

## **Michigan**

### **Detroit, Muskegon County, Allegan County, and Berrien County Nonattainment Areas**

#### **Final Area Designations for the 2015 Ozone National Ambient Air Quality Standards Technical Support Document (TSD)**

##### **1.0 Summary**

This technical support document (TSD) describes the EPA's intent to designate four areas in Michigan – part of Allegan County, Berrien County, part of Muskegon County and the Detroit area - as nonattainment for the 2015 ozone National Ambient Air Quality Standards (NAAQS).

On October 1, 2015, the EPA promulgated revised primary and secondary ozone NAAQS (80 FR 65292; October 26, 2015). The EPA strengthened both standards to a level of 0.070 parts per million (ppm). In accordance with Section 107(d) of the Clean Air Act (CAA), whenever the EPA establishes a new or revised NAAQS, the EPA must promulgate designations for all areas of the country for that NAAQS.

Under section 107(d), states were required to submit area designation recommendations to the EPA for the 2015 ozone NAAQS no later than 1 year following promulgation of the standards, i.e., by October 1, 2016. Tribes were also invited to submit area designation recommendations. On October 13, 2016, Michigan recommended counties to be designated as nonattainment for the 2015 ozone NAAQS based on air quality data from 2013-2015. These recommendations were revised on February 22, 2018. These counties (and partial counties) are identified in Table 1.

After considering these recommendations and based on the EPA's technical analysis as described in this TSD, the EPA is not modifying the state's recommendation to designate the areas listed in Table 1 as nonattainment for the 2015 ozone NAAQS. The EPA must designate an area nonattainment if it has an air quality monitor that is violating the standard or if it has sources of emissions that are contributing to a violation of the NAAQS in a nearby area. Detailed descriptions of the nonattainment boundaries for these areas are found in the supporting technical analysis for each area in Section 3.

**Table 1. Michigan’s Recommended Nonattainment Areas and the EPA’s Designated Nonattainment Areas for the 2015 Ozone NAAQS**

Area	Michigan’s Recommended Nonattainment Counties	EPA’s Designated Nonattainment Counties
Detroit, MI	Livingston, Macomb, Monroe, Oakland, St. Clair, Washtenaw and Wayne Counties	Livingston, Macomb, Monroe, Oakland, St. Clair, Washtenaw and Wayne Counties
Muskegon, MI	Muskegon Partial County	Muskegon Partial County
Allegan, MI	Allegan Partial County	Allegan Partial County
Berrien, MI	Berrien County	Berrien County

On November 6, 2017 (82 FR 54232; November 16, 2017), the EPA signed a final rule designating most of the areas Michigan did not recommend for designation as nonattainment as attainment/unclassifiable.<sup>1</sup> EPA explains in section 2.0 the approach it is now taking to designate the remaining areas in the State.

The EPA will designate all tribes in accordance with two guidance documents issued in December 2011 by the EPA Office of Air Quality Planning and Standards titled, “Guidance to Regions for Working with Tribes during the National Ambient Air Quality Standards (NAAQS)) Designations Process,”<sup>2</sup> and “Policy for Establishing Separate Air Quality Designations for Areas of Indian Country.”<sup>3</sup>

## **2.0 Nonattainment Area Analyses and Final Boundary Determination**

The EPA evaluated and determined the boundaries for each nonattainment area on a case-by-case basis, considering the specific facts and circumstances of the area. In accordance with the CAA section 107(d), the EPA is designating as nonattainment the areas with the monitors that are violating the 2015 ozone NAAQS and nearby areas with emissions sources (i.e., stationary, mobile, and/or area sources) that contribute to the violations. As described in the EPA’s designations guidance for the 2015 NAAQS

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<sup>1</sup> In previous ozone designations and in the designation guidance for the 2015 ozone NAAQS, the EPA used the designation category label Unclassifiable/Attainment to identify both areas that were monitoring attainment and areas that did not have monitors but for which the EPA had reason to believe were likely attainment and were not contributing to a violation in a nearby area. The EPA is now reversing the order of the label to be Attainment/Unclassifiable so that the category is more clearly distinguished from the separate Unclassifiable category.

