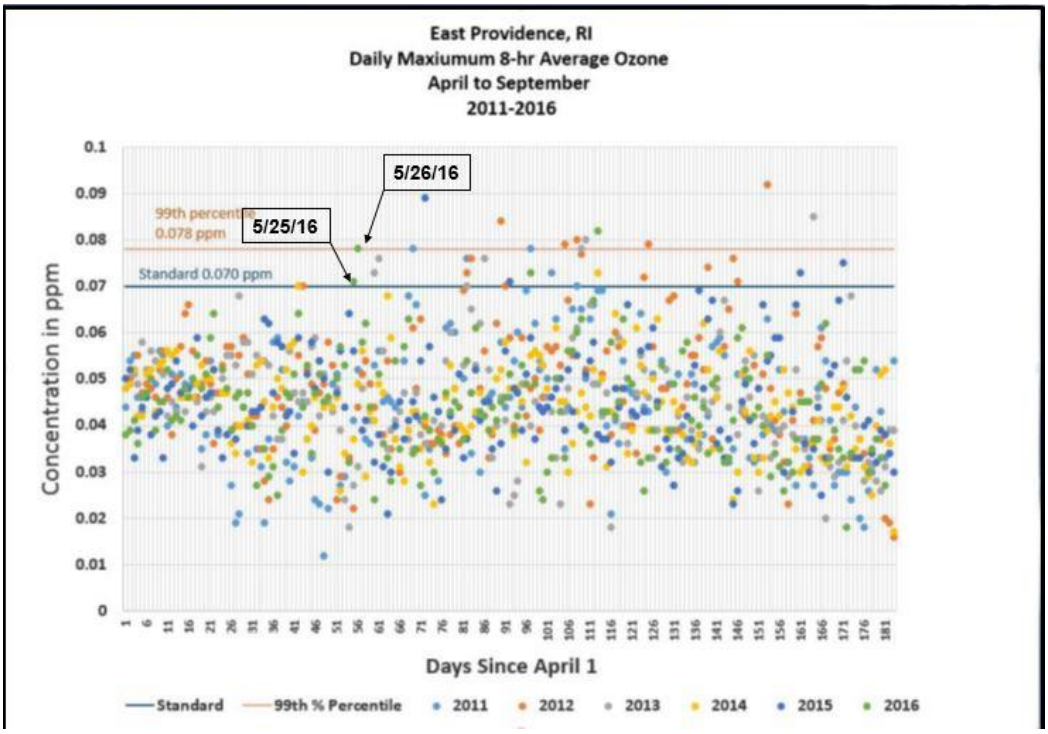


Figure 6 - Plots of 2011-2016 daily maximum 8-hr ozone averages for the entire ozone season, April-September. The blue Standard line represents the 0.070 ppm 8-hr NAAQS. The orange line represents the 99th percentile. Exceptional event dates are labeled.

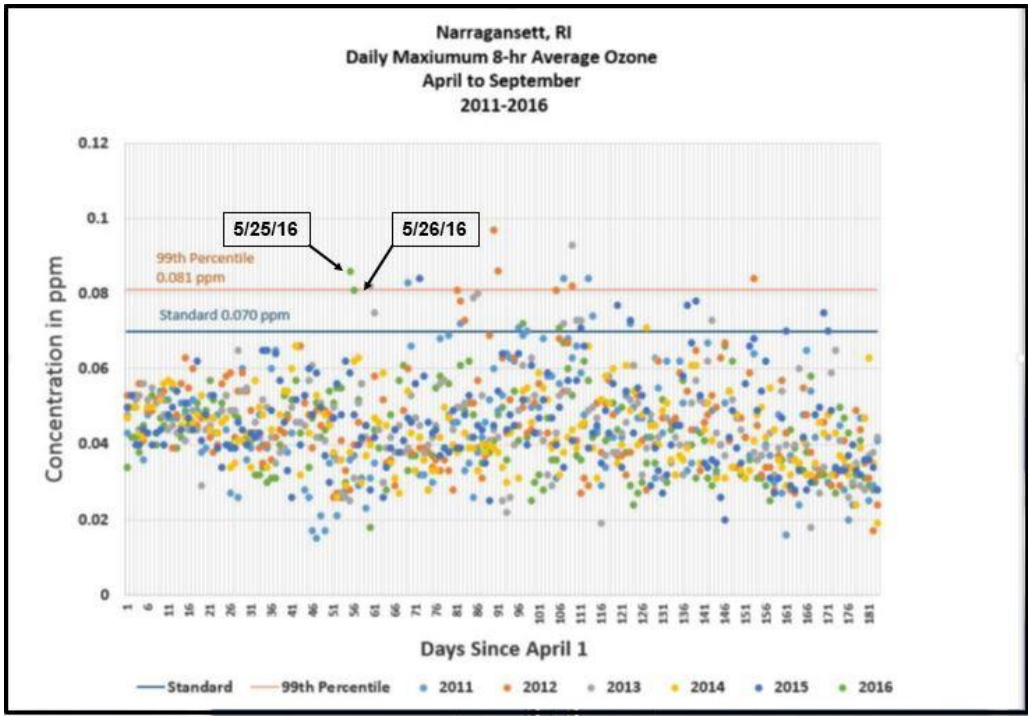


Figure 7 – Plots of 2011-2016 daily maximum 8-hr ozone averages for the entire ozone season, April-September. The blue Standard line represents the 0.070 ppm 8-hr NAAQS. The orange line represents the 99th percentile. Exceptional event dates are labeled.

CONCLUSION

EPA guidance suggests that for each monitor requested for data exclusion, a 5-year percentile of the data on a per monitor basis be determined. If the flagged data is above the 99th or higher percentile of the 5-year distribution of zone monitoring data, or is one of the four highest ozone concentrations within 1 year, these data can be considered outliers and provide strong evidence for the event. The above RIDEM analysis included 6-year percentile data.

For the May 25 to 26, 2016 time frame, all three of the ozone monitors in Rhode Island experienced one daily 8-hour ozone average reading in the 99th percentile for the May-June data sets for the years 2011-2016. For May 25, the Narragansett monitor exceeded the 99th percentile, while for May 26, the West Greenwich and East Providence monitors both exceeded the 99th percentile.

For the entire ozone season of April to September, 2011-2016, for the May 25 day, both the Narragansett and West Greenwich monitors were at or above the 99th percentile, while on May 26, all three monitors were at or above 99th percentile.

For the 2016 season alone for East Providence, May 26 represented the 2nd highest 8-hour ozone reading. For West Greenwich, May 26 represented the highest 8-hour ozone reading of 2016, with May 25 as the 3rd highest reading of 2016. For Narragansett, May 25 represented the highest 8-hour reading, with May 26 the 2nd highest 8-hour ozone reading. All of these data is above the fourth highest for each site for 2016 data.

IV. Wildfire Event and Smoke Transport to Rhode Island

It has been documented within several peer reviewed journals, that there exists a relationship between wildfire smoke, ozone precursors, and elevated ozone levels. These publications contain examples of wildfire smoke plumes enhancing levels of ozone within close proximity of fires, as well as enhancing ozone levels at distances substantially further from the fires, either in the form of precursor buildups in the plume, or the transport of formed ozone. Photochemical modeling results have simulated wildfire smoke effects on ozone and have provided evidence of enhancement. *The following information was obtained from a previously approved exceptional event demonstration completed by the State of Kansas Department of Health and the Environment, complete with full original citations.*

https://www.epa.gov/sites/production/files/2015-05/documents/kdhe_exevents_final_042011.pdf

Smoke from biomass burning contains ozone precursors such as nitrogen oxides (NOx) and non-methane hydrocarbons (NMHCs) (McKeen et al., 2002; Jaffe et al., 2008). Previous observational studies have shown that smoke from biomass burning can enhance the formation of ozone under a variety of conditions (e.g., Hobbs et al., 2003; Junquera et al., 2005; Pfister et al., 2006). Ozone enhancement due to biomass burning is highly variable and depends on a number of factors including fuel type, combustion efficiency, and available solar radiation (Jaffe and Wigder, 2012).

In addition, ozone enhancement associated with biomass burning can take place both immediately downwind of a fire and after long-range smoke transport. Junquera et al. (2005) found ozone enhancements of up to 60 ppb within 10 km of fires in eastern Texas. Using ozonesondes, Morris et al. (2006) found a 25–100 ppb increase in aloft ozone concentrations over Texas due to long-range transport of smoke from wildfires in Canada and Alaska. In the analysis of a November 2009 smoke plume in California, Akagi et al. (2012) found that "despite occurring approximately one month before the winter solstice, the plume was photochemically active and significant amounts of ozone formed within a few hours", demonstrating that ozone enhancement due to smoke can take place in the cool season when ozone concentrations are typically lower. Conversely, in some cases, ozone concentrations were shown to be suppressed near wildfires, possibly because of thick smoke obstructing incoming UV radiation and/or titration of ozone due to high NOx concentrations in the smoke plume (Bytnerowicz et al., 2010; Stith et al., 1981).

Previous studies have also shown that fires contributed to exceedances of the NAAQS for 8-hour ozone (*Jaffe et al., 2004; Junquera et al., 2005; Bein et al., 2008*). And, using photochemical model simulations, Pfister (2008) found 10–15 ppb increases in ozone near fires in Northern California over the September 1-20, 2007, period and near fires in Southern California over the October 15-30, 2007, period, concluding that "intense wildfire periods frequently can cause ozone levels to exceed current health standards." In addition, the EPA previously agreed to a request from the California Air Resources Board (CARB) and the Sacramento Metropolitan Air Quality Management District (SMAQMD) to exclude exceedances of the NAAQS for 1-hour ozone concentrations due to emissions from biomass burning under the Exceptional Events Rule. EPA also approved a 2012 request from the Kansas Department of Health and Environment (KDHE) to exclude several 8-hour average ozone concentrations in April 2011 that were in exceedance of the NAAQS due to numerous fires in areas upwind of monitoring locations. In these cases, CARB, SMAQMD, and KDHE used a weight-of-evidence approach similar to the approach used for this Exceptional Events demonstration—including analysis of air quality and meteorological data, satellite imagery, and air parcel trajectories – to show that smoke from wildfires resulted in ozone exceedances in their respective regions.

Based on its considerable size, significant amounts of ozone precursors, NOx and VOCs were emitted from the Fort McMurray wildfire, in addition to other smoke ingredients. On May 18, the plume from the Fort McMurray wildfire began dispersing toward the US upper Midwest and Great Lakes region where it became trapped due to subsidence, atmospheric stability, and light winds associated with a large area of high pressure. This high pressure area was the dominant meteorological feature in the Midwest area of the country in the following days (May 19-23) and then began to shift eastward on May 24th. Weather conditions where characterized by seasonable temperatures accompanied by generally light winds during the period. **SLIDE #2** is an animation of the National Weather Service (NWS) Surface Analysis Maps for May 18-24 for the United States. Each map shows locations of meteorological features including centers of high and low pressure, frontal systems, and current weather observations from NWS reporting stations. The broad area of high pressure over the Great Lakes region/upper Midwest and its transition slowly eastward is evident in the animation.

The event fire event began on May 1st, 2016, in a remote portion of forest southwest of Fort McMurray, Alberta, Canada. Only two days later, the fire forced the largest wildfire evacuation in Alberta history and eventually spanned approximately 589,995 hectares (1,500,000 acres) before being declared under control on July 5th. Three days after the fire began, it was already deemed extreme by Alberta Agriculture and Forestry.

Date	Hectares	Acres
5/4/16	10,000	25,000
5/5/16	85,000	210,000
5/6/16	100,000	250,000
5/7/16	156,000	390,000
5/16/16	285,000	700,000
5/21/16	504,443	1,246,510

Table 7 - Fort McMurray Fire burn area.

By mid-June, rain and cooler temperatures aided in the firefighting effort. June 13th marks the first date the fire was held in check since becoming out of control. No official cause has been determined to date, though it is suspected to be caused by human activity. However, the conditions leading up to the outbreak were a bit unusual. A hot air mass (temps 90 degrees or higher) with very low humidity (less than 20%) combined with intense winds of 45 mph on May 4th contributed significantly to the fire's growth. The conditions prior to the outbreak were unusually dry, with a low snowpack due to an El Nino cycle, followed by an abnormally warm and dry spring which resulted in a fire season start some four weeks sooner than usual, creating the dry tinder and soil conditions.

SLIDE #3 (https://www.giss.nasa.gov/research/features/201605_fires/) reveals land surface temperature anomalies nearly 10 degrees centigrade above average for the period of 4/26/16 to 5/3/16. Although specific fires cannot be attributed to climate change, a correlation between climate change, earlier spring seasons, and increased fuel aridity can increase forest wildfire activity. (https://www.ncbi.nlm.nih.gov/pubmed/16825536). It's unclear if extreme fire events such as the Fort McMurray fire may become more frequent in the future, but it is known that forest fire smoke is part of a normal summertime atmosphere.

The Hazards Mapping System daily smoke analysis was obtained from the following website (http://www.ospo.noaa.gov/Products/land/hms.html). The HMS tool is used to identify fires and smoke produced over North America in an operational environment, incorporating imagery from multiple environmental satellites. After generating a comprehensive fire analysis, a smoke analysis is performed manually each day, relying exclusively on visible band imagery, as smoke is typically not discernable in infrared imagery. A challenge in the analysis is discriminating between smoke and clouds using GOES as the primary platform. The smoke analysis cannot be performed at night. Identified smoke is depicted using contours of approximated concentrations. Since smoke often remains aloft, air quality forecasters need to determine if smoke is reaching the ground using monitoring data, forecasting mixing profiles, and ultimately

trying to determine potential population health impacts. Ground impact generally can't be determined by the HMS smoke product. For more information refer to: http://journals.ametsoc.org/doi/pdf/10.1175/2008WAF2222165.1.

AirNow Tech is a password protected website for air quality management analysis which is utilized by State, Tribal, and local air quality organizations. The site is a tool to provide air quality forecasts, access monitoring data, analyze current and past air quality episodes, view meteorological and air quality data, and create GIS based maps with air quality and meteorological conditions. The AirNow Tech Navigator tour incorporates the HMS fire smoke analysis. **SLIDE #4** is an animation of the daily HMS fire/smoke analysis generated from the AirNow Tech navigator tool (http://airnowtech.org/) from 5/18/16 to 5/29/16, with smoke represented as various shades of gray, and fire hotspots indicated in red.

SLIDE #4 reveals that by 5/18, the plume from the Fort McMurray wildfires had been well established over much of central Canada. Through May 19th and May 20th, lobes of the plume was transported over the Northeast, while the brunt of the plume remained over the Upper Midwest and Great Lakes Region. Starting on May 21st, the plume began to expand and steer to the eastern U.S during successive days May 22-24th, before directly impacting the Northeast and Rhode Island on May 25-26th. By May 27th onward until May 29th, the HMS smoke analysis indicates the plume had been transported out of the Northeast.

During the time period leading up to the exceptional event (5/19-5/24), elevated ozone levels were experienced in association with the plume under an expansive area of high pressure, light winds, and seasonable temperatures. The impacted air quality associated with the plume is well represented by **SLIDE #5**, which shows a loop of the daily Air Quality Index (ozone only). ***Click or use right/left arrows to advance the animation of this slide***. Ozone in the moderate range is represented by yellow, unhealthy for sensitive groups is represented by orange, with red represented unhealthy for all groups. The daily Air Quality Index was obtained from the AirNow public website archives; https://airnow.gov/. The elevated ozone expanded in size and with increased ozone concentrations in association with the plume as it drifted eastward. This type of pattern indicated that ozone precursors from the wildfire were transported within the smoke plume and resulted in higher ozone levels that would have been expected under similar smoke free meteorological conditions.

As mentioned, visible satellite data is useful for detecting smoke in cloud free locations. **SLIDES #6-8** indicate characteristics of smoke from the 1-km visible satellite images (https://worldview.earthdata.nasa.gov/) for the timeframe of May 20th to May 27th for areas in the Eastern United States that were not obscured by cloud cover. Plumes of smoke are labeled with white arrows. Note that smoke generally does not show up on infrared satellite images, while clouds are shown on infrared. Therefore a side by side comparison of both satellite products is useful for smoke identification. Also note there were instances where cloud cover in the Northeast did not make smoke identification possible on May 21st, May 22nd, and May 24th.

SLIDE #9 is an animation from 5/20/16 – 5/28/16 of AOD (aerosol optical depth), with warm colors indicating higher AOD (higher aerosol concentrations). Aerosols are suspended particles that scatter and absorb sunlight. The aerosol optical depth is a quantitative measurement of aerosol loading in a vertical column from the top of the atmosphere to the Earth's surface. It is an effective proxy for near surface aerosol concentration including dust and smoke. The challenge with AOD is discerning aerosols from clouds and bright surfaces from the imagery. The animation and this slide was provided courtesy of CT DEEP, with images originally obtained from https://worldview.earthdata.nasa.gov/. This animation compares well with the smoke plume represented by the HMS smoke animation and the development of the McMurray fire plume as its signature tracks into the Northeast United States.

It should be noted that during the mid-May timeframe, there was significant fire activity on the Yucatan Peninsula in Mexico. Smoke originating from this region may have impacted the Northeast during the exceptional event. However, it is believed that the wildfire events in Fort McMurray provided by and large the greatest impact on the exceptional event and the wildfire activity in Mexico is not being considered as part of this narrative.

V. Trajectory Analysis and Plume Tracking

The NOAA HYSPLIT (Hybrid Single-Particle Lagrangian Integrated Technology) model is a complete system for computing simple air parcel trajectories, as well as transport, dispersion, and deposition simulations. The model calculates the position of parcels of air over time based on meteorological data. Transport at different altitudes can be specified for simultaneous analysis and display. This allows for better determination of a consistent flow in ascending levels of the atmosphere or if the flow changes direction and/or speed with height. Increments of six hours in each trajectory are indicated by a point on the trajectory line with larger markers indicating every 24-hours. A common application is a back trajectory analysis, which determines the origin of air masses, and forward trajectory analysis to determine the transport of an air parcel from a particular location. Both of these analysis are used in this demonstration. A longer space between points implies faster wind speeds and more travel distance covered in shorter time.

SLIDE #10 represents the HYSPLIT model results and indicates that air parcels on May 18 at the higher 2000m level (green line) may have traveled in a more easterly direction remaining over Canada. However, the model clearly indicates that parcels at the 1000m (red line) and 1500m (blue line) levels would likely have been transported from the Fort McMurray area to the Great Lakes area arriving on or about May 21 (denoted by larger markers over Michigan). With surface high pressure over the region, particles within these parcels would likely have become trapped due to light winds and limited vertical mixing associated with the high pressure system, with increased precursor levels and subsequent ozone readings at the surface. This slide shows that the wildfire plume was transported from its source in Alberta into the Great Lakes Region.

The National Oceanic and Atmospheric Administration (NOAA) HYSPLIT model can was run using the AirNow Tech Navigator tool (http://airnowtech.org/navigator/) to produce the upcoming slides.

SLIDE #11 – The animation on the left represents a 72 forward HYSPLIT trajectory analysis from Fort McMurray for May 21st and May 22nd. At this time, the smoke plume covers much of the central US and Canada, with indications of high ozone shown as yellow dots in the Upper Midwest underneath the plume. The trajectory at all levels traces back to Fort McMurray (indicated by the dark red square) and all at three levels (100, 500, and 1500 meters). From May 21st to May 22nd, the plume shifts significantly east, along with the elevated ozone concentrations.

The slide animation to the right shows backward, followed by forward trajectory analysis for Seney, Michigan for each May 21st, 22nd, and 23rd. On May 21st, the short 48 hour back trajectory lines indicated stagnation and short distances traveled with lighter flows. By May 23rd, there is a more pronounced eastward movement to the smoke plume, indicated by the May 23rd forward trajectory.