<sup>2</sup> <https://www.epa.gov/sites/production/files/2016-02/documents/ozone-designation-tribes.pdf>

<sup>3</sup> <https://www.epa.gov/sites/production/files/2016-02/documents/indian-country-separate-area.pdf>

(hereafter referred to as the “ozone designations guidance”<sup>4</sup> after identifying each monitor indicating a violation of the ozone NAAQS in an area, the EPA analyzed those nearby areas with emissions potentially contributing to the violating area. In guidance issued in February 2016, the EPA provided that using the Core Based Statistical Area (CBSA) or Combined Statistical Area (CSA)<sup>5</sup> as a starting point for the contribution analysis is a reasonable approach to ensure that the nearby areas most likely to contribute to a violating area are evaluated. The area-specific analyses may support nonattainment boundaries that are smaller or larger than the CBSA or CSA.

On November 6, 2017, the EPA issued attainment/unclassifiable designations for approximately 85% of the United States and one unclassifiable area designation.<sup>6</sup> At that time, consistent with statements in the designations guidance regarding the scope of the area the EPA would analyze in determining nonattainment boundaries, EPA deferred designation for any counties in the larger of a CSA or CBSA where one or more counties in the CSA or CBSA was violating the standard and any counties with a violating monitor not located in a CSA or CBSA. In addition, the EPA deferred designation for any other counties adjacent to a county with a violating monitor. The EPA also deferred designation for any county that had incomplete monitoring data, any county in the larger of the CSA or CBSA where such a county was located, and any county located adjacent to a county with incomplete monitoring data.

The EPA is proceeding to complete the remaining designations consistent with the designations guidance (and EPA’s past practice) regarding the scope of the area EPA would analyze in determining nonattainment boundaries for the ozone NAAQS as outlined above. For the deferred Detroit, MI area the technical analysis for the nonattainment area includes any counties in the larger of the relevant CSA or CBSA. For the approach in Western Michigan see section 3.2, Technical Analysis for Western Michigan Areas. For counties with a violating monitor not located in a CSA or CBSA, EPA explains in the 3.0 Technical Analysis section, its decision whether to consider in the five-factor analysis for each area any other adjacent counties for which EPA previously deferred action. We are designating all counties not included in five-factor analyses for a specific nonattainment or unclassifiable area analyses, as attainment/unclassifiable. These deferred areas are identified in a separate document entitled “Designations for Deferred Counties and County Equivalents Not Addressed in the Technical Analyses.” which is available in the docket.

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<sup>4</sup> The EPA issued guidance on February 25, 2016 that identified important factors that the EPA evaluated in determining appropriate area designations and nonattainment boundaries for the 2015 ozone NAAQS. Available at <https://www.epa.gov/ozone-designations/epa-guidance-area-designations-2015-ozone-naaqs>

<sup>5</sup> Lists of CBSAs and CSAs and their geographic components are provided at [www.census.gov/population/www/metroareas/metrodef.html](http://www.census.gov/population/www/metroareas/metrodef.html). The Office of Management and Budget (OMB) adopts standards for defining statistical areas. The statistical areas are delineated based on U.S. Census Bureau data. The lists are periodically updated by the OMB. The EPA used the most recent July 2015 update (OMB Bulletin No. 15-01), which is based on application of the 2010 OMB standards to the 2010 Census, 2006-2010 American Community Survey, as well as 2013 Population Estimates Program data.

<sup>6</sup> Air Quality Designations for the 2015 Ozone National Ambient Air Quality Standards published on November 16, 2017(82 FR 54232).

## Master Legend

Ozone monitoring site with 2014-2016 design value

- No valid value
- 0 - 0.070 parts per million (ppm)
- 0.071 and above


National Emissions Inventory (NEI) 2014 v1


- Large Point Sources (VOC or NO<sub>x</sub> >= 100 gross tons)
- ★ Small Point Sources


Hysplit


Elevation (Meters)


- ~ 100
- ~ 500
- ~ 1,000


 EPA's Final Nonattainment Area Boundary


 Federal American Indian Reservations and Off Reservation Lands

 State Boundaries



 County Boundaries

 CSAs - Combined Statistical Areas



 CBSAs - Metropolitan Statistical Areas

 CBSAs - Micropolitan Statistical Areas






NAAAs-8 Hour Ozone (1997 NAAQS)

-  Maintenance (NAAQS revoked)
-  Nonattainment (NAAQS revoked)






NAAAs-8 Hour Ozone (2008 NAAQS)

-  Nonattainment
-  Maintenance






County Population (2010)

-  > 5,194,675 to 9,818,605
-  > 2,035,210 to 5,194,675
-  > 744,344 to 2,035,210
-  > 220,000 to 744,344
-  0 to 220,000

Census Tracts Population (2012)

-  0 to 2,825
-  > 2,825 to 4,481
-  > 4,481 to 6,373
-  > 6,373 to 10,145
-  > 10,145 to 39,143

Vehicle Miles Traveled - 2014

-  0 - 36,071,088
-  36,071,088.01 - 52,484,020
-  52,484,020.01 - 88,659,368
-  88,659,368.01 - 204,018,496
-  204,018,496.01 - 5,247,588,352

Figures in the remainder of this document refer to the master legend above.

### 3.0 Technical Analysis

This technical analysis identifies each area with monitors that violate the 2015 ozone NAAQS. It also provides EPA's evaluation of these areas and any nearby areas to determine whether those nearby areas

have emissions sources that potentially contribute to ambient ozone concentrations at the violating monitors in the area, based on the weight-of-evidence of the five factors recommended in the EPA's ozone designations guidance and any other relevant information. In developing this technical analysis, the EPA used the latest data and information available to the EPA (and to the states and tribes through the Ozone Designations Mapping Tool and the EPA Ozone Designations Guidance and Data web page).<sup>7</sup> In addition, the EPA considered any additional data or information provided to the EPA by states or tribes.

The five factors recommended in the EPA's guidance are:

1. Air Quality Data (including the design value calculated for each Federal Reference Method (FRM) or Federal Equivalent Method (FEM) monitor);
2. Emissions and Emissions-Related Data (including locations of sources, population, amount of emissions, and urban growth patterns);
3. Meteorology (weather/transport patterns);
4. Geography/Topography (including mountain ranges or other physical features that may influence the fate and transport of emissions and ozone concentrations); and
5. Jurisdictional Boundaries (e.g., counties, air districts, existing nonattainment areas, areas of Indian country, Metropolitan Planning Organizations (MPOs)).

Below, EPA applies the five factors separately for each of the four areas in Michigan that EPA is designating nonattainment. For the areas in western Michigan with violating ozone monitors, the EPA acknowledges that these areas are impacted by the unique air flow and meteorology of Lake Michigan and the resulting subregional transport of ozone and ozone-forming emissions from major urban areas in the Lake Michigan area (e.g., Chicago, Gary, and Milwaukee). At shoreline locations, the contribution of ozone-forming emissions from sources in Michigan is negligible. (See EPA report "Western Michigan Ozone Study," April 24, 2009), The EPA has taken these unique facts into account in determining the scope of its approach to analyzing the five factors in these areas in western Michigan.