SLIDE #12 - 72 hour backward trajectory analysis for East Syracuse, New York for May 22nd and May 23rd. The analysis shows flows arrive to this location on May 22nd, originating from a dense smoke region in Canada north of Michigan, carrying with it the smoke plume under northwest mid to upper level flows (blue and red lines). On May 23rd, the flows are more northerly at all three levels (100, 500, 1500 meters) and continue to arrive from a smoke rich region north of the monitoring site.

By **SLIDE #13**, the smoke has been established to our northwest. The 36 hour forward trajectory analysis for East Syracuse indicates a more northerly flow on May 23rd, around an area of low pressure which was situated east of this location. There will be more detail on the synoptic meteorology later in this demonstration. On May 24th, elevated ozone readings are evident northwest, west, and west southwest of Rhode Island, while locally readings remained low, as the plume still had not arrived. But flows were beginning to back more northwest in the trajectory analysis and by May 25th, low pressure had exited the Northeast, and northwest flows had transported the ozone plume and precursors into the area.

SLIDE #14 – With this slide and subsequent slides with archived weather analysis, a surface map (courtesy of the National Weather Service (NWS) Weather Prediction Center (WPC) Archive (http://www.wpc.ncep.noaa.gov/archives/web_pages/sfc/sfc_archive.php) and an 850 millibar (mb) chart from the NWS Storm Prediction Center and 500 mb ETA vorticity analysis (both courtesy of (http://www2.mmm.ucar.edu/imagearchive/). The surface analysis indicates areas of high and low pressure, surface fronts, temperatures, dew points, wind speed and direction, and barometric pressure. The 850 mb chart is useful as that level in the atmosphere represents the top or near top of the boundary layer, above which frictional influence of the earth's surface is no longer felt at about 1500 meters. This level approximates low level transport. The 500 mb level shows curvature in the wind flow at a much higher level along with upper level areas of

high and low pressure at approximately 5000 meters, representing wind flows and steering at that elevation.

VI. Local Trajectory Analysis

The Narragansett monitor is the farthest monitor from the smoke source and the other monitoring locations are located in close proximity to each other (Narragansett to East Providence is 24 miles, Narragansett to West Greenwich is 20 miles). The trajectories are serving two purposes. One is to show that the flows during the May 25th exceedances are atypical of high ozone events. Secondly, the trajectories show that flows were originating along a course with which the plume was traveling.

On May 24th, there was an area of low pressure just offshore of Southern New England with an occluded front extending from Cape Cod to an area offshore of Nova Scotia. A closed upper level low was situated just off the coast of Southern New England. The surface wind component is from the northeast (typically fresh clean marine air) up to 500 meters or more, as shown by the HYSPLIT 36 hour back trajectory run for Narragansett (**SLIDE #15 animation**), which begins at 4PM on May 24th through 7PM on May 25th. At a height of 1500 meters, flows ranged from the south and southeast. Early on 5/25/16, the trajectories began to back to the north and eventually northwest at 500 and 1500 meters by 10 AM, while surface flows had back rotated to the southwest (again see **SLIDE #15 animation**). **SLIDE #16 animation** (West Greenwich) and **SLIDE #17 animation** (East Providence) both reveal the same trajectory pattern and directional change. **SLIDE #18** indicates that the surface, 500 mb, and 850 mb low pressure troughs have all shifted east and northeast with a cold front soon to move into Upstate New York. By this time, the directional change in winds at the surface up to 500 mb or more originate from the well-established smoke plume that had been lingering west and northwest of the area, and the plume was transported into Rhode Island's air shed. Previous forward trajectory analysis (**SLIDE #13**) from East Syracuse also confirms flows from this region headed to Rhode Island

By May 26th, the exceptional event did begin to take on some characteristics of a traditional non-event day of ozone exceedances, but by that time, the region was already under the influence of the significant smoke plume. At the surface (**SLIDE #19**), a stationary boundary was situated just northwest of the state, 850 mb flows had shifted more west and southwest, and 500 mb flows exhibited a more westerly regime. **SLIDE #20-22** animations for Narragansett, West Greenwich, and East Providence beginning on May 26th at 7AM through May 27th at 7AM. May 26th shows trajectories taking on the characteristics of more typical elevated ozone events with favorable transport. However, by that time, the smoke and ozone plume had been already well entrenched and continued to exacerbate and enhance ozone concentrations. By early May 27th, (**SLIDE #20-22 animations**) 850 mb flows (**SLIDE #23)** had shifted to a more south southwesterly component with substantial fetch over the ocean, possibly mixing in cleaner marine air, and reducing impacts of the plume. Although there is indication of precursors and smoke impacting Rhode Island on May 27th and May 28th, we are focusing this demonstration on

May 25th and May 26th as there is clearer indication of smoke influence on these days. There were western areas of the Northeast that continued to be impacted by the plume on those later dates that were not as affected by the mixing of cleaner marine air, due to their proximity away from the coast.

RIDEM obtained raw web camera images via Camnet (with assistance from George Allen, Senior Scientist, NESCAUM) for Blue Hills Observatory, Milton, Massachusetts. The camera is situated facing northwest, at an elevation near 600 feet, and is located approximately 35 miles from Providence, Rhode Island. Camnet operates a network of real-time visibility cameras at scenic urban and rural locations, with pictures every 15 minutes for the purpose of awareness on the effects of air pollution on visibility.

Refer to the Blue Hill Camnet animation for May 25 on **SLIDE #24**. At 8AM, the camera indicated fog, with visibility of less than a ¼, supported by the Blue Hill Meteorological Observatory daily discussion and climate summary. http://www.bluehill.org/Data/2016/may/may25.txt. By 10AM, the fog had evaporated and visibility improved to 25 miles and very hazy, with the smoke plume visible in the distance northwest of the camera. By 1pm, the visibility has dropped to 20 miles under clear skies. The loop reveals the increasing haze and a light brown hue indicative of particle pollution, with visibility deteriorating into the evening. The **SLIDE #25** animation for May 26-27 continued to show haze and decreased visibilities throughout the day, which matched the Blue Hills observation…..”Visibility was restricted to 20 miles due to hazy conditions”. http://www.bluehill.org/Data/2016/may/may26.txt. Reports of haze continued into May 27 per, http://www.bluehill.org/Data/2016/may/may27.txt.

VII. Chemical Speciation Network (CSN) Data

To further illustrate that the plume was crossing the Great Lakes area during this time period, data from EPA’s PM2.5 Chemical Speciation Monitoring Network (CSN) were analyzed by the CT DEEP. Both organic carbon (OC) and potassium (K, K+) are closely associated with wildfire emissions and were plotted along with maximum 8-hour ozone concentrations. These data are collected at various locations on an every 3-day schedule by the CSN. Please refer to the Attachment IV at the end of this document for the full CT DEEP CSN analysis.

The CSN data for the East Providence site for the month of May 2016 is presented below. Unfortunately, the run days captured at East Providence did not fall on the days of the exceptional event, with run days on May 24th and May 27th. The May 24th data is reflective of the relatively clean air the day mass prior to the smoke plume reaching Rhode Island. The May 27th at East Providence does show some elevated ozone (8-hour maximum concentration of 0.058 ppm) that coincided with elevated levels of OC and K/K+.

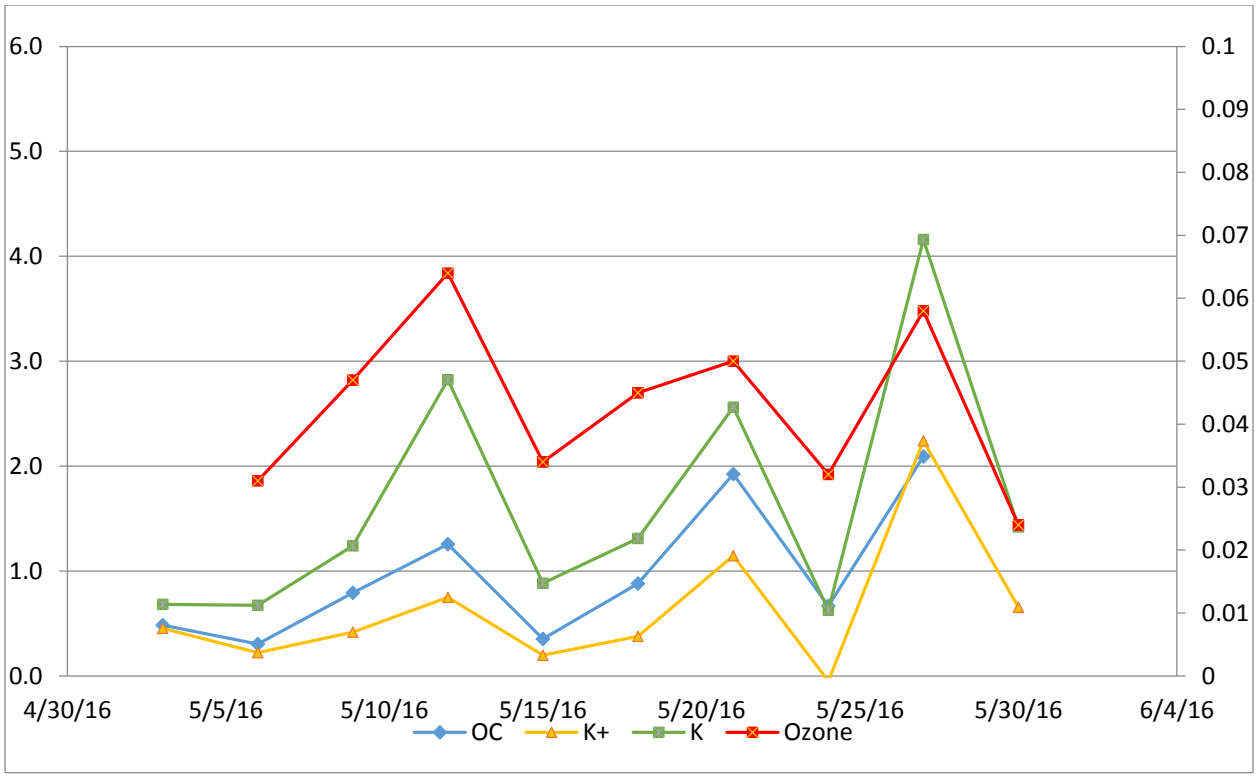


Figure 8 - May 2016 CSN data for East Providence along with 8-hour maximum ozone concentrations.

VIII. CSAPR NOx Source Emissions

Ground-level ozone in the Northeast has long been associated with warm sunny days, which coincides with high electricity demand. The increased electricity demand results in increased NOx emissions from electric generating units (EGUs), which promotes ozone formation. Emissions from EGUs are highest on hot, humid summer days, as more electricity is used by households and businesses to power air conditions. During these times, the peak electric demand can be two to three times greater than the base electric load. (https://www.epa.gov/sites/production/files/2015-09/documents/mackintosh.pdf).

Recognizing the ability of these sources to affect cross state air pollution, the EPA monitors the real-time emissions from these facilities and regulates them as under the Cross-State Air Pollution Rule (CSAPR). CT DEEP evaluated the emissions for May-September 2016 for closest upwind states, and plotted the NOx emission versus exceedances of CT monitors. As Rhode Island is located upwind of Connecticut and upwind of typical flow patterns during high ozone events, it's assumed this analysis is also relevant to RIDEM's air quality. The CT DEEP analysis indicated that peak NOx emissions from electrical demand *did not* occur until later in the ozone season. Please refer to Attachment V at the end of this document for the full CT DEEP analysis.

IX. Examination of Typical Non-Event Ozone Exceedances

There are several meteorological predictor variables (temperature, wind speed, wind direction, cloud cover, relative humidity, and mixing heights) for forecasting high ozone. It is well known that days with high ozone correlate strongly with high maximum temperatures, often a result of strong ultraviolet light on clear days. When examining a plot of ozone exceedances versus high temperatures for the full ozone seasons for 2011-2016, May 25th especially appears as an outlier. NWS observed high temperatures were plotted along with 8-hr ozone values on exceedance days. The red dots indicate May 25th 8-hr average ozone concentrations, with yellow indicating May 26th.

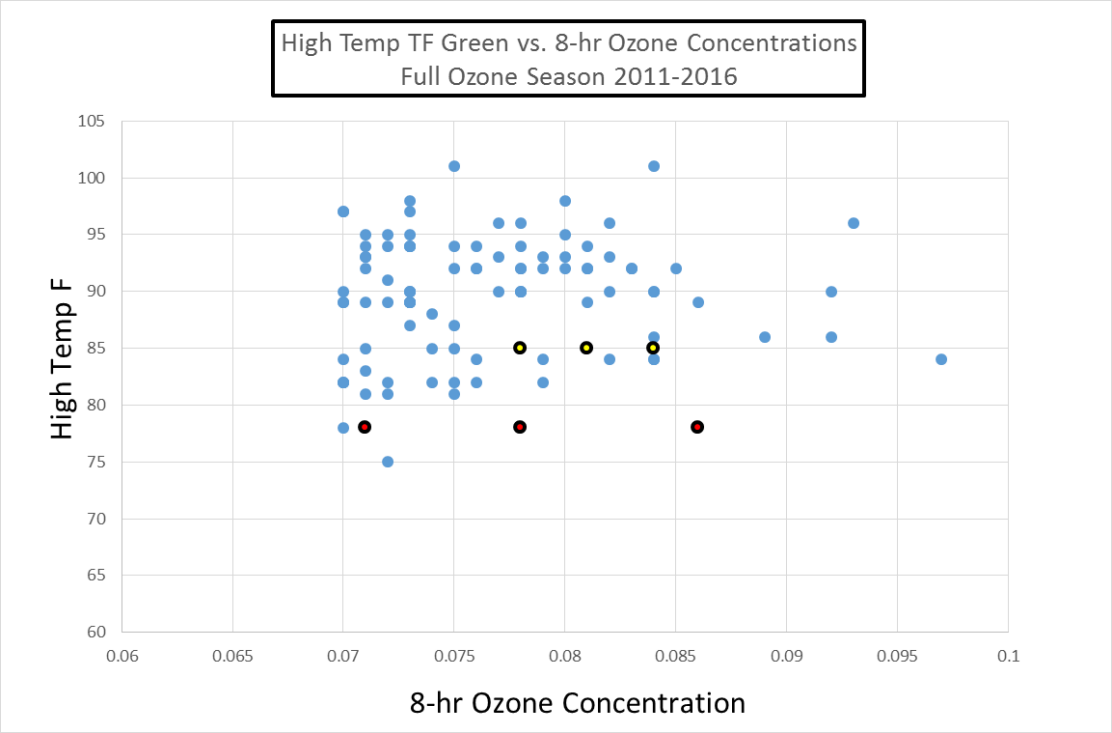


Figure 9 - TF Green Airport daily high temperatures versus maximum daily 8-hour ozone concentrations exceedances for 2011-2016.

The high temperature at TF Green on May 25th only reached 78F. The average daily maximum temperature for TF Green for ANY exceedance of the 0.070 ppm standard for that period was 89F. May 26th, as mentioned, was still heavily influenced by the persistence of the plume, but more closely resembled a non-event ozone exceedance, as high temperatures reached 85F at TF Green on that date. As was the case in the upper Midwest on 5/19/16 and 5/20/16, meteorological conditions on May 25th and May 26th were not favorable for such elevated ozone readings.

Characteristics of the typical non-event (no smoke), synoptic weather, and trajectories will be established. It is hoped that the discrepancies between non-events and the exceptional event of May 25th and 26th will be evident.

Rhode Island's geography is characterized by coastal lowlands around Narragansett Bay and low rolling hills central and north, with the highest point only 812 feet above sea level. The state experiences a humid continental climate which is strongly influenced by its proximity to the Atlantic Ocean. Narragansett Bay intersects the state, with a tidal shoreline of 384 miles. The state experiences all four seasons, prevailing westerly flow, with summer heat and humidity along with deep continental polar air masses in winter. Interior portions well away from the coast tend to have more extreme temperatures fluctuations as opposed to the immediate coast which is moderating by ocean temperatures.

Rhode Island's weather is highly changeable, therefore its air quality is also highly changeable and is substantially affected by transport. Based on the most recent processed emissions inventory for 2011, nearly 43% of NOx emissions (an ozone precursor) originated from on road mobile sources. The West Greenwich Regional PAMS Type I location ozone monitor was established to measure upwind background measurements, as it situated in a heavily wooded, unpopulated region, far from and even upwind of any potential local mobile source impacts of precursor pollutants. Concentrations at West Greenwich are typically assumed to be nearly all transport.

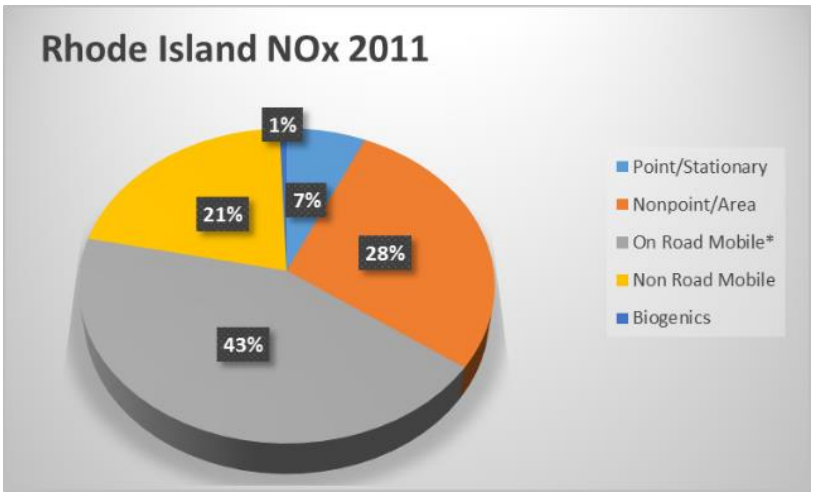


Figure 10 - Source of Rhode Island NOx emissions on a percentage basis. Based upon most recent processed emissions inventory from 2011.

It should be noted that since ozone monitoring began in the state, there has been a measurable decrease in high ozone days. Ozone concentrations during the summer season in Rhode Island are influenced by several factors and weather scenarios that result in the highest 8-hr concentrations each season.

The “classic” conceptual event involves surface flow along the 95 corridor from more densely populated and industrialized precursor pollution source regions of Connecticut, New York, New Jersey, eastern Pennsylvania, and even into the Mid Atlantic states via a generally southwest or west southwest low level component. Mid-level transport is also from the southwest or west southwest, with a more westerly component in the upper levels. Ozone plumes may pool in Long Island sound and migrate along coastal Rhode Island before being brought inland with light and localized sea breezes. Other surface flow regimes from the west can transport ozone plumes within relatively stable marine air along Long Island sound (and again from more precursor rich locations) before also with localized coastal sea breezes bringing the plume inland. The sea breezes typically become more vigorous during afternoon peak heating times. These scenarios are most often associated with Bermuda high anticyclone in the Atlantic and localized ridging (high pressure/high temperature heights) aloft, which provide the surface flows from the southwest and west southwest, all within a relatively stable air mass, with limited cloud formation, allowing the significant ultraviolet light necessary for the chemical formation of ozone.

Ozone transport and formation can also be exacerbated by an approaching cold front (with no associated precipitation) situated west of the state during peak daylight heating. The front acts as a sort of squeegee, resulting in a substantial buildup of precursors in the prefrontal warm sector. Stagnation events as a result of days of high pressure, upper level subsidence, and limited vertical atmospheric mixing may also compound ozone readings over the course of several days. A prolonged stagnation event, without a passage of a cold front, wind shift to a cleaner direction, can lead to several days with subsequently higher ozone readings. In Rhode Island, local emissions are not substantial enough for significant local ozone formation, or immediately problematic upwind formation in Massachusetts, with our highest days only resulting from transport from more emissions rich locations.