### **3.1 Technical Analysis for the Detroit, Michigan Area**

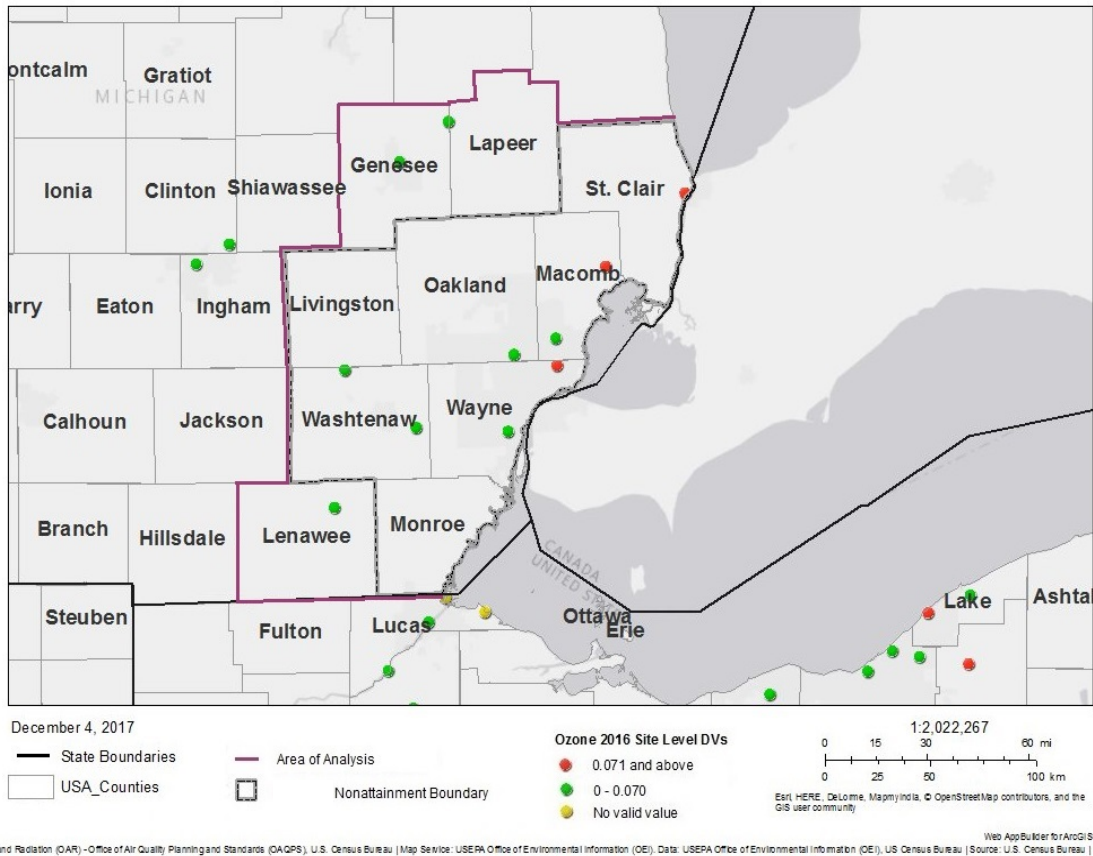
The area of analysis for the Detroit area is the Detroit-Warren-Ann Arbor CSA, which includes the following counties: Genesee, Lapeer, Lenawee, Livingston, Macomb, Monroe, Oakland, St. Clair, Washtenaw and Wayne. Figure 1 is a map of the EPA's nonattainment boundary for the Detroit Area. The map shows the location of the ambient air quality monitors, county, CSA and other jurisdictional boundaries.

For purposes of the 1997 ozone NAAQS, this area was designated nonattainment. The nonattainment area for the 1997 ozone NAAQS included the entire counties of Genesee, Lapeer, Lenawee, Livingston, Macomb, Monroe, Oakland, St. Clair, Washtenaw and Wayne. For purposes of the 2008 ozone NAAQS all of the counties in this area were designated unclassifiable/attainment.

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<sup>7</sup> The EPA's Ozone Designations Guidance and Data web page can be found at <https://www.epa.gov/ozone-designations/ozone-designations-guidance-and-data>.

**Figure 1. EPA's Nonattainment Boundaries for the Detroit Area**



The EPA must designate as nonattainment any area that violates the NAAQS and any nearby areas that contribute to the violation in the violating area. Macomb, Wayne and St. Clair counties each have a monitor in violation of the 2015 ozone NAAQS, therefore these counties are included in the nonattainment area. Based on the analysis below the EPA has preliminarily determined that Livingston, Monroe, Oakland, and Washtenaw counties contribute to the violating area. The following sections describe the five factor analysis. While the factors are presented individually, they are not independent. The five factor analysis process carefully considers the interconnections among the different factors and the dependence of each factor on one or more of the others, such as the interaction between emissions and meteorology for the area being evaluated.

## Factor Assessment

### Factor 1: Air Quality Data

The EPA considered 8-hour ozone design values in ppm for air quality monitors in the Detroit area based on data for the 2014-2016 period (i.e., the 2016 design value, or DV). This is the most recent three-year period with fully-certified air quality data. The design value is the 3-year average of the annual 4<sup>th</sup> highest

daily maximum 8-hour average ozone concentration.<sup>8</sup> The 2015 NAAQS are met when the design value is 0.070 ppm or less. Only ozone measurement data collected in accordance with the quality assurance (QA) requirements using approved (FRM/FEM) monitors are used for NAAQS compliance determinations.<sup>9</sup> The EPA uses FRM/FEM measurement data residing in the EPA’s Air Quality System (AQS) database to calculate the ozone design values. Individual violations of the 2015 ozone NAAQS that the EPA determines have been caused by an exceptional event that meets the administrative and technical criteria in the Exceptional Events Rule<sup>10</sup> are not included in these calculations. Whenever several monitors are located in a county (or designated nonattainment area), the design value for the county or area is determined by the monitor with the highest valid design value. The presence of one or more violating monitors (i.e. monitors with design values greater than 0.070 ppm) in a county or other geographic area forms the basis for designating that county or area as nonattainment. The remaining four factors are then used as the technical basis for determining the spatial extent of the designated nonattainment area surrounding the violating monitor(s) based on a consideration of what nearby areas are contributing to a violation of the NAAQS.

The EPA identified monitors where the most recent design values violate the NAAQS, and examined historical ozone air quality measurement data (including previous design values) to understand the nature of the ozone ambient air quality problem in the area. Eligible monitors for providing design value data generally include State and Local Air Monitoring Stations (SLAMS) that are operated in accordance with 40 CFR part 58, appendix A, C, D and E and operating with an FRM or FEM monitor. These requirements must be met in order to be acceptable for comparison to the 2015 ozone NAAQS for designation purposes. All data from Special Purpose Monitors (SPMs) using an FRM or FEM are eligible for comparison to the NAAQS, subject to the requirements given in the March 28, 2016 Revision to Ambient Monitoring Quality Assurance and Other Requirements Rule (81 FR 17248).

The 2014-2016 design values for counties in the area of analysis are shown in Table 2.

**Table 2. Air Quality Data (all values in ppm)<sup>a</sup>.**

County, State	State Recommended Nonattainment?	AQS Site ID	2014-2016 DV	2014 4 <sup>th</sup> highest daily max value	2015 4 <sup>th</sup> highest daily max value	2016 4 <sup>th</sup> highest daily max value
Genesee, MI	No	260490021	0.068	0.068	0.066	0.072
Genesee, MI	No	260492001	<b>0.069</b>	0.068	0.067	0.073
Lapeer, MI	No	No Monitor				
Lenawee, MI	No	260910007	<b>0.067</b>	0.068	0.065	0.069
Livingston, MI	Yes	No Monitor				
Macomb, MI	Yes	260990009	<b>0.072</b>	0.071	0.072	0.075

<sup>8</sup> The specific methodology for calculating the ozone design values, including computational formulas and data completeness requirements, is described in 40 CFR part 50, appendix U.

<sup>9</sup> The QA requirements for ozone monitoring data are specified in 40 CFR part 58, appendix A. The performance test requirements for candidate FEMs are provided in 40 CFR part 53, subpart B.

<sup>10</sup> The EPA finalized the rule on the Treatment of Data Influenced by Exceptional Events (81 FR 68513) and the guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events in September of 2016. For more information, see <https://www.epa.gov/air-quality-analysis/exceptional-events-rule-and-guidance>.

County, State	State Recommended Nonattainment?	AQS Site ID	2014-2016 DV	2014 4 <sup>th</sup> highest daily max value	2015 4 <sup>th</sup> highest daily max value	2016 4 <sup>th</sup> highest daily max value
Macomb, MI	Yes	260991003	<b>0.067</b>	0.068	0.064	0.071
Monroe, MI	Yes	No Monitor				
Oakland, MI	Yes	261250001	<b>0.069</b>	0.067	0.066	0.075
St. Clair, MI	Yes	261470005	<b>0.073</b>	0.071	0.075	0.073
Washtenaw, MI	Yes	261610008	0.067	0.070	0.064	0.069
Washtenaw, MI	Yes	261619991	<b>0.068</b>	0.067	0.064	0.074
Wayne, MI	Yes	261630001	0.066	0.064	0.064	0.070
Wayne, MI	Yes	261630019	<b>0.072</b>	0.073	0.070	0.074
Wayne, MI	Yes	261630093	N/A	N/A	N/A	0.058
Wayne, MI	Yes	261630094	N/A	N/A	N/A	0.070

<sup>a</sup>The highest design value in each county is indicated in bold type.