Stronger sea breezes or surface southerly wind gradients typically result in the mixing in of cleaner, precursor deprived maritime air masses, which will limit ozone exceedances. Narragansett and East Providence, due to their proximity to the ocean, are especially susceptible southerly gradients ushering in clean marine air. The passage of a surface cold front, a wind switch to the west, northwest, and north results in increased mixing of air sourced from “cleaner” less populated, less polluted source regions. Lastly, other flows not consistent with high ozone concentrations are southeast, east, and northeast, as those directions bring in cleaner marine air.

CONCLUSION

The May 25 and May 26 timeframe did not display meteorological conditions historically associated with high zone events in Rhode Island. There was not a period of stagnation, as the day prior and early on May 25, an area of low pressure was situated just offshore. Soon after a switch in the flow regime at all levels, Rhode Island was quickly impacted by an existing smoke plume with ozone and ozone precursors. Unlike typical exceedances, there was no prolonged offshore Bermuda high pressure, and flows at all levels were at least initially unfavorable for

exceptionally high ozone readings. The trajectories for May 25 and May 26 did not indicate the air mass was arriving from the typical transport and emissions rich source regions to our west and south. There was not intense heat typically associated with days of high ozone readings. For all of these reasons, nearly all the Northeast air quality forecasters were taken off guard at the geographical scale and high ozone concentrations of this event, and had forecasted substantially lower ozone readings at the start of the event on May 25, which unfortunately did not provide adequate warning for public health implications.

X. Non Event Comparison

As mentioned above, typical high ozone events have some characteristics synoptically which equate in high ozone readings in Rhode Island and the Northeast. For purposes of this demonstration, several typical ozone exceedance days will be evaluated below, examining the meteorological characteristics of several non-event days (without smoke influence). These classic events displayed flow regimes, weather patterns, and temperatures that were not present during the May 25 and 26 exceptional event.

7/6/2011

SLIDE #26 – This date experienced exceedances at West Greenwich and East Providence. Trajectories at 100/500 meters from the southwest, 1500 meter flows from the WSW, all favorable transport directions. Plume is evident upwind of NYC metro in Central CT into Rhode Island. **SLIDE #27** 500mb and 850 mb maps show an upper trough to the *wes*t of Rhode Island, with the surface map indicating a cold front moving into Upstate New York, and a Bermuda High offshore. Note that on May 25th an upper trough was located to the *east*, offshore of Rhode Island. The TF Green high temperature was 90F.

7/14/2012

SLIDE #28 – Exceedances occurred at Narragansett, East Providence, and West Greenwich. Light flows and stagnation with a southwest component at all levels, high ozone readings in New York City and southwest CT headed towards Rhode Island. **SLIDE #29** surface map shows an area of high pressure offshore and Rhode Island under high pressure locally. 500 mb and 850 mb charts show general ridge of high pressure over the Northeast, with a weak trough at 500 mb. A broad trough is approaching from the Upper Midwest. High temperature at TF Green reached 92F.

8/31/2012

Exceedances occurred at East Providence, Narragansett, and West Greenwich. Trajectories on **SLIDE #30** show very favorable flows at both 100 and 500m from a west southwest component from favorable transport areas, with an evident ozone plume in New Jersey, Long Island, Coastal Connecticut, moving into Rhode Island with high ozone readings. Flows originate from the west northwest at 1500m.

SLIDE #31 shows high pressure was located offshore and south of RI, with a cold front well off to the northwest, and a pre frontal trough draped northeast to southwest along the northeast. A ridge of high pressure is evident over the East Coast at 500 mb, with a trough located well north of RI into Canada, with flows a bit west northwest ahead of the approaching trough. Flows at 850 mb are generally straight west. High temperature at TF Green Airport reached 90F.

7/19/2013

SLIDE #32 – Trajectory analysis is southwest at 100 and 500 meters, with significant ozone plume in southeast and central CT and into Rhode Island. **SLIDE #33** indicates a broad area of low pressure offshore on the surface chart, ridging at 500 mb over the Northeast, with a broad trough approaching from the west located in the Upper Midwest indicated on the 500 mb and 850 mb charts. High temperature at TF Green was 98F.

XI. Matching Day Analysis

To determine if ozone concentrations would not have been above the standard but for smoke impacts, days with trajectories and meteorological conditions similar to those on May 25th and 26th were examined, but without smoke impacts. The days chosen had high temperatures at TF Green above 90F, all three sites had full data capture for ozone, trajectories were similar (generally a NW or WNW), some synoptic features were similar (as described on the slides), and sky cover was determined as mostly sunny to partly cloudy with no precipitation.

7/23/2016 – SLIDE #34 (trajectory analysis) **SLIDE #35** (synoptic maps)
7/26/2016 – SLIDE #36 (trajectory analysis) **SLIDE #37** (synoptic maps)
8/16/2015 – SLIDE #38 (trajectory analysis) **SLIDE #39** (synoptic maps)

Pollution Wind Roses

RIDEM utilizes Agilaire, LLC software (http://agilaire.com/solutions-for/airvision/) to manage our air quality monitoring data activities. Using this software, pollution roses were generating for the months of May and June for 2014-2016 using ozone concentrations and wind data from the three ozone monitoring location to compare wind directional frequency as compared to ozone readings. ***Click or use right/left arrows to advance through 3 pollution roses on each slide***.

West Greenwich – **SLIDE #40** The 2014-2015 pollution roses reveal a more typical wind regime from the west southwest, southwest, and even some south, which resulted in exceedances of the 8-hr standard, as indicated by warm colors. When advancing to the 2016 rose, the exceptional event exceedance resulted from a northwest and west northwest flow, which is an atypical flow resulting in high ozone concentrations.

Narragansett – **SLIDE #41** The 2014-2015 pollution roses, high ozone concentrations resulted from statistically favorable transport directions of west, west southwest, and southwest. The 2016 rose again shows the unusual elevated ozone from the west northwest component.

East Providence – **SLIDE #42** The East providence location is a more susceptible to spring time bay breezes, when the water land temperature differences are the greatest, which can shift prevailing winds southwest to more of southeast direction. Additionally, due to the frictional change of air flow going from the land over the West Bay to the East Bay and a meteorological phenomenon known as the Ekman spiral, this location in particular may see higher ozone concentrations under a wider variety of flows, including southeast (transport brought in on bay breeze), south, southwest, west southwest, and west, as indicated by the pollution roses for 2014 and 2015. However, the May 2016 exceptional event signal is still evident, with high ozone resulting from a west northwest surface flow.

When examining East Providence more closely on the May 2016 exceptional event, it appeared the ozone on 5/26/16 did not climb as high if not having been impacted by a bay breeze. At 11AM the winds shifted from the southwest (213 degrees) to south southeast (171 degrees) and eventually to southeast (157 degrees), with a 6 ppb drop in the hourly ozone value from 85 ppb to 79 ppb (**SLIDE #43**). Narragansett (**SLIDE #44**) and West Greenwich (**SLIDE #45**) did not experience a sea breeze and winds retained a westerly component, while ozone values remained high.

XII. Air Quality Model Performance during Exceptional Event

Throughout the exceptional event, both the CMAQ and NOAA models vastly under predicted in tracking the plume, when compared to observations. On 5/24/15 (**SLIDE #46**) the NOAA model (top panels) did not capture any of the exceedances around Lake Ontario and Lake Erie to our northwest, the day prior to the exceptional event in RI. As the plume impacted RI and the Northeast on 5/25/16, the under prediction continued by an entire health impact category on the Air Quality index, with models only predicting MODERATE along the immediate coast of Southern New England. Observed ozone concentrations reached UNHEALTHY at monitors in CT and RI.

Refer to the images on **SLIDE #46** and **SLIDE #47**, provided to RIDEM by Joel Dreesen of The Maryland Department of the Environment. The plotted maps of interpolated NOAA/CMAQ predicted concentrations versus observed 8-hour concentrations tracks the substantial negative bias in the models with the plume as it tracks into Rhode Island from the northwest. The negative bias reaches approximately 15-25 ppb on May 25th, continuing on to May 26th (**SLIDE #48**). May 27th, as the plume exits the region, the model prediction goes from a negative bias to a more neutral bias as the smoke impact lessened. By that time, the weather pattern and trajectories indicate a more southerly, cleaner flow off the Atlantic for Rhode Island, which displaced some of the plume out of the region and mixed in cleaner marine air. Note that both models do not assimilate gaseous smoke emissions in predicting ozone concentrations, which may have resulted in the negative bias.

XIII. Monitoring Data and Smoke Evidence at RI Monitors

Smoke is a complex mixture of carbon dioxide, water vapor, carbon monoxide, particulate matter, hydrocarbons and other organic chemicals, nitrogen oxides, and trace minerals. The individual compounds present in smoke number in the thousands. Smoke composition depends on multiple factors, including how efficiently a fuel burns, the fuel type, fuel moisture content, fire temperature, wind conditions, and other weather-related influences, whether the smoke is fresh or "aged," and other variables (https://www3.epa.gov/airnow/wildfire_may2016.pdf).

In addition to the many ingredients that comprise of fire smoke, ozone precursor emissions of NOx and VOCs can generate ozone within the plume or combine with emissions from other sources to generate ozone (*Jaffe, D.A., Wigder, N.L., 2012. Ozone production from wildfires: A critical review. Atmospheric Environment 51, 1-10*). There are many variables that impact the magnitude and ratios of fire emissions, including the acreage burned, the characteristics of the fuel burned, and the meteorological conditions (*Akagi, S., Craven, J., Taylor, J., McMeeking, G., Yokelson, R., Burling, I., Urbanski, S., Wold, C., Seinfeld, J., Coe, H., 2012. Evolution of trace gases and particles emitted by a chaparral fire in California.Atmospheric Chemistry and Physics, 12, 1397-1421*). In an analysis conducted by (*Pfister, G., Wiedinmyer, C., Emmons, L., 2008. Impacts of the fall 2007 California wildfires on surface ozone: Integrating local observations with global model simulations. Geophysical Research Letters, 35*), smoke impacts were modeled for the busy 2007 California wildfire season. An increase in observed ozone was found when the model predicts a strong impact of pollution from the fires, where measured afternoon 8-hour concentrations increased, on average, by about 10 ppb. The findings demonstrate that intense wildfire periods can significantly increase the frequency of ozone concentrations exceeding current U.S. health standards.

The resultant rapid increase in smoke parameters and ozone that all three monitors in Rhode Island experienced under the aforementioned meteorological conditions and trajectories is quite remarkable. The response with the monitors is revealed in the upcoming plots.

Note that scales for all non-ozone parameters have been normalized as indicated on the figures below to provide for better scaling and comparison between different parameters.

All hourly PM 2.5 readings were performed by Met One beta attenuation monitors (BAMs). Thermo-Fisher instrumentation analyzed gaseous measurements of ozone (TE 49i) and carbon monoxide (TE 48i). Black carbon measurements were performed by a Magee Scientific AE33 Aethalometer (primary) and a Magee Scientific AE21 Aethalometer (collocated unit). Note that high PM 2.5 and black carbon readings typically build incrementally over time, but for the exceptional event, PM 2.5 and black carbon increased very rapidly.

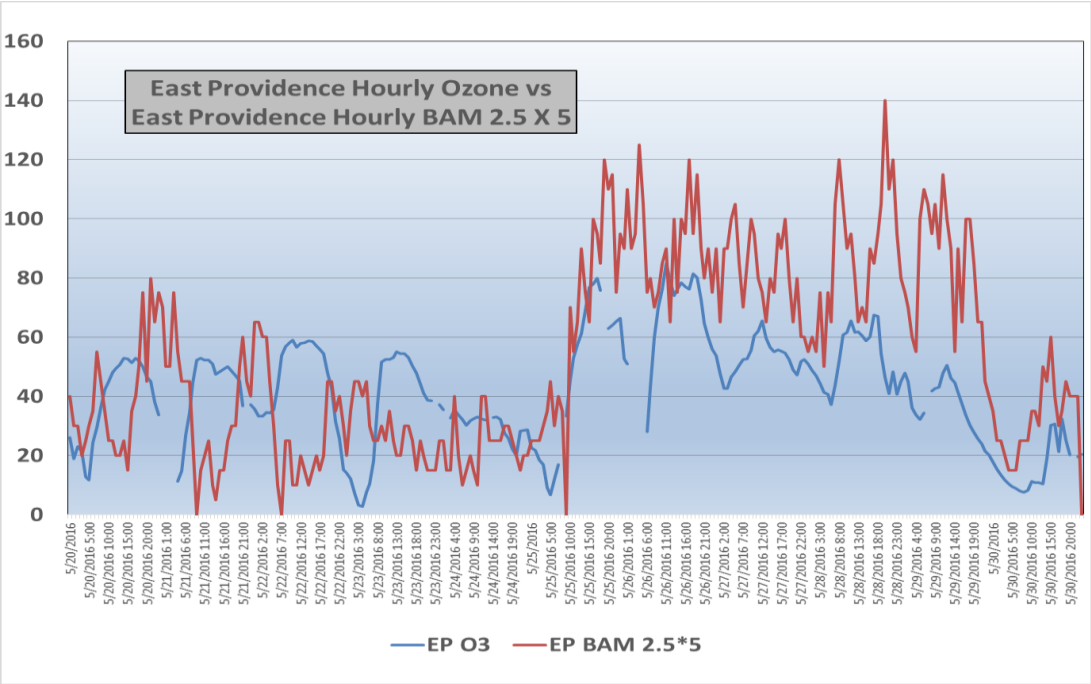


Figure 11 – Hourly ozone plot versus hourly PM 2.5 shows both pollutants increasing quickly together with the plume arrival early on May 25th.

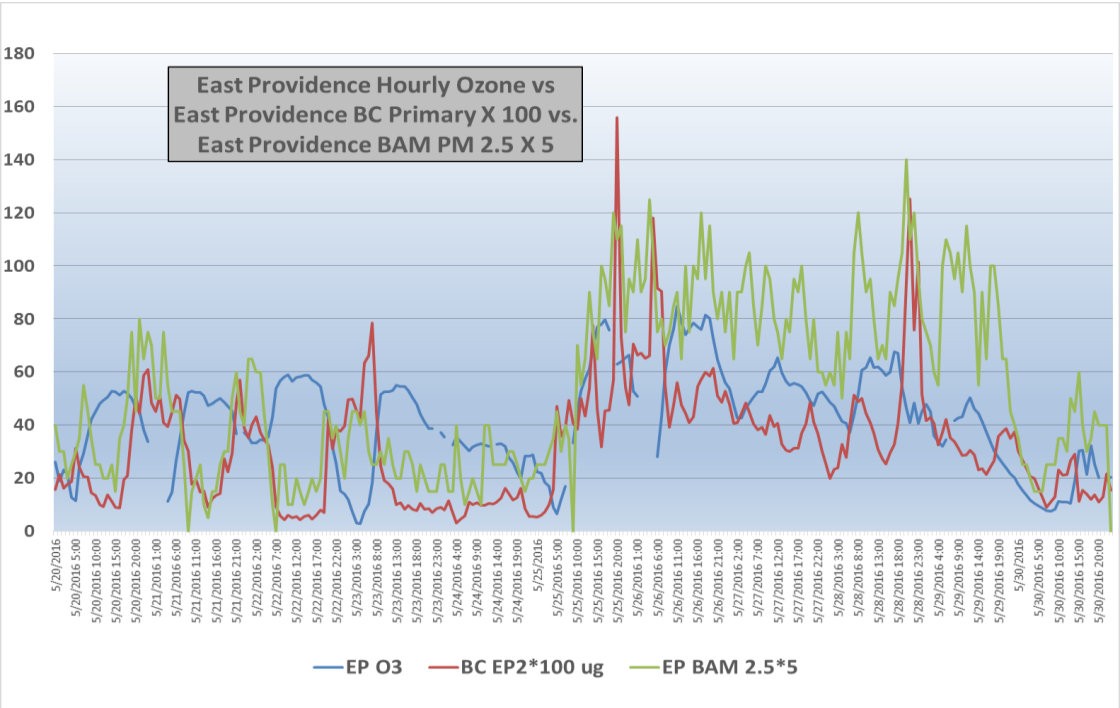


Figure 12 – Plot of hourly ozone, black carbon, and PM 2.5 climb similarly with the arrival of plume early on May 25th.

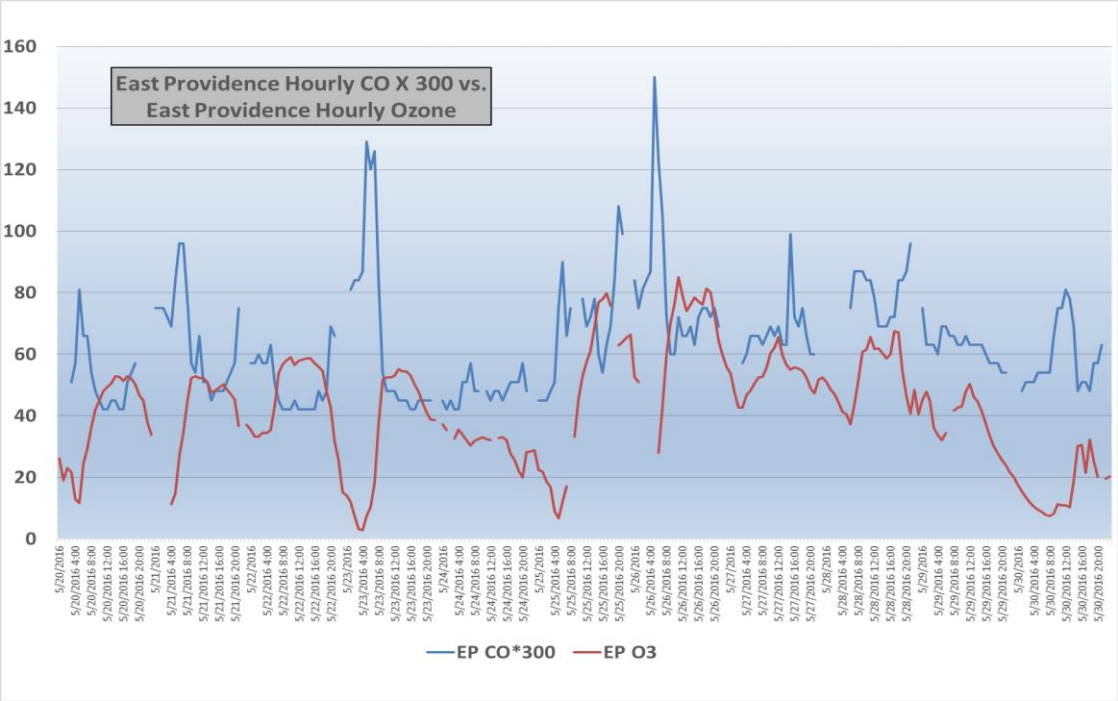


Figure 13 - Hourly carbon monoxide versus hourly ozone at East Providence show both pollutants climb with the plume arrival on May 25th.