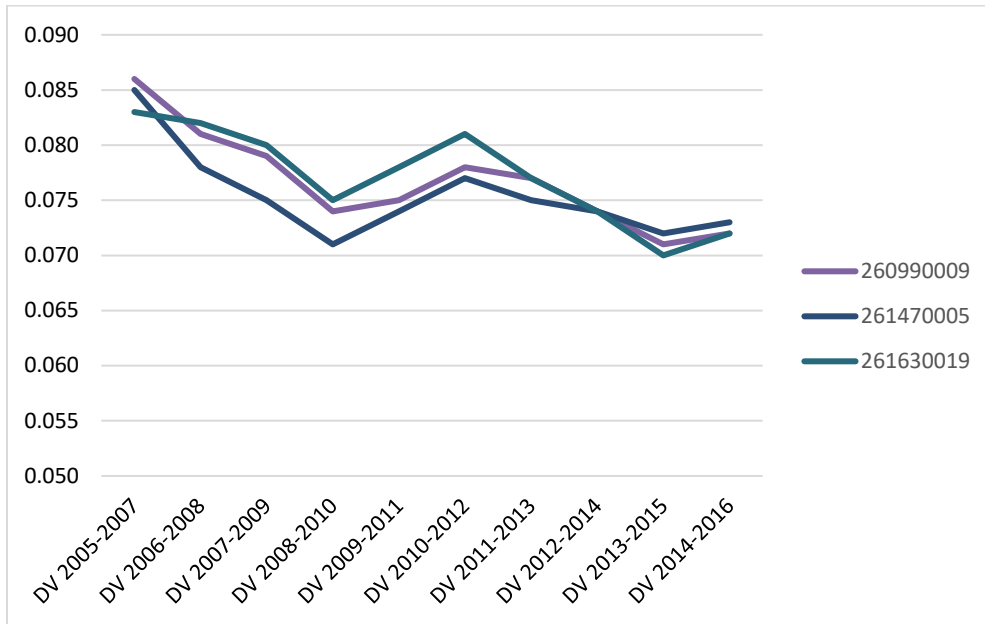
N/A means that the monitor did not meet the completeness criteria described in 40 CFR, part 50, Appendix U, or no data exists for the county.

Macomb, St. Clair and Wayne Counties show a violation of the 2015 ozone NAAQS, therefore these counties are included in the nonattainment area. A county (or partial county) must also be designated nonattainment if it contributes to a violation in a nearby area. Each county without a violating monitor that is located near a county with a violating monitor has been evaluated based on the weight-of-evidence of the five factors and other relevant information to determine whether it contributes to the nearby violation.

Figure 1, shown previously, identifies the Detroit nonattainment area, the Detroit-Warren-Ann Arbor CSA boundary and the violating monitors. Table 2 identifies the design values for all monitors in the area of analysis and Figure 2 shows the historical trend of design values for the violating monitors. As indicated on the map, there are three violating monitors that are located in New Haven in Macomb County, in Port Huron in St. Clair County and in the Northeast corner of Wayne County. There are also monitors in Southwest Macomb County and East Central Wayne County that are not violating based on air quality data from 2014-2016. As shown in Figure 2, with the exception of an increase for the 2012 design values and another uptick for the 2014-2016 design values, there has been a general downward trend in three-year design values.



**Figure 2. Three-Year Design Values for Violating Monitors (2007-2016).**



Three eastern counties in the area of analysis have violating monitors with design values of 0.072 or 0.073 ppb. All other monitors in the CSA are between 0.66 and 0.69 ppb. Therefore, any nearby area determined to be contributing to the three violating monitors also need to be designated as nonattainment.