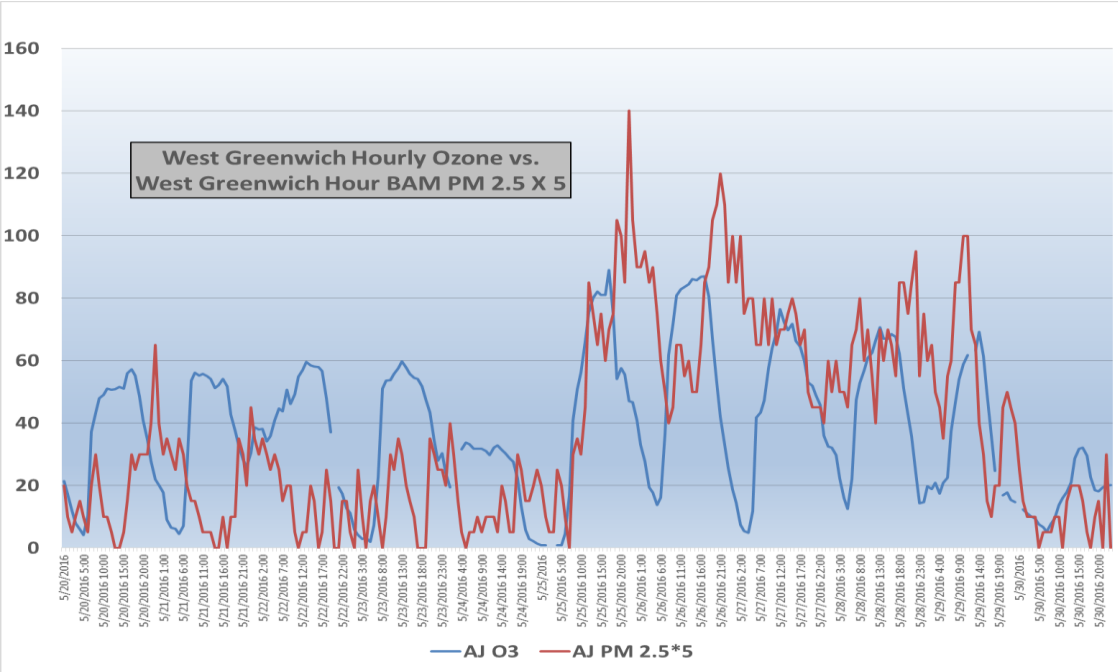


Figure 14 – West Greenwich hourly ozone plot versus hourly PM 2.5 shows both pollutants increasing quickly together with the plume arrival early on May 25th, similar to East Providence.

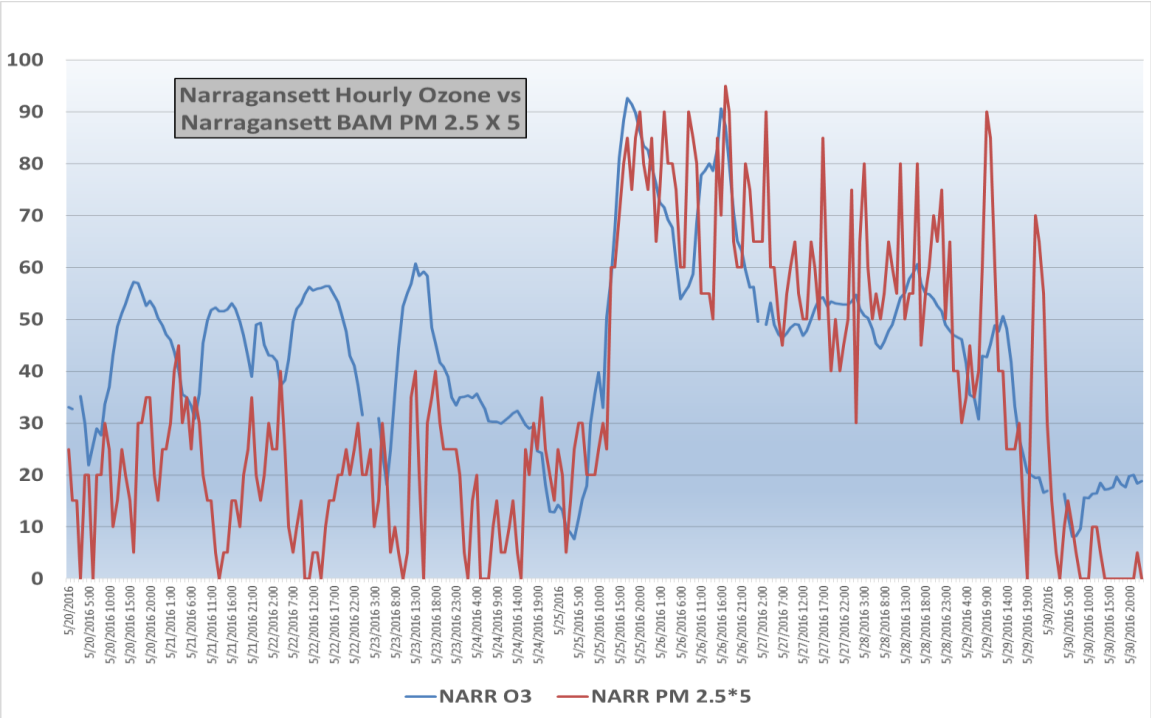


Figure 15 - Hourly ozone plot versus hourly PM 2.5 shows both pollutants increasing quickly together with the plume arrival early on May 25th, similar to both East Providence and West Greenwich.

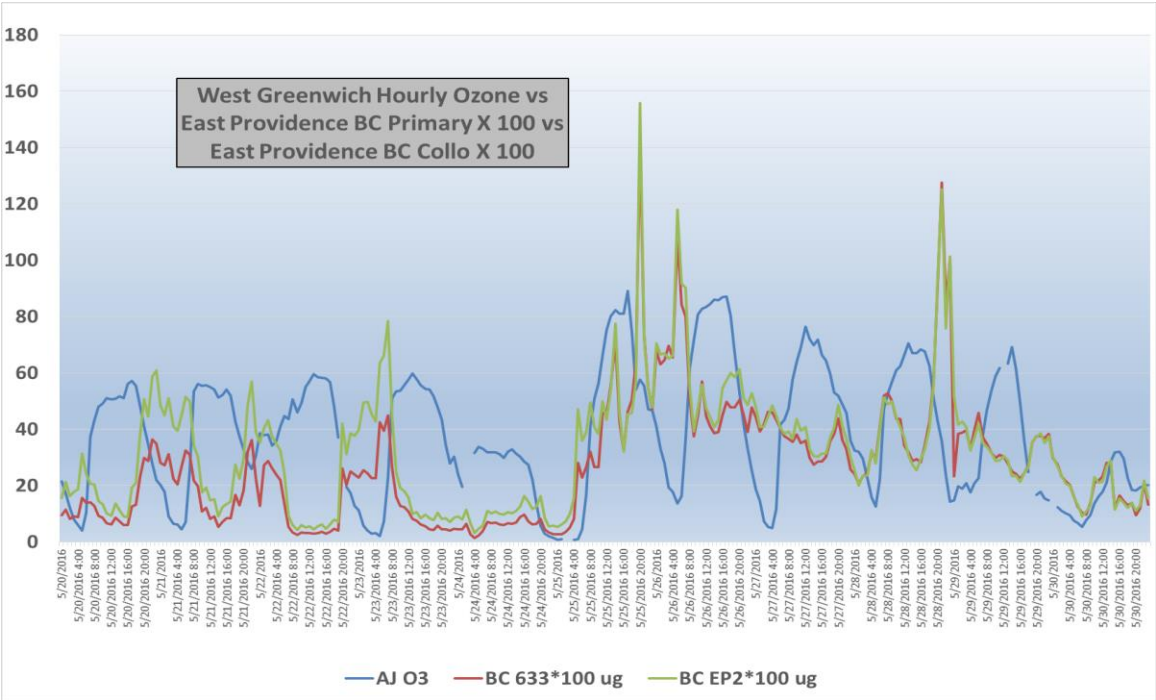


Figure 16 - West Greenwich hourly ozone versus East Providence hourly black carbon and a co-located hourly black carbon. The co-located black carbon measurements are typically in very good agreement. All readings climbed similarly with the plume arrival early on May 25th.

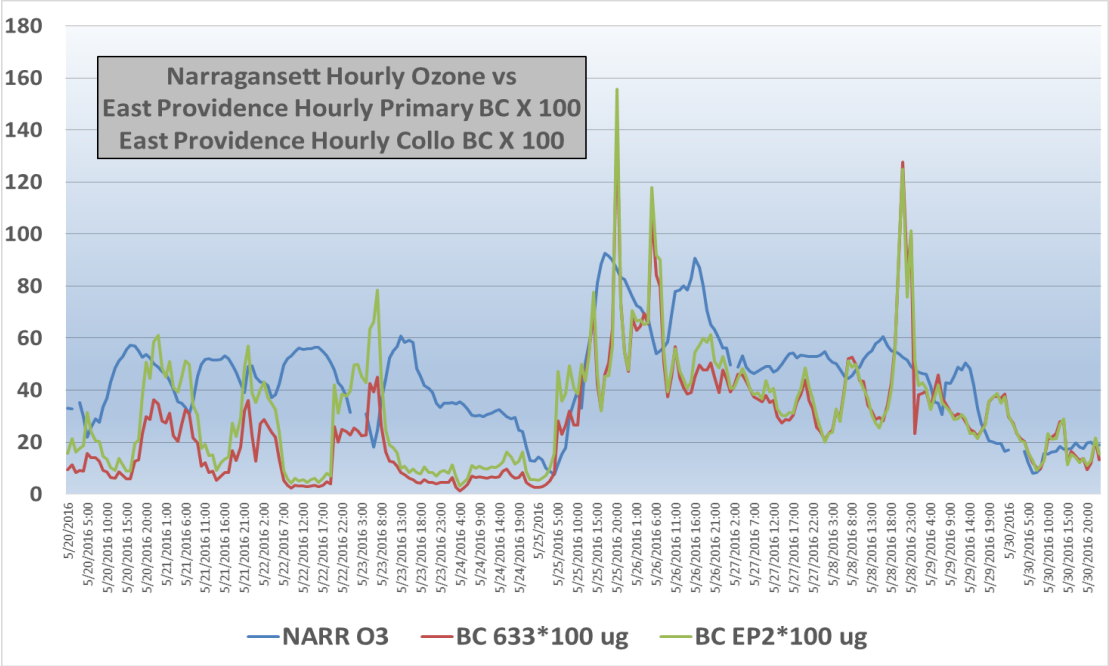


Figure 17 – Narragansett hourly ozone versus East Providence hourly black carbon and a co-located hourly black carbon. The co-located black carbon measurements are typically in very good agreement. All readings climbed similarly with the plume arrival early on May 25th.

The East Providence Magee Aethalometer operates on dual channels for two different wavelengths, usually near-IR (880 nanometers or BC) and near-UV (at 370 nanometers or UVC). Organic components of wood smoke particles absorb light at 370 nm more effectively than 880 nm in two wavelength measurements. Aethalometer Delta-C is determined by the difference of the 370 and 880 Aethalometer measurements in ug/m^3. Delta-C, although not quantitative, is a specific indicator of wood smoke PM, with BC comprising nearly 10% of wood smoke PM (*Allen GA, Babich P, Poirot RL (2004) Evaluation of a new approach for real time assessment of woodsmoke PM. In "Proceedings of the Regional and Global Perspectives on Haze: Causes, Consequences and Controversies", Paper #16 Air and Waste Management Association Visibility Specialty Conference, Asheville, NC)*.

As mentioned, the East Providence location operates two Magee Aethalometers as a primary and collocated unit. The AE33 dual channel unit operated both a K1 (370 UV) channel and a K6 (880 nm) channel. The data was evaluated with assistance of George Allen, a Senior Scientist at the Northeast States for Coordinated Air Use Management (NESCAUM), who has had specific experience evaluating Magee Aethalometer data sets. It was determined that the Delta-C data did not reveal anything to indicate wood smoke during the time of the event, as there may have been some quality control problems with the K1 370 nm UV channel and K6 880 nm channel, resulting in some instrument performance issues. Unfortunately, the older AE21 collated unit

did not have an operational 370 UV channel, so Delta-C data was not available. Per George, the BC channel data was not impacted by any quality control issues.

CONCLUSION

The plots of smoke parameters (PM 2.5, BC, CO) showed a significant upward trend from pre-event baseline readings, indicative of a smoke plume interacting with the surface. The peaks of each parameter coincide well with each other, and match the timing of plume arrival as evidenced previously in this demonstration. The measurements also coincide well with the peaking ozone readings of the event. The trends are consistent with what would be expected from a distant smoke plume arriving locally. These trends are evident in parameters measured at all three locations of East Providence, West Greenwich, and Narragansett.

XIV. Monitoring Data During Typical Non Event Ozone Exceedances

The following plots are for the East Providence monitoring location and include data obtained during two previous exceedance days which have already been examined in Section IX. as part of a non-event high ozone day comparison on 7/6/2011 and 7/19/2013.

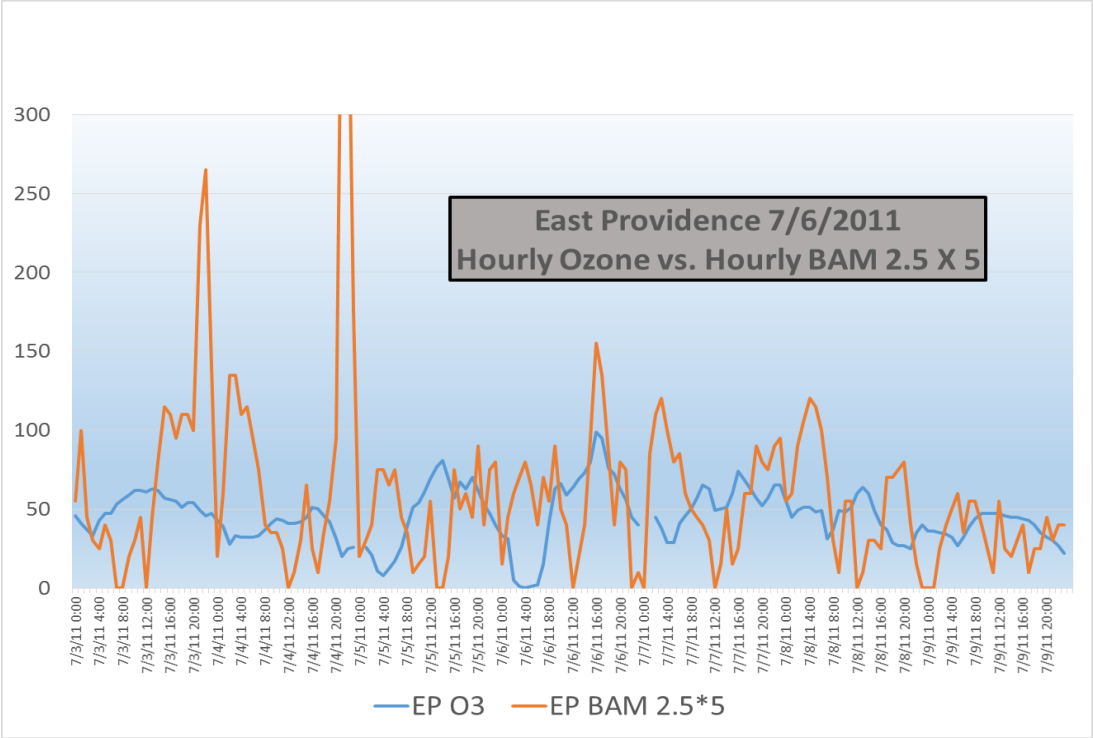


Figure 18

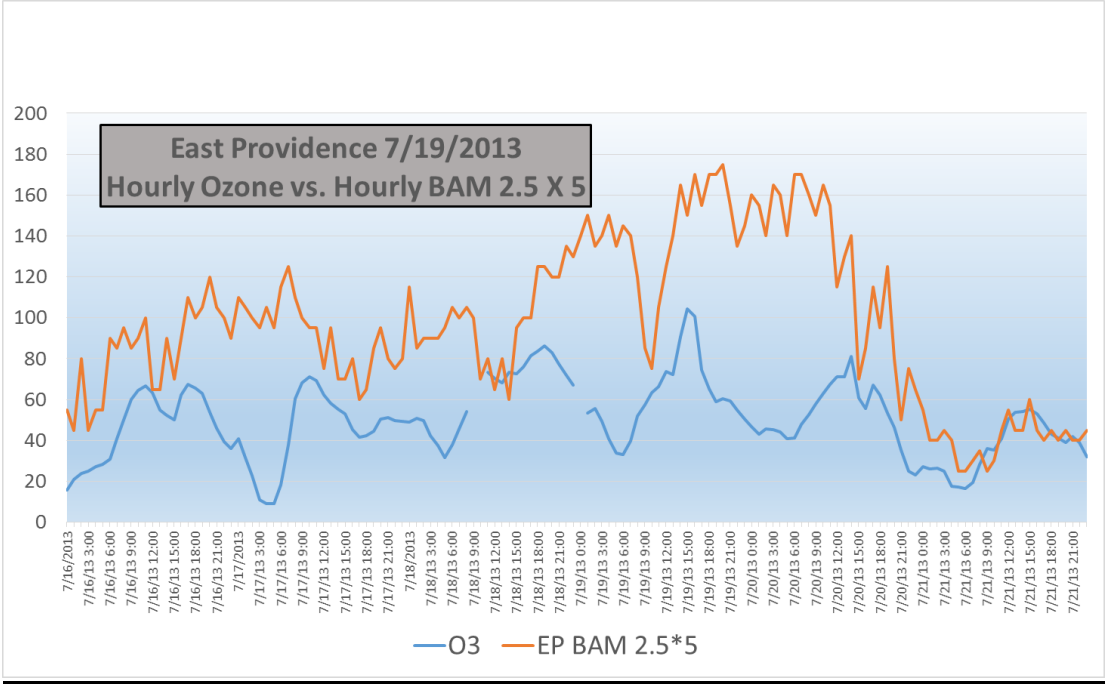


Figure 18 and Figure 19 (above) plot East Providence hourly ozone versus hourly PM 2.5 for exceedance days on 7/6/11 and 7/19/13. Ozone and PM 2.5 can and will climb together on ozone exceedance days, but the plots do not show the drastic climb as shown on the exceptional event plots.

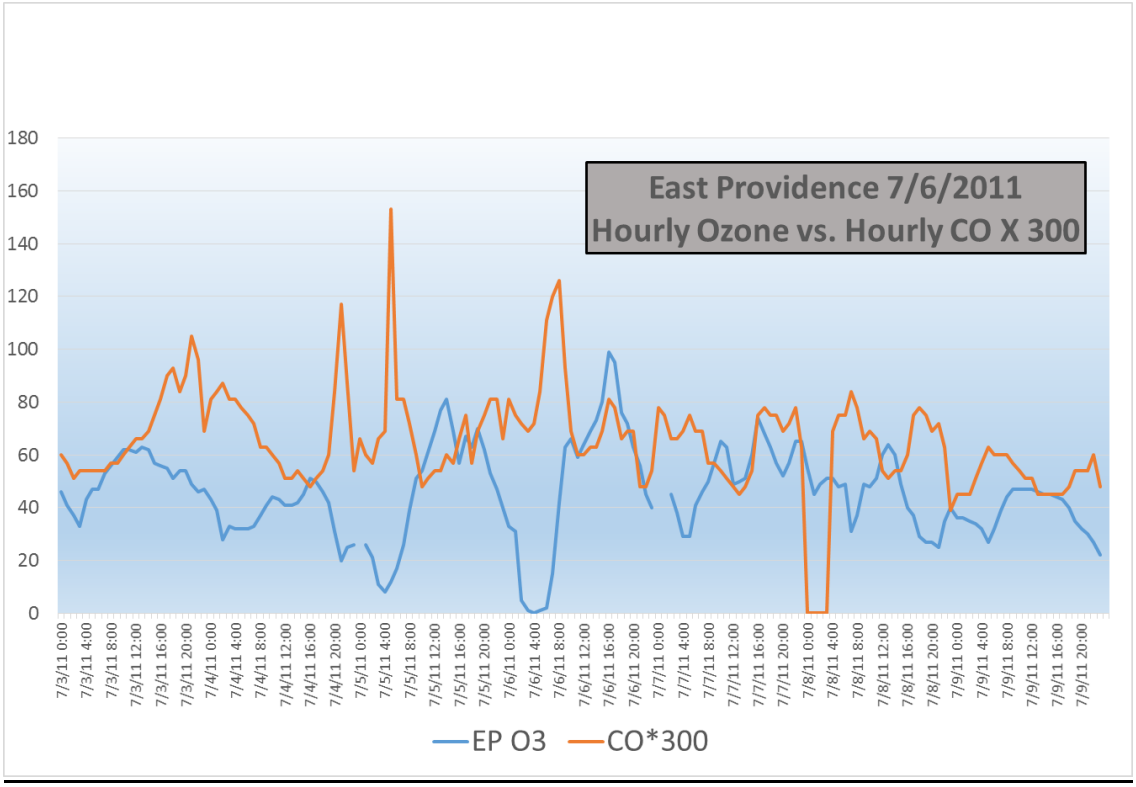


Figure 20

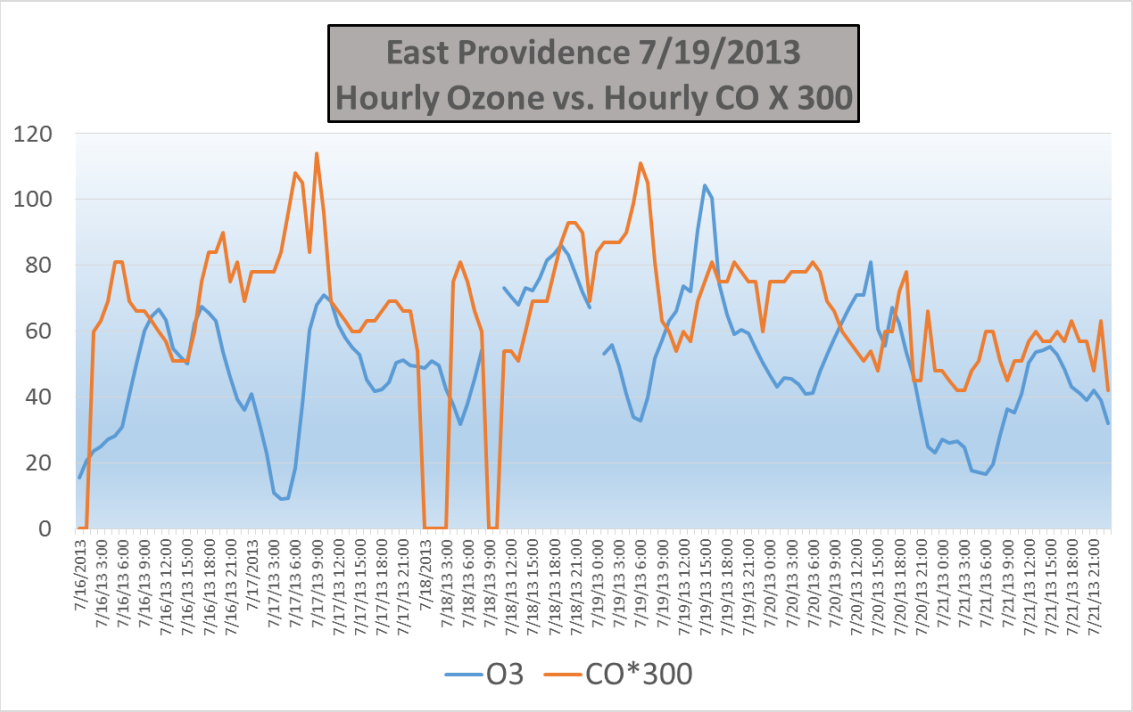


Figure 20 and 21 (above) – Hourly ozone plots of versus hourly CO for exceedance days on 7/6/11 and 7/19/13. Highest hourly ozone readings do not coincide with highest CO readings.

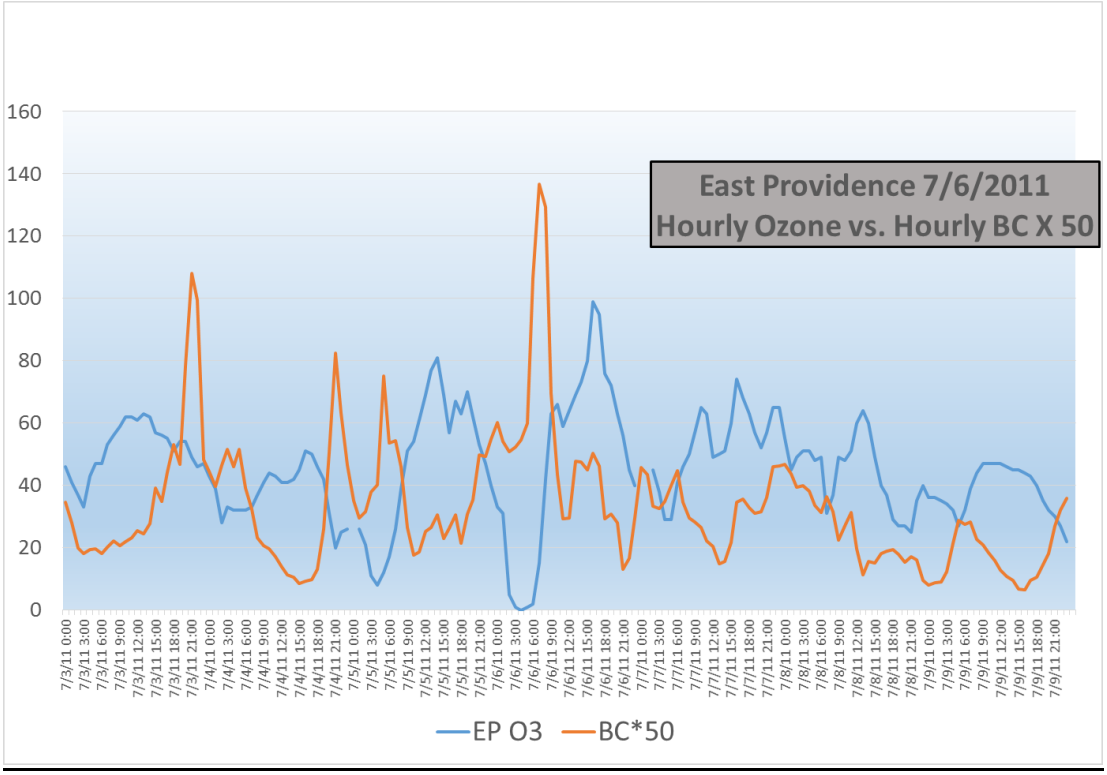


Figure 22

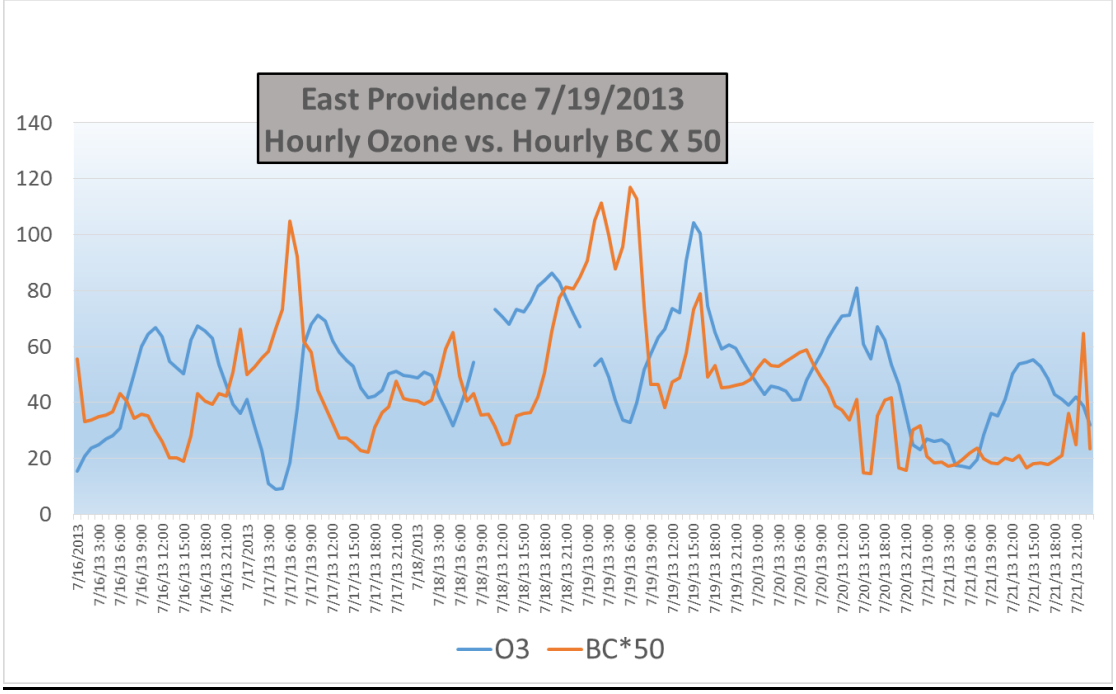


Figure 22 and Figure 23 (above) – Hourly plots of ozone versus hourly black carbon. Highest hourly ozone readings do not coincide with highest black carbon readings.

XV. Event Caused by Human Activity/Not Likely to Recur

Clean Air Act Section 319(b)(1)(A)(iii) defines an exceptional event as "an event caused by human activity that is unlikely to recur at a particular location or a natural event". The current exceptional events rule at 40 CFR Section 50.14(c)(3)(iv)(A) requires that evidence be provided in an exceptional event demonstration that this definition has been met.

There has been no official cause determined for the Fort McMurray fire. However, several Canadian officials have strongly suggested that at the time, there was no ongoing weather pattern that would be able to produce lightning, which according to the Canadian National Fire Database accounts for 47% of fires, with human activity the number one cause. In these instances with a lack of lightning, it is inferred that the cause if human activity, especially in spring, which results in more outdoor human activity.

Below are excerpts of press releases from Canadian news organizations regarding the event with links to the article online.

"*Mike Flannigan, a professor of wildland fires at the University of Alberta, says the fire's proximity to the city, as well as data that shows there were no lightning strikes in the area, lead him to believe the cause of the fire was likely human.*"

Flannigan said weather conditions in Western Canada have been perfect for wildfires as the warm, dry winter has led to an abundance of dead, dry leaves and wood ready to light up. "It's really extreme conditions," he said, adding that the low humidity and lack of green vegetation combined with windy conditions contributed to the incredibly intense fire in the northern Alberta city.

http://globalnews.ca/news/2684741/fort-mcmurray-wildfire-likely-caused-by-humans/

From Alberta Senior Wildfire Manager, Chad Morrison….

While the investigation continues into the inferno known informally as 'The Beast,' Chad Morrison told the Globe and Mail on Saturday that the fire was probably the result of human action–a broad category that includes everything from careless ATV drivers to issues with power lines. "Human-caused really means anything other than lightning. It's most likely human caused, but we're continuing to investigate," Mr. Morrison said.

He continues……

"It wasn't natural," said Mr. Spring of the fire that ignited on May 1. "There was no probability of a fire starting naturally that day. There was no lightning in the forecast, nothing that we look for."

http://www.theglobeandmail.com/news/national/fort-mcmurray-wildfire-most-likely-human-caused-alberta-senior-wildfire-manager-says/article30279836/

The Royal Canadian Mounted Police (RCMP) have been investigating the cause of the fire, which may never be officially determined.

Cpl. Hal Turnbull said this area is popular with hikers and ATV riders.

"It's not an area that's remote and isolated, it's an area that's frequently accessed by the individuals who reside in and around the Fort McMurray area," Turnbull said. Because of the unique scope and magnitude of the fire, Turnbull said, it's only natural that police would investigate the cause.

http://www.cbc.ca/news/canada/edmonton/fort-mcmurray-wildfire-cause-investigation-rcmp-1.3635241

In a news release, the RCMP said that investigators ruled out lightning as the "probable cause" of the wildfire, which began in early May and prompted a massive evacuation in several Fort McMurray communities. Officials have dubbed the wildfire MWF-009.

As a result, the RCMP is asking for the public's help in the investigation into the cause of the wildfire, which an airborne forestry crew first spotted 15 kilometres southwest of Fort McMurray on May 1.

http://www.ctvnews.ca/canada/fort-mcmurray-wildfire-likely-result-of-human-activity-rcmp-1.2946737

Cpl. Hal Turnbull with the Alberta RCMP K Division said as they rule out natural causes such as lightning, they're left with human activity-related causes.

http://www.metronews.ca/news/calgary/2016/06/14/rcmp-want-publics-help-in-fort-mcmurray-fire-investigation.html

The Exceptional Events Rule (40 CFR 50.1(n)) defines a wildfire as "…any fire started by an unplanned ignition caused by lightning; volcanoes; other acts of nature; unauthorized activity; or accidental, human-caused actions, or a prescribed fire that has developed into a wildfire. A wildfire that predominantly occurs on wildland is a natural event." The 2016 Exceptional Events Rule revisions also codified the following definition of wildland: "Wildland means an area in which human activity and development are essentially non-existent, except for roads, railroads, power lines, and similar transportation facilities. Structures, if any, are widely scattered" (40 CFR 50.1(o)).

Based on the evidence above, the Fort McMurray event qualifies as a wildfire because unplanned human activity or arson is assumed to have caused the unplanned event. EPA generally considers the emissions of smoke and ozone precursors from wildfires on wildland to meet the regulatory definition of a natural event at 40 CFR 50.1(k). This wildfire event occurred predominantly on wildland as noted. Rhode Island DEM has shown that the Fort McMurray wildfire is a natural event and may be considered for treatment as an exceptional event.

XVI. Not Reasonably Controllable or Preventable

Clean Air Act Section 319(b)(1)(A)(ii) requires that an exceptional event be "not reasonably controllable or preventable". The current exceptional events rule at 40 CFR Section 50.14(c)(3)(iv)(A) also requires that evidence be provided in an exceptional event demonstration that the event was not reasonably controllable or preventable. This criterion applies to both natural events and events caused by human activity unlikely to recur.

Below are excerpts of press releases from Canadian news organizations regarding the event with links to the article online.

Few on the front lines had ever seen anything like it. "It's an unprecedented fire with respect to the rate it spread, how it involved the community," said regional fire chief Darby Allen earlier this week, after cooler temperatures and higher humidity allowed crews to get a handle on the fire.

"The way this thing happened, the way it travelled, the way it behaved – they're rewriting their formulas on how fires behave, based on this fire," he said.

"No amount of tankers or resources, or no size of firebreak, could have prevented it from hitting the community that day," Morrison said. "Sometimes Mother Nature is going to do what it wants to do and bad things happen."

https://www.theguardian.com/world/2016/may/15/alberta-wildfire-the-beast-fort-murray-canada

On the first day of May near-record temperatures and bone dry forests created the perfect conditions for a fire to start.

A wildfire crew landed almost immediately after the fire was discovered and began to tackle the two-hectare fire, which is larger than two Canadian football fields. As the crew approached, MWF-009 was already sending sparks into the sky and leaping to the crowns of tall trees.

"When a fire starts at that time it moves to a full crown within minutes. It was in the crowns and rolling by the time the helicopters showed up," Mr. Morrison said. "When these fires occur, Mother Nature is going to do what it's going to do. It's going to challenge us."

http://www.theglobeandmail.com/news/national/fort-mcmurray-wildfire-most-likely-human-caused-alberta-senior-wildfire-manager-says/article30279836/

Based on the information from this demonstration, the Fort McMurray fire started in a wildland ("wilderness area known as the Horse River Trail System") due likely to human activities that authorities have not been able to officially determine. RIDEM is not aware of any evidence clearly demonstrating that prevention or control efforts beyond those actually made would have been reasonable. Therefore, emissions from this wildfire were not reasonably controllable or preventable.

XVII. Conclusion

The Fort McMurray wildfire that began on May 1, 2016 generated high levels of ozone precursors and ozone concentrations that resulted in exceptional ozone readings at all three of the ozone monitors in Rhode Island. This demonstration has used the following evidence to demonstrate this exceptional event:

- Ambient air quality monitoring data
- Analysis of wildfire smoke emissions
- Analysis of meteorological conditions of the event
- Analysis of historical high ozone events as part of a conceptual model
- Analysis of historical matching days with that of the event
- HYSPLIT trajectory analysis
- Satellite data
- Camnet Visibility cameras and observations

- HMS daily smoke analysis
- Pollution roses
- Air quality model performance during the event
- Local evidence at Rhode Island monitors

Throughout most of May 2016, this intense and historic fire event resulted in a significant smoke plume, which traversed thousands of miles. The plume eventually was transported east and southeast, resulting in some of the highest ozone readings of the past six years for Rhode Island, along with other New England and Mid-Atlantic States.

This demonstration revealed that weather conditions were not favorable for ozone formation as the event unfolded on May 25, lasting into May 26, 2016. The smoke plume had significant effect on ozone readings for those days.

XVIII. Public Comment

Exceptional Events Rule (40 CFR 50.14(c)(1)(i)) determines that air agencies must "notify the public promptly whenever an event occurs or is reasonably anticipated to occur which may result in the exceedance of an applicable air quality standard." Additionally, according to 40 CFR 50.14(c)(3)(v), air agencies must "document [in their exceptional events demonstration] that the [air agency] followed the public comment process and that the comment period was open for a minimum of 30 days…." Further, air agencies must submit any received public comments to the EPA and address in their submission those comments disputing or contradicting the factual evidence in the demonstration.