**Factor 2: Emissions and Emissions-Related Data**

The EPA evaluated ozone precursor emissions of nitrogen oxides (NO<sub>x</sub>) and volatile organic compounds (VOC) and other emissions-related data that provide information on areas contributing to violating monitors.

**Emissions Data**

The EPA reviewed data from the 2014 National Emissions Inventory (NEI). For each county in the area of analysis, the EPA examined the magnitude of large sources (NO<sub>x</sub> or VOC emissions greater than 100 tons per year) and small point sources and the magnitude of county-level emissions reported in the NEI. These county-level emissions represent the sum of emissions from the following general source categories: point sources, non-point (i.e., area) sources, non-road mobile, on-road mobile, and fires. Emissions levels from sources in a nearby area indicate the potential for the area to contribute to monitored violations.

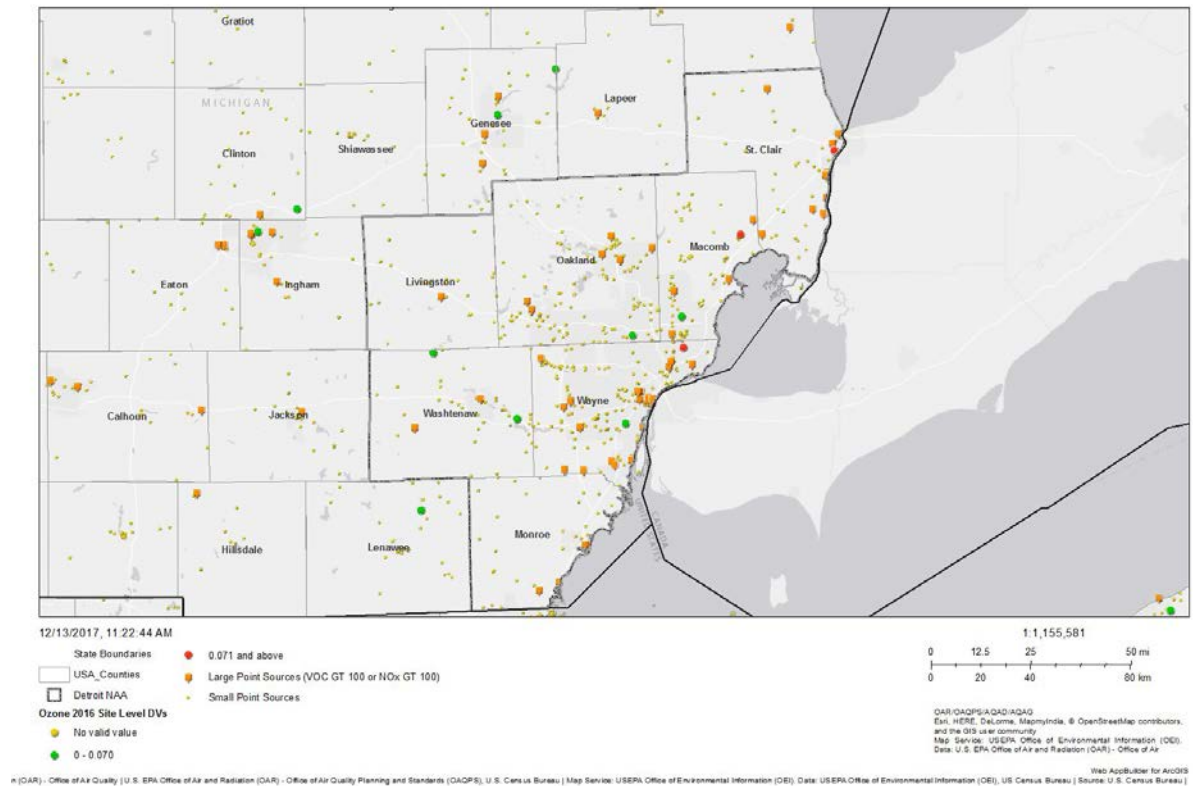
Table 3 provides a county-level emissions summary of NO<sub>x</sub> and VOC (given in tons per year (tpy)) for the area of analysis considered for inclusion in the Detroit nonattainment area.