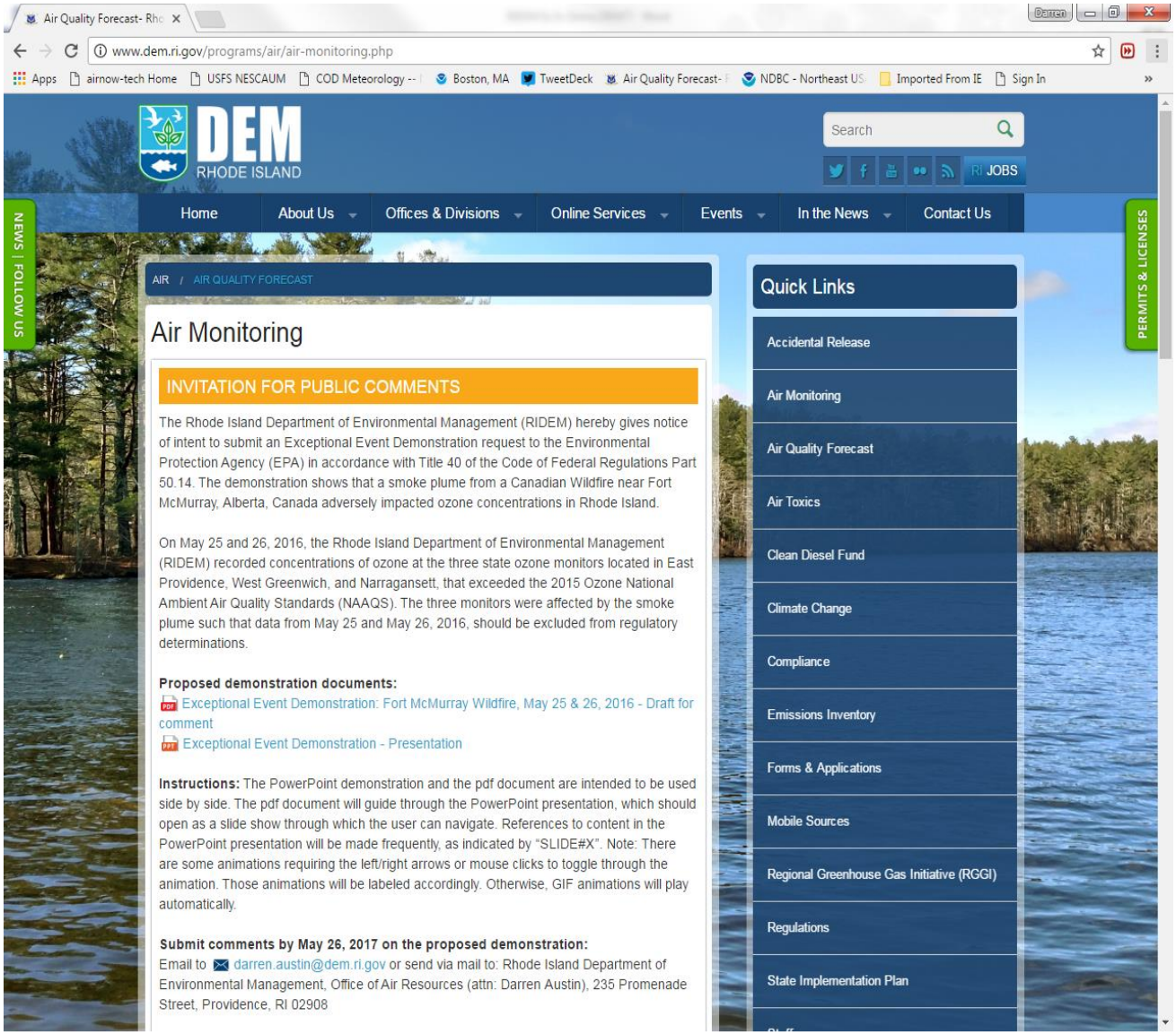
RIDEM posts a daily air quality forecast available on the following websites.

http://www.dem.ri.gov/programs/air/air-quality-forecast.php
http://airnow.gov/

Additionally, on days of forecasted exceedances, RIDEM issues a formal press release sent via an email list to stakeholders, notifies all local media outlets, the National Weather Service, and posts to social media. In accordance with 40 CFR §50.14 (c)(1)(i), RIDEM issued an Air Quality Alert for May 26, 2016, as ozone concentrations had unexpectedly climbed much higher than forecasted on May 25, 2016, and the event was unfolding with ozone concentrations being under-predicted. Please refer to the press release email (sent to all stakeholders) and press release at the end of this document of the air quality alert. Also refer to the Enviroflash email alert for the event on May 26, sent to subscribers of www.AirNow.gov Enviroflash notification email list. Note an Air Quality Alert was also issued for May 27, but concentrations were not as high as forecasted as the smoke influenced diminished.

RIDEM posted this exceptional events demonstration and notice of public comment on April 24th, 2017, which was available on RIDEM Air Resource's website at the following URL, with links to the presentations. The posting was available for comment for a minimum of 30 days, with RIDEM accepting comments through May 26, 2017.

http://www.dem.ri.gov/programs/air/air-monitoring.php



RIDEM Website Posting for the Public Comment Period April 24, 2017 through May 26, 2017.

RIDEM made notice of public comment period via our email listserv sent on April 24, 2017, which reaches nearly 300 stake holders, including members of the regulated community, environmental organizations, consultants, state agencies, and other state air agencies.

Austin, Darren (DEM)

From:	Gold, Ruth (DEM)
Sent:	Thursday, June 15, 2017 2:11 PM
To:	Austin, Darren (DEM)
Subject:	FW: [Airresources] FW: Website Posting
Attachments:	ATT00001.txt

From: airresources-bounces@listserve.ri.gov [mailto:airresources-bounces@listserve.ri.gov] **On Behalf Of** Grandchamp, Laurie (DEM)
Sent: Monday, April 24, 2017 3:30 PM
To: airresources@listserve.ri.gov
Cc: Grandchamp, Laurie (DEM) <laurie.grandchamp@dem.ri.gov>
Subject: [Airresources] FW: Website Posting

RHODE ISLAND
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
OFFICE OF AIR RESOURCES

Notice of Intent to Submit an Exceptional Event Demonstration to EPA and Opportunity for Public Comment

The Rhode Island Department of Environmental Management (RIDEM) hereby gives notice of intent to submit an Exceptional Event Demonstration request to the Environmental Protection Agency (EPA) in accordance with Title 40 of the Code of Federal Regulations Part 50.14. The demonstration shows that a smoke plume from a Canadian Wildfire near Fort McMurray, Alberta, Canada adversely impacted ozone concentrations in Rhode Island.

On May 25th and 26th, 2016, the Rhode Island Department of Environmental Management (RIDEM) recorded concentrations of ozone at the three state ozone monitors located in East Providence, West Greenwich, and Narragansett, that exceeded the 2015 Ozone National Ambient Air Quality Standards (NAAQS). The three monitors were affected by the smoke plume such that data from May 25th and May 26th, 2016 should be excluded from regulatory determinations.

RIDEM is making the draft demonstration available for public comment, as required by 40 CFR 50.14(c)(3):

http://www.dem.ri.gov/programs/air/air-monitoring.php

Any comments on the proposed demonstration should be submitted via electronic mail to darren.austin@dem.ri.gov or via mail to:

Rhode Island Department of Environmental Management
Office of Air Resources (attn: Darren Austin)
235 Promenade Street
Providence, RI 02908

Note: Public Comment Period Ends May 26, 2017.

1

Copy of Listserv email

Below is a copy of a cover letter sent to EPA Region I along with the RIDEM submittal on May 30, 2017.

RHODE ISLAND
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

OFFICE OF AIR RESOURCES
235 Promenade Street, Room 230
Providence, Rhode Island 02908

VIA ELECTRONIC MAIL

May 30, 2017

Arthur Johnson, Acting Director
Office of Ecosystem Protection
5 Post Office Square – Suite 100
Boston, MA 02109-3912
johnson.arthur@epa.gov

RE: Rhode Island Exceptional Event Demonstration for May 25-26, 2016

Dear Mr. Johnson,

Attached, please find for your approval, the Rhode Island Exceptional Event Demonstration for May 25-26, 2016 (Demonstration). The Rhode Island Department of Environmental Management Office of Air Resources (RIDEM) drafted this Demonstration to fulfill requirements set forth in the Exceptional Events Rule at 40 CFR 50.14.

RIDEM worked with your staff in developing the Demonstration and also sought out public comment. The Department posted the draft Demonstration on its website for over a 30-day public comment period from April 24 to May 26, 2017. RIDEM also reached out via an email listserv to over 300 stake holders including members of the regulated community, environmental organizations, consultants, state agencies, and other state air agencies, all of whom have interest in Rhode Island's air quality issues.

The only comments RIDEM received were from a letter dated May 19, 2017 from David Conroy, Chief, Air Programs Branch of EPA Region 1. Within the letter were 3 comments recommended to strengthen the discussion. RIDEM will be addressing these items within a final submittal to EPA prior to June 30, 2017, at which point RIDEM will be fulfilling the public comment requirement of the Demonstration according to the provisions in 40 CFR 50.14.

I look forward to receiving your approval on this demonstration for the state of Rhode Island. If you have any questions concerning this demonstration, please contact me at 401-222-2808 extension 7430.

Sincerely,

Darren J Austin
Senior Air Quality Specialist
RIDEM Air Resources

CC: Robert Judge, EPA R1
David Conroy, EPA RI

Enc: Rhode Island Exceptional Event Demonstrations for May 25 and May 26, 2016

The only public comments received on the Exceptional Event Demonstration was in a letter (below) from David B. Conroy, received on May 24, 2017. The comments have been addressed in the body of the demonstration in the appropriate section listed below.

Comment 1 – refer to Section XIII., page 36
Comment 2 – refer to Section VIII, page 25
Comment 3 – refer to the conclusions at the end of each section and demonstration

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Region 1
5 Post Office Square
Boston, MA 02109-3912

RECEIVED
MAY 24 2017
RIDEM
Office of Air Resources

May 19, 2017

Darren Austin
Office of Air Resources
Department of Environmental Management
235 Promenade Street, Room 230
Providence, RI 02908

Dear Mr. Austin:

The Rhode Island Department of Environmental Management (RI DEM) is proposing a demonstration under the exceptional events rule at 40 CFR 50.14 to show that the elevated ozone concentrations recorded at the East Providence, West Greenwich, and Narragansett monitoring locations on May 25 and 26, 2016 were the result of high levels of ozone and ozone precursors being transported from the Fort McMurray wildfire to Rhode Island. The public comment period for the demonstration ends on May 26, 2017.

EPA Region 1 has reviewed RI DEM's demonstration that is currently available for public comment and is providing recommendations to strengthen the discussion. You will find our comments in the enclosure. Please note that if the EPA determines additional information is necessary during the review of your submittal, we may request further evidence to support elements of the demonstration in accordance with 40 CFR §50.14(c)(3)(vi).

If you have any questions regarding this matter, please contact Eric Wortman at (617) 918-1624, or Catie Taylor at (617) 918-8607.

Sincerely,

David B. Conroy, Chief
Air Programs Branch

Enclosure

cc: Laurie Grandchamp, RI DEM
Gina Friedman, RI DEM

Enclosure

EPA Comments on Rhode Island's Exceptional Events Demonstration for the Ft. McMurray Wildfire Event in May 2016

The RI DEM provided the public with an opportunity to comment on its exceptional events demonstration on April 25, 2017 for air quality impacts from the 2016 Fort McMurray wildfire. The demonstration requests the exclusion of 8-hr ozone monitoring data on May 25 and 26, 2016 for the East Providence, West Greenwich, and Narragansett monitoring locations. The comments below are based on EPA's review of the publicly available demonstration.

1. Because delta C data can be used to indicate wood smoke at ground level, RI DEM should include an assessment of the delta C data for the East Providence site. The East Providence site is the only monitoring location, of the three sites included in the demonstration, that has a dual channel aethalometer. Therefore, we recommend RI DEM discuss this data in the demonstration.

2. The EPA suggests that RI DEM include an analyze of NOx emissions from upwind power plants in its exceptional events demonstration. We believe this information would help illustrate to the public that May 25 and 26 were not peak electricity demand days, which are often associated with ozone exceedance days in southern New England. RI DEM could include the analysis presented in Section 2.3 of CT DEEP's "*May 2016 Ozone Exceptional Event Analysis Technical Support Document*" as an appendix to its demonstration.

3. We recommend that Sections III, VIII, and the end of the document include a conclusion/summary of the information presented and how it supports the demonstration. The EPA provides suggestions of summaries and conclusion statements in the wildfire guidance and other exceptional event narrative examples on our website at: https://www.epa.gov/air-quality-analysis/treatment-air-quality-data-influenced-exceptional-events.

Attachment I

RHODE ISLAND
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

OFFICE OF AIR RESOURCES
235 Promenade Street, Room 230
Providence, Rhode Island 02908

9 January 2017

Mr. David Conroy
United States Environmental Protection Agency Region I
EPA New England
5 Post Office Square, Suite 100
Boston, MA 02109-3912

Re: Formal Initial Notification for a Potential Exceptional Event for Ozone from May 25-28, 2016

Dear Mr. Conroy:

This letter serves to notify the USEPA that the State of Rhode Island, Department of Environmental Management will be examining the aforementioned period as an exceptional event, per the Clean Air Act (CAA) section 319(b).

Preliminary data analysis indicates that significant fires in Fort McMurray, Canada and possibly elsewhere in the eastern United States may have significantly influenced an ozone episode from May 25th to May 28th.

In accordance with 40 CFR 50.14(c)(2) of the "Exceptional Events Rule", all ozone data for that period has been flagged in EPA's Air Quality System with an IF "Informational" Flag.

Feel free to call or e-mail me with any questions concerning this notification.

Sincerely,

Douglas McVay
Chief
Office of Air Resources

Cc: Robert Judge, EPA R1

Telephone 401.222.4700 | www.dem.ri.gov | Rhode Island Relay 711

Attachment II

CT DEEP Fort McMurray Wildfire Emissions using a Q/d Analysis

EPA guidance[1] recommends conducting a fire emissions – transport distance ration (Q/d) analysis as a rough assessment of the ability of a wildfire to cause increased ozone concentrations. The Q/d analysis is simply a comparison of the ratio of Q, the daily tons of VOC and NOx emitted from the fire, to d, the distance in kilometers from the fire to the point of concern. If the Q/d value compares favorably to analytical data from other fires, then the fire can be presumed to have had a causal effect on ozone concentrations at the point of concern.

EPA guidance indicates that a fire should have a Q/d in excess of 100 tons per day per kilometer (tpd/km) in order to be considered to have a clear causal impact on ozone. This method is intended to be a simple and conservative approach to establishing clear causality. Failure to meet the 100 ton per day per kilometer threshold does not preclude a finding clear causality. EPA developed this value based on limited analyses of four fires which occurred in 2011.

Estimate of Q

The emissions from the fire can be estimated using information from EPA's AP-42 Compilation of Air Emission Factors Section 13.1 Wildfires and Prescribed Burning. The equations given are as follows:

Fi = Pi * L (Equation 1)
Ei = Fi * A (Equation 2)
Fi = emission factor (mass of pollutant/unit area of forest consumed)
Pi = yield for pollutant "i" (mass of pollutant/unit mass of forest fuel consumed)
= 12 kg/Mg (24 lb/ton) for total hydrocarbon (as CH4)
= 2 kg/Mg (4 lb/ton) for nitrogen oxides (NOx)
L = fuel loading consumed (mass of forest fuel/unit land area burned)
A = land area burned
Ei = total emissions of pollutant "i" (mass pollutant)
Combining equations 1 and 2, we have: Ei = Pi * L * A

Pi is given above for total hydrocarbons and for nitrogen oxides. The fuel loading is given in AP-42 for different regions of the United States and ranges from 9 to 60 tons per acre. Conservatively, we will estimate a low end emission rate using 10 tons per acre which is associated with North Central US conifer forests. Note that our results could increase by a factor of 6 were we to expect the high end of emissions.

The Alberta government reported that by June 10, 2016 the fire ultimately covered 589,995 hectares (1,457,909 acres) with a perimeter of 996 kilometers (618 miles). For reference, the total land area of Rhode Island is approximately 270,000 hectares. The chart below (Figure 1) indicates the total area covered by the fire as reported by the Alberta government[2]. During the week prior to the exceptional event in Connecticut the fire grew by approximately 60,000 hectares (148,263 acres).

[1]Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations, Final, EPA, September 2016
[2]https://www.alberta.ca/release.cfm?xID=41701E7ECBE35-AD48-5793-1642C499FF0DE4CF [Final Update 39: 2016 Wildfires (June 10 at 4:30 p.m.), Alberta Government]
Therefore, ignoring the smoldering of approximately 500,000 hectares we estimate the total hydrocarbon emissions from the week to be:

Ehc = 24 lbs of HC / ton of forest fuel consumed * 10 tons fuel / acre * 148,263 acres
Ehc = 35,583,120 pounds of HC
Ehc = 17,791 tons of HC emitted during the period from May 19 to May 24

Similarly for NOx:

Enox = 4 lbs of NOx / ton of forest fuel consumed * 10 tons fuel / acre * 148,263 acres
Enox = 5,930,520 pounds of NOx 17
Enox = 2,965 tons of NOx emitted during the period from May 19 to May 24

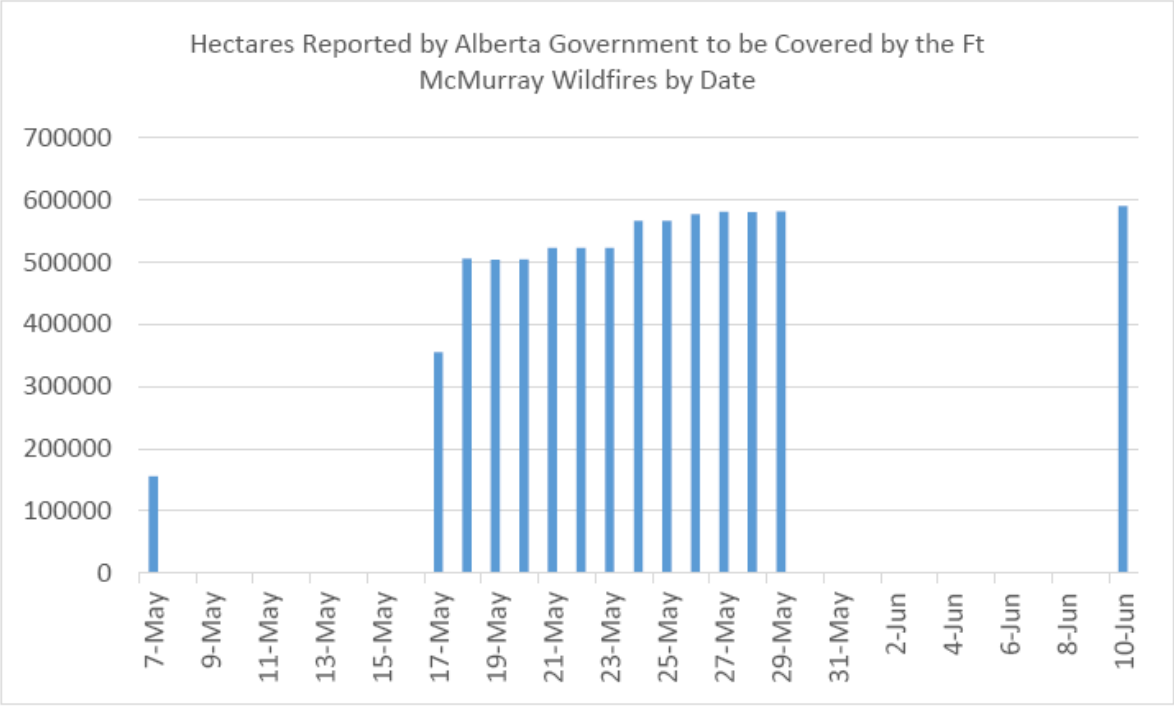


Figure 1. Chart of Hectares Burned. Reported by the Alberta Government from May 7-June 10, 2016.

Q is the total daily emission rate in tons per day of reactive hydrocarbons and nitrogen oxides. EPA recommends, in the exceptional events guidance, that only 60% of the hydrocarbons should be considered reactive. Therefore the reactive hydrocarbon emissions become rHC = 0.6 * Ehc or 0.6 * 17,991 = 10,794 tons of reactive HC emitted during the period of interest. No adjustments are suggested for the NOx emissions. Therefore the total rHC and NOx emissions over the period are 10794 + 2965, or 13,759 tons over the six days. On average this results in a daily emission rate, or Q, of 2293 tons per day.

Estimate of d

Based on the large distance, we will not present individual analyses for each monitor in Connecticut but estimate the distance from the Fort McMurray fire to the most distant point in Connecticut. We will therefore use a value of d of 3286 kilometers, the flight distance from Fort McMurray to Stonington, CT.

Q/d Estimate

Using the values determined above, Q/d then becomes 2293 tpd divided by 3286 km or 0.69 tpd/km. This value is well below the EPA recommended level of 100 tpd/km indicating clear causality.

Taking a less conservative approach and using the maximum extent of the burn area over the life of the fire, the result would be a Q/d of 40.8 tpd/km. This is still sufficiently below the EPA recommended threshold for establishing clear causality. Recalling that a worst case fuel loading would increase our results by a factor of six, Q/d would in this case result in 240 tpd/km and would indicate clear causality. While this approach might be justified by the ongoing smoldering of the peat, the intensity of the Fort McMurray fire, variability in the burn rate and other factors, it is difficult to justify without further details that may only be obtained through estimates which introduce their own error.

Taking a slightly different approach we consider the basis for the EPA guidance and look at emissions from one of the four fires EPA relied on in developing their guidance. Appendix A2 of the EPA guidance indicates that EPA based their conclusions on 12 km grid CMAQ modeling of four 2011 multiday fires: Wallow, Waterhole, Big Hill and Flint Hills. Emissions from the fires were based on a program called SMARTFIRE. Using information available on the Wallow Fire, we can approximate the emissions that might be calculated for the Fort McMurray fire.

The Wallow Fire burned in eastern Arizona and western New Mexico from May 29, 2011 through July 8, 2011 and burned 841 square miles (538,240 acres) by June 26th. The maximum daily emissions from that fire were reported as approximately 15,000 tons of rVOC and 1,000 tons of NOx[3]. If we scale this fire up by a factor of three to approximate the acreage burned in the Fort McMurray fire, then we have daily emissions as high as 45,000 tons for rVOC and 3,000 tons for NOx. These emissions produce a Q of 48,000 tpd and Q/d becomes 14.6 – still well below EPA expectation for causality.

15 Simulating Fire Event Impacts on Regional O3 and PM2.5 and Looking Forward Toward Evaluation, Kirk Baker, EPA October 5, 2015 and Using SOAS and related field study data for scientific and regulatory modeling, Kirk Baker, EPA, undated; both are slide presentations.

Noting the wide variability in emissions estimates from different approaches, and as the Q/d method does not generally satisfy the expectation of a clear causal impact, we present other evidence demonstrating that the plume from the Fort McMurray fire caused elevated ozone levels in Connecticut.

[3] Simulating Fire Event Impacts on Regional O3 and PM2.5 and Looking Forward Toward Evaluation, Kirk Baker, EPA October 5, 2015 and Using SOAS and related field study data for scientific and regulatory modeling, Kirk Baker, EPA, undated; both are slide presentations.

Attachment III

State of Rhode Island and Providence Plantations
State House
Providence, Rhode Island 02903-1196
401-222-2080

Gina M. Raimondo
Governor

September 27, 2016

Curt Spalding
Regional Administrator
US Environmental Protection Agency Region I
5 Post Office Square, Suite 100
Mail Code: ORA01-4
Boston, MA 02109-3912

Dear Mr. Spalding:

Pursuant to the requirements of Section 107(d)(1) of the Clean Air Act Amendments of 1990, Rhode Island is hereby submitting its recommendation for the State's attainment status designation for the 2015 revised National Ambient Air Quality Standard (NAAQS) for ozone. Section 107(d)(1) defines nonattainment areas as areas that do not meet, or that contribute to ambient air quality in a nearby area that does not meet, the NAAQS for a pollutant.

A site is in violation of the eight-hour NAAQS if the monitored design value for that site is greater than 70 parts per billion (ppb). The design value is calculated by averaging the fourth highest maximum daily eight-hour ozone concentration measured at a site each year in three consecutive years. The eight-hour ozone design values for the three Rhode Island ozone monitoring sites for the most recent three-year period with certified data, 2013 – 2015, are included in the table below.

Site	County	Design Value (ppb)
W. Greenwich	Kent	70
Narragansett	Washington	73
E. Providence	Providence	70

The design value for the Narragansett monitoring site exceeds 70 ppb. On the basis of the most recent certified data (2013 – 2015), our designation recommendation should be nonattainment. However, we ask that the EPA consider 2014 – 2016 data when making the designation decision. The 2014 – 2016

data set is preliminary and not yet certified, however it will be certified by the time EPA is required to make its designation for the 2015 ozone NAAQS. The eight-hour ozone design values for the three Rhode Island ozone monitoring sites for the 2014 – 2016 three-year period were calculated as follows:

Site	County	Design Value (ppb)
W. Greenwich	Kent	70
Narragansett	Washington	70
E. Providence	Providence	68

No monitoring site in Rhode Island would exceed the 70 ppb standard based on this data set. Therefore, we ask that you consider a designation recommendation of attainment per the 2014 – 2016 data set.

The EPA's guidance for designating areas for the 2015 revised ozone NAAQS[1] states that the EPA intends to consider information relevant to designations associated with counties in the Combined Statistical Area (CSA) or the Core Based Statistical Area (CBSA) associated with the violating monitor for determining the boundaries of a nonattainment area. The Rhode Island monitors are located in the Providence–Warwick, RI-MA CBSA, which includes all five of the Rhode Island counties as well as Bristol County in Massachusetts.

For ease of administration, I am recommending that, as with previous ozone NAAQS, the Rhode Island 2015 ozone nonattainment (or attainment) area be defined by the boundaries of the State of Rhode Island, rather than the boundaries of the CBSA.

Rhode Island is keenly aware that the State's ozone levels are strongly influenced by upwind states' emissions. Therefore, for Rhode Island's ozone air quality to continue to improve, it is essential for the EPA to fully address significant contribution responsibilities of upwind states under section 110(a)(2)(D) of the Clean Air Act.

If you have any questions about this issue, I encourage you to contact Douglas McVay or Laurie Grandchamp at the Rhode Island Department of Environmental Management's Office of Air Resources at (401) 222-4700.

Sincerely,

Gina M. Raimondo
Governor

1 Memo from Janet G. McCabe, Acting Assistant Administrator, US EPA, to Regional Administrators, "Area Designations for the 2015 Ozone National Ambient Air Quality Standards," February 25, 2016.

Attachment IV

Power facilities, or electric generating units (EGUs), have traditionally played a major role during ozone events on the East Coast. EGUs are capable of producing a large amount of emissions over a short duration and generally emit at elevations conducive to transport. Therefore, during hot days many of the less frequently used high emitting EGUs come online to supply the high electric demand of air conditioning and refrigeration along with base load units operating at full capacity.

Recognizing the ability of these sources to affect cross state air pollution, EPA monitors the real-time emissions from these facilities and regulates them as under the Cross-State Air Pollution Rule (CSAPR). The following figures show the actual total daily NOx emissions from these CSAPR sources for our closest upwind States -- New York, New Jersey and Pennsylvania – for the 2016 ozone season. Plotted on the right hand axis, as yellow bars, are the number of Connecticut monitors that exceeded the 70 ppb NAAQS each day. Clearly, the May 25-26th ozone event had the most monitored daily exceedances of the summer, while peak NOx emissions from these facilities did not occur until later in the season.
Therefore, the exceedances of May 25 -26th cannot be attributed to EGUs operating on high electric demand days as is more typically the case later in the ozone season.

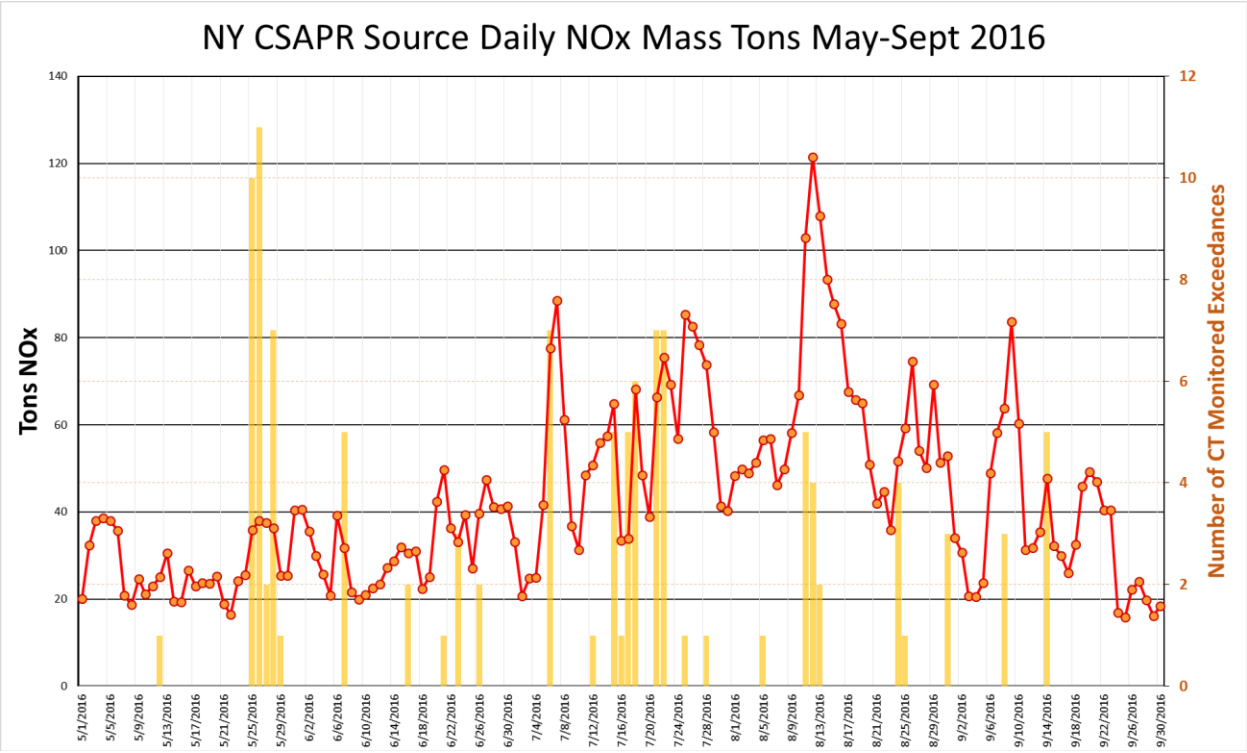


Figure 5. New York CSAPR Source 2016 Daily NOx Emissions

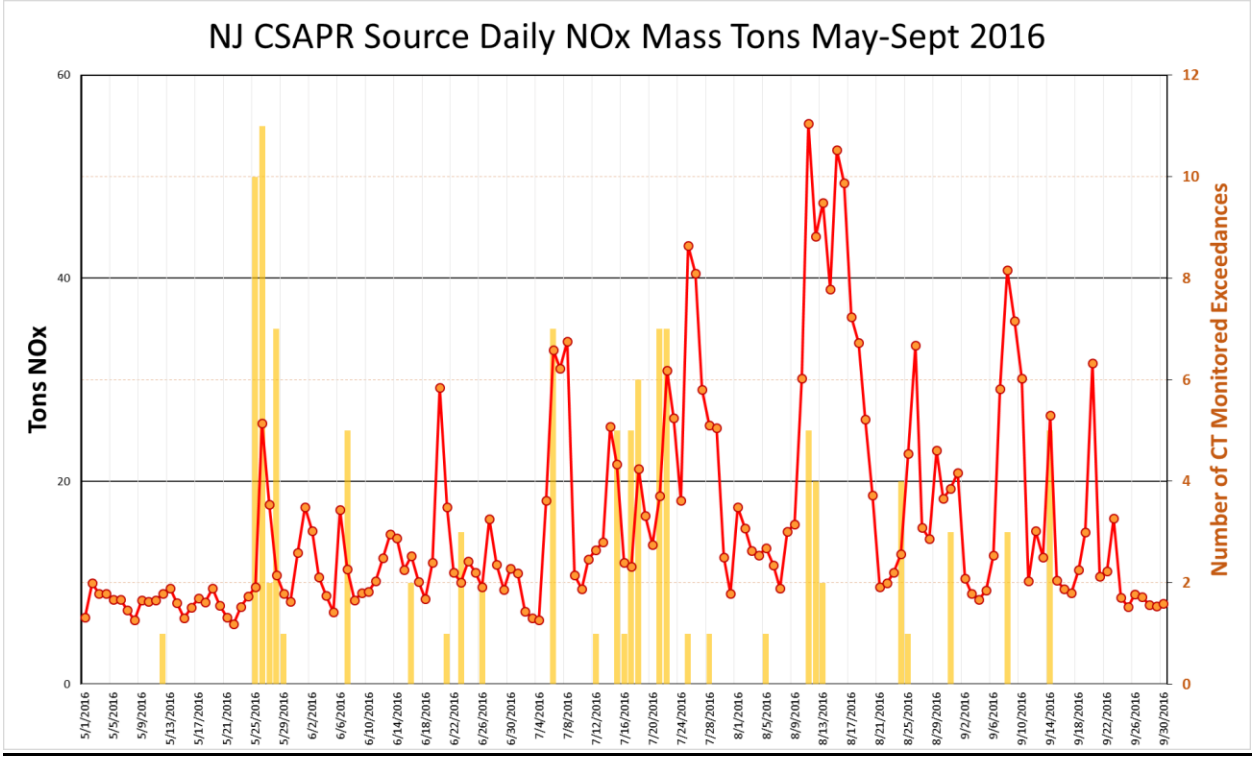


Figure 6. New Jersey CSAPR Source 2016 Daily NOx Emissions

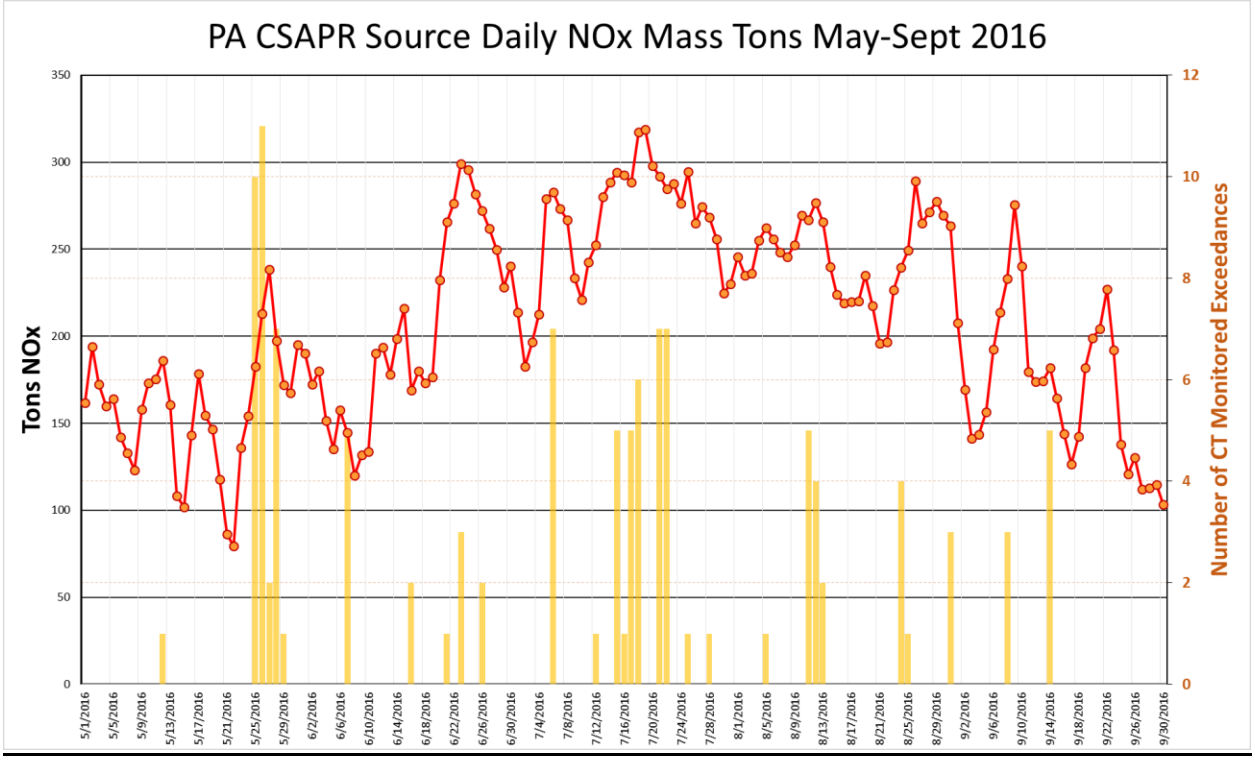


Figure 7. Pennsylvania CSAPR Source 2016 Daily NOx Emissions

Attachment V

CT DEEP Upwind Chemical Speciation Network (CSN) Sites

The U.S. EPA initiated the national PM2.5 Chemical Speciation Monitoring Network (CSN) in 2000 to support evaluation of long-term trends and to better quantify source impacts of particulate matter (PM) in the size range below 2.5 µm aerodynamic diameter (PM2.5; fine particles). EPA also administers the long standing Interagency Monitoring of Protected Visual Environments (IMPROVE) visibility monitoring network in rural Class 1 Areas across the country. Both networks measure the major chemical components of PM2.5 using historically accepted filter-based methods.

Target Species:

- PM2.5 Mass by gravimetry,
- 33 trace elements (such as Al and Pb by X-ray fluorescence),
- Anions (nitrate and sulfate by ion chromatography),
- Cations (ammonium, sodium, and potassium by ion chromatography), and
- Organic Carbon (OC) and Elemental Carbon (EC) by thermal optical methods

Organic Carbon (OC) and Potassium (K) species are most closely associated with wildfire emissions, so we have selected the sites in Figure 23 below to plot this data against the monitored 8-hour ozone maximums for these days. Samples are only available at three or six day intervals at these sites.

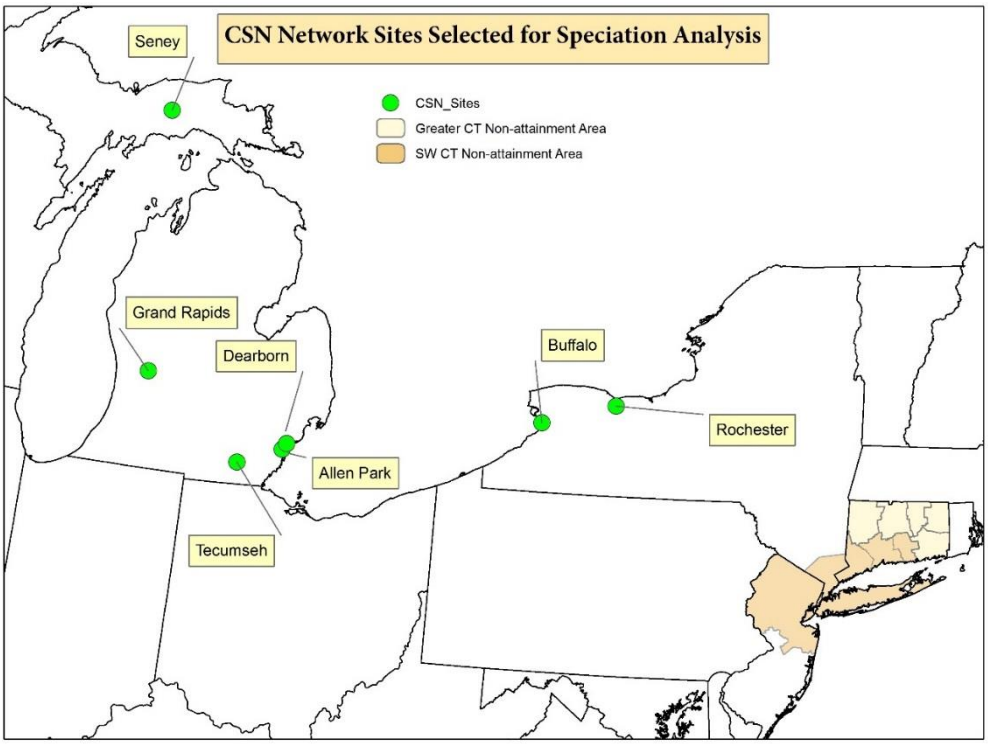


Figure 19. CSN Sites Selected for Speciation Analysis

The following figures (24-30) generally show that K and/or K+ and OC exhibited upward trends, coinciding with elevated ozone levels. This is particularly evident on May 24th, 2016. This concurs with the presence of a wildfire smoke plume over the area on that day. Seney, Michigan, an IMPROVE wilderness background site, and Grand Rapids, show distinct double peaks, which is no doubt due to the meandering nature of the smoke plume over several weeks.

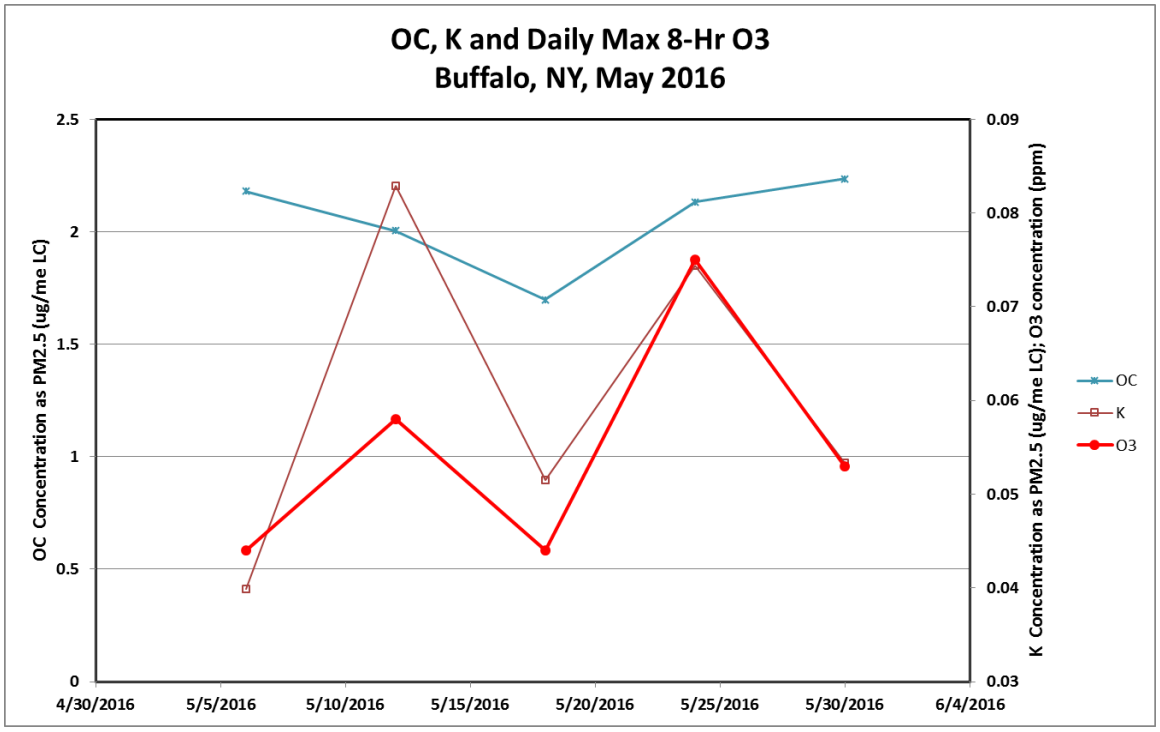


Figure 20. Buffalo New York CSN Data

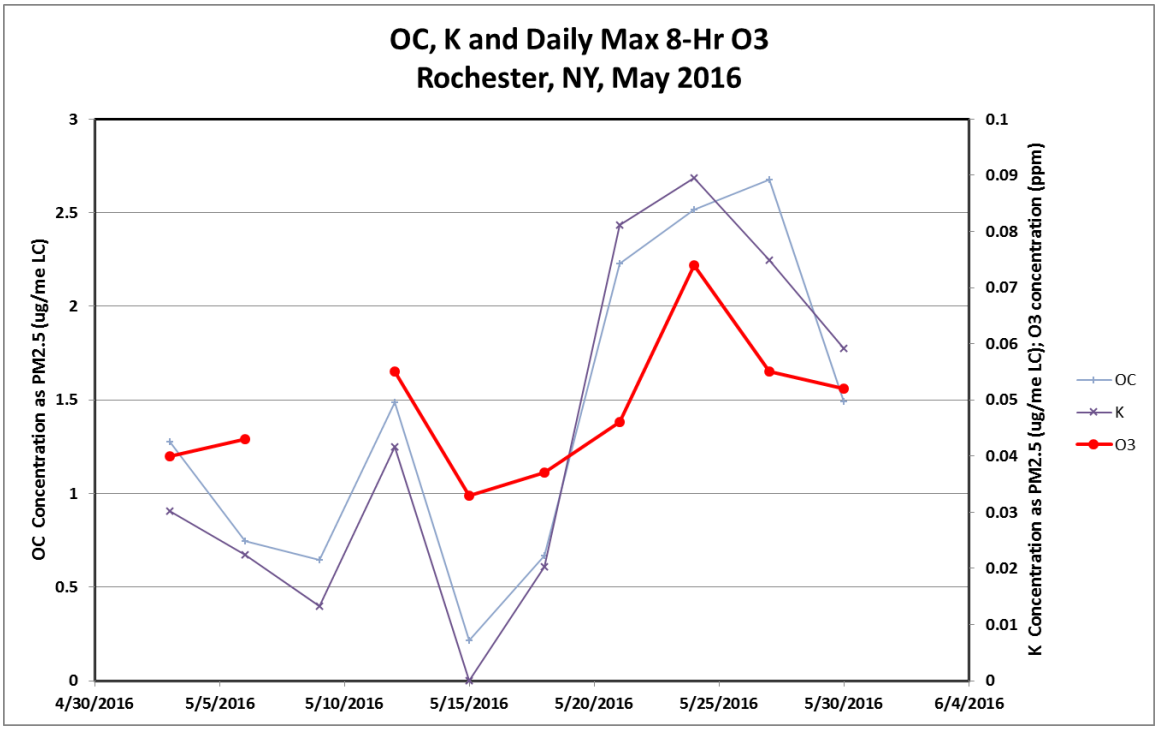


Figure 21. Rochester New York CSN Data

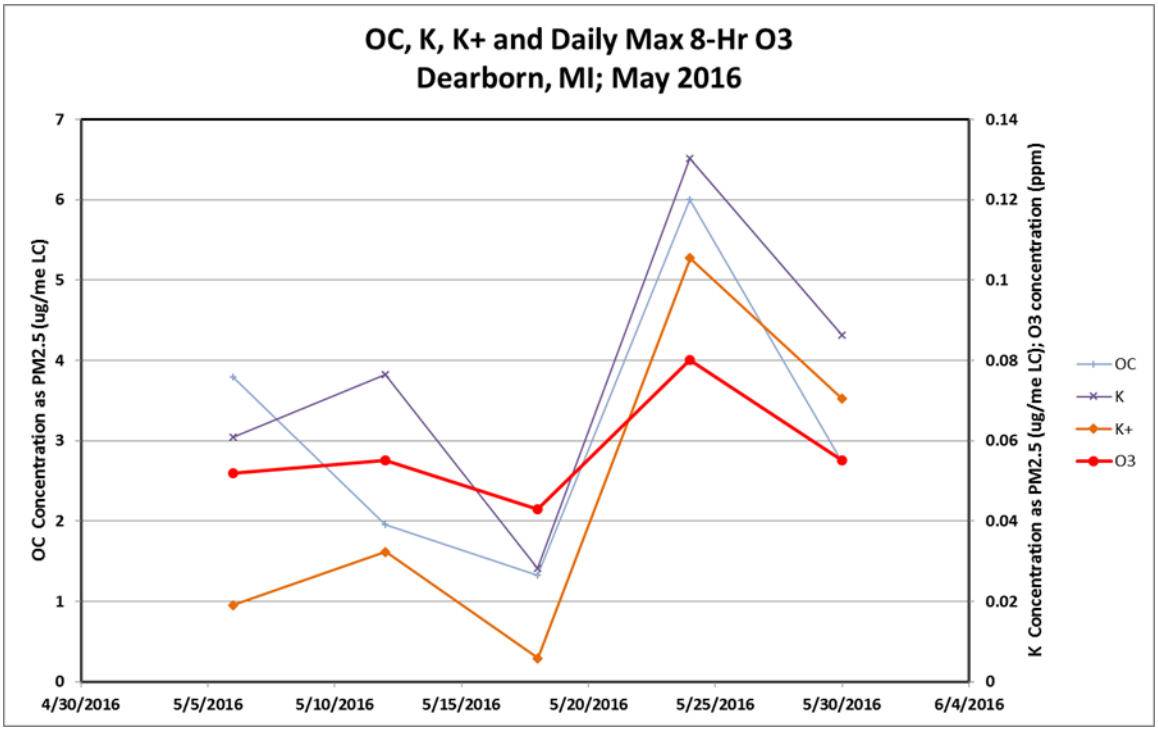


Figure 22. Dearborn Michigan CSN Data

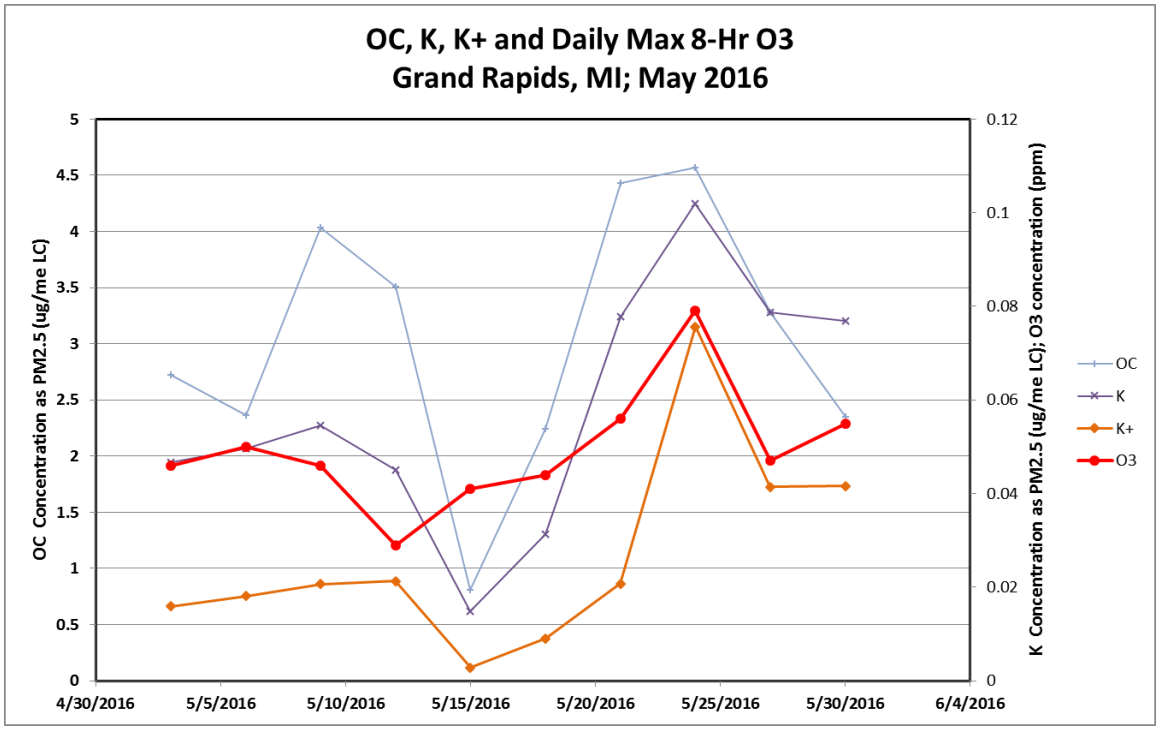


Figure 23. Grand Rapids Michigan CSN Data

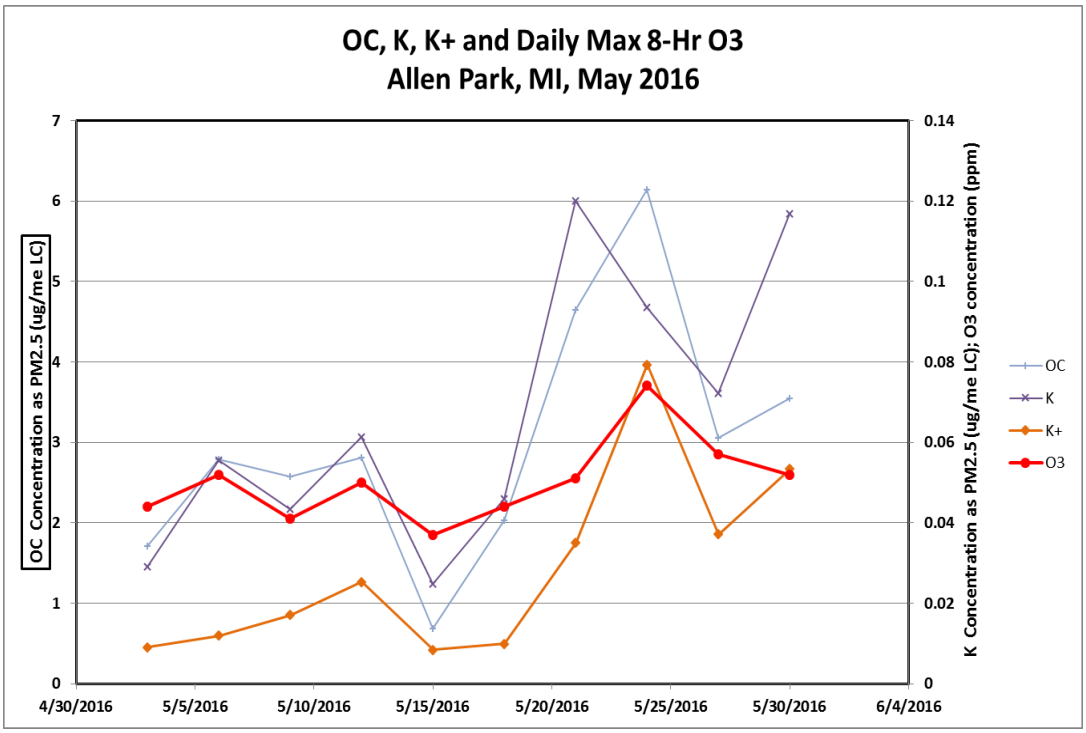


Figure 24. Allen Park Michigan CSN Data

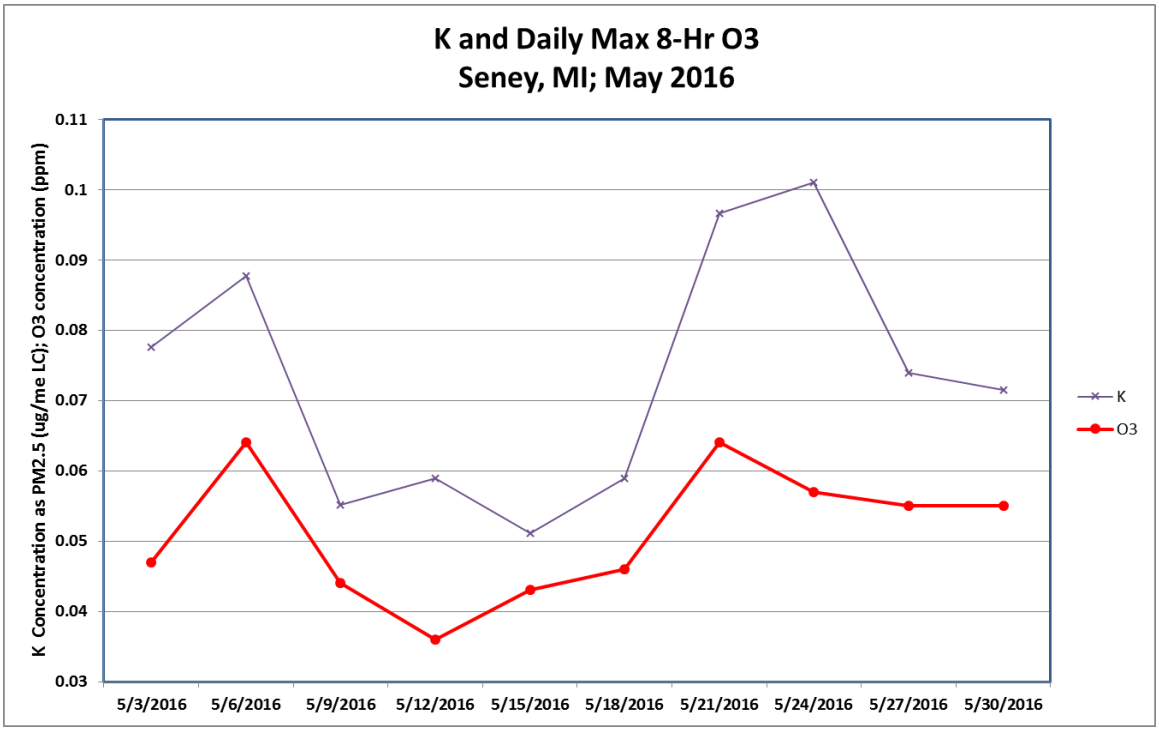


Figure 23. Seney Michigan IMPROVE Data

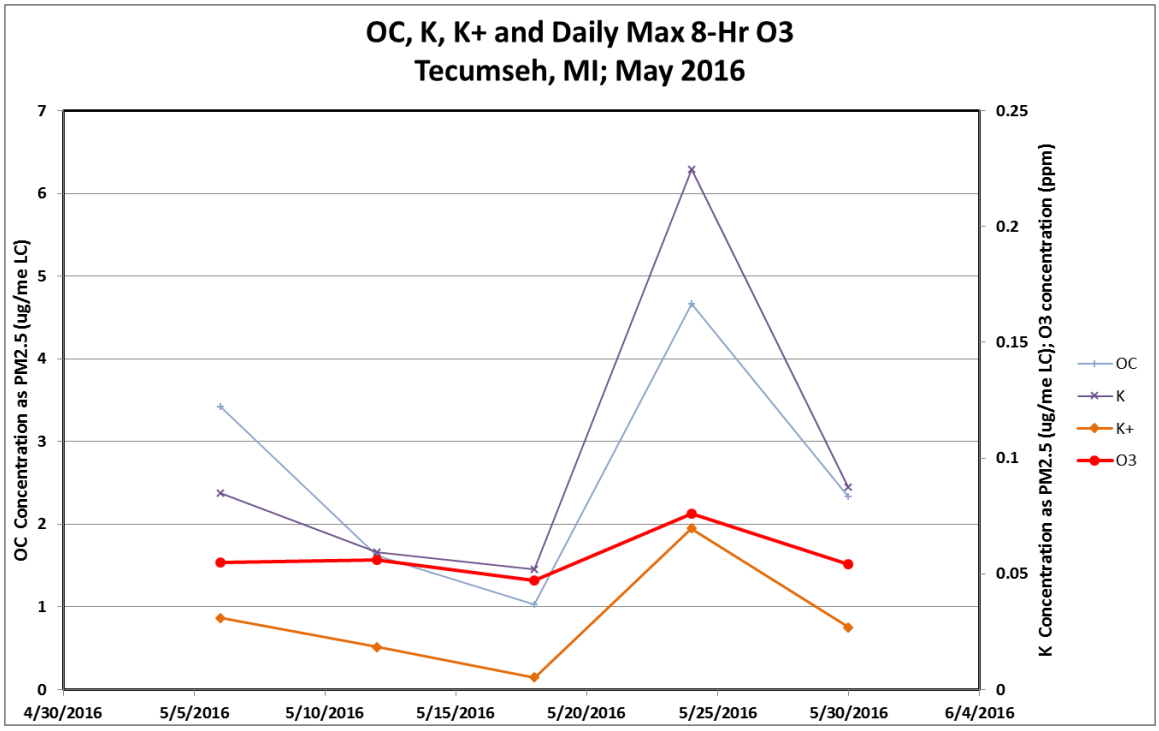


Figure 24. Tecumseh Michigan CSN Data