**Table 3. Total County-Level NO<sub>x</sub> and VOC Emissions.**

County	State Recommended Nonattainment?	Total NO <sub>x</sub> (tpy)	Total VOC (tpy)
Wayne, MI	Yes	53,119	40,418
Oakland, MI	Yes	29,561	30,340
St. Clair, MI	Yes	25,371	6,915
Monroe, MI	Yes	18,089	5,727
Macomb, MI	Yes	17,322	22,138
Washtenaw, MI	Yes	9,682	9,304
Genesee, MI	No	9,619	11,623
Livingston, MI	Yes	5,662	5,508
Lenawee, MI	No	2,683	3,654
Lapeer, MI	No	2,555	3,504
Area wide:		173,663	139,131

In addition to reviewing county-wide emissions of NO<sub>x</sub> and VOC in the area of analysis, the EPA also reviewed emissions from large and small point sources. The location of these sources, together with the other factors, can help inform nonattainment boundaries. The locations of the large and small point sources are shown in Figure 3 below. The nonattainment boundary is also shown.

**Figure 3. Large and Small Point Sources in the Area of Analysis**



In summary, the EPA’s analysis of relevant county-level emissions and the geographic locations of the relevant emissions showed that Wayne County has higher NO<sub>x</sub> emissions than the other counties. The counties with the next highest level of NO<sub>x</sub> emissions, Oakland and St. Clair Counties, have NO<sub>x</sub> emissions that are approximately 56 and 48 percent of the emissions in Wayne County and greater VOC and NO<sub>x</sub> emissions than the other counties in the CSA. After Oakland and St. Clair, the counties with the next highest NO<sub>x</sub> emissions – Macomb and Monroe - have approximately 33 and 34 percent of those in Wayne County. The NO<sub>x</sub> emissions in the remaining counties are all less than 20 percent of the level in Wayne County with the lowest emissions in Lapeer and Lenawee Counties.

Wayne County also has the highest VOC emissions with Oakland County emitting approximately 75 percent of that amount and Macomb approximately 55 percent. VOC emissions in Genesee are approximately 29 percent the level in Wayne County and Washtenaw approximately 23 percent. The remaining counties all have lower emissions with Lapeer and Lenawee ranking the lowest again. The large and small point sources are concentrated in Wayne, St. Clair, Oakland, Monroe and Macomb Counties. Lenawee County is the only one in the CSA without a large point source. Wayne, St. Clair, Oakland, Monroe and Macomb Counties have 20, 9, 6, 5 and 4 large point sources. The remaining counties in the area of analysis have only seven large point sources combined.

**Population density and degree of urbanization**

In this part of the factor analysis, the EPA evaluated the population and vehicle use characteristics and trends of the area as indicators of the probable location and magnitude of non-point source emissions.

These include emissions of NO<sub>x</sub> and VOC from on-road and non-road vehicles and engines, consumer products, residential fuel combustion, and consumer services. Areas of dense population or commercial development are an indicator of area source and mobile source NO<sub>x</sub> and VOC emissions that may contribute to violations of the NAAQS. Table 4 shows the population, population density, and population growth information for each county in the area of analysis. Figure 4 shows the county-level population density for the area of analysis.

**Table 4. Population and Growth.**

County	State Recommended Nonattainment?	2010 Population	2015 Population	2015 Population Density (per sq. mi.)	Absolute change in population (2010-2015)	Population % change (2010-2015)
Wayne, MI	Yes	1,820,584	1,759,335	2874	-61,249	-3
Oakland, MI	Yes	1,202,362	1,242,304	1432	39,942	3
Macomb, MI	Yes	840,978	864,840	1805	23,862	3
Genesee, MI	No	425,790	410,849	645	-14,941	-4
Washtenaw, MI	Yes	344,791	358,880	508	14,089	4
Livingston, MI	Yes	180,967	187,316	331	6349	4
St. Clair, MI	Yes	163,040	159,875	222	-3,165	-2
Monroe, MI	Yes	152,021	149,568	272	-2,453	-2
Lenawee, MI	No	99,892	98,573	132	-1,319	-1
Lapeer, MI	No	88,319	88,373	137	54	<1
Area wide:		5,318,744	5,319,913	815	1169	<1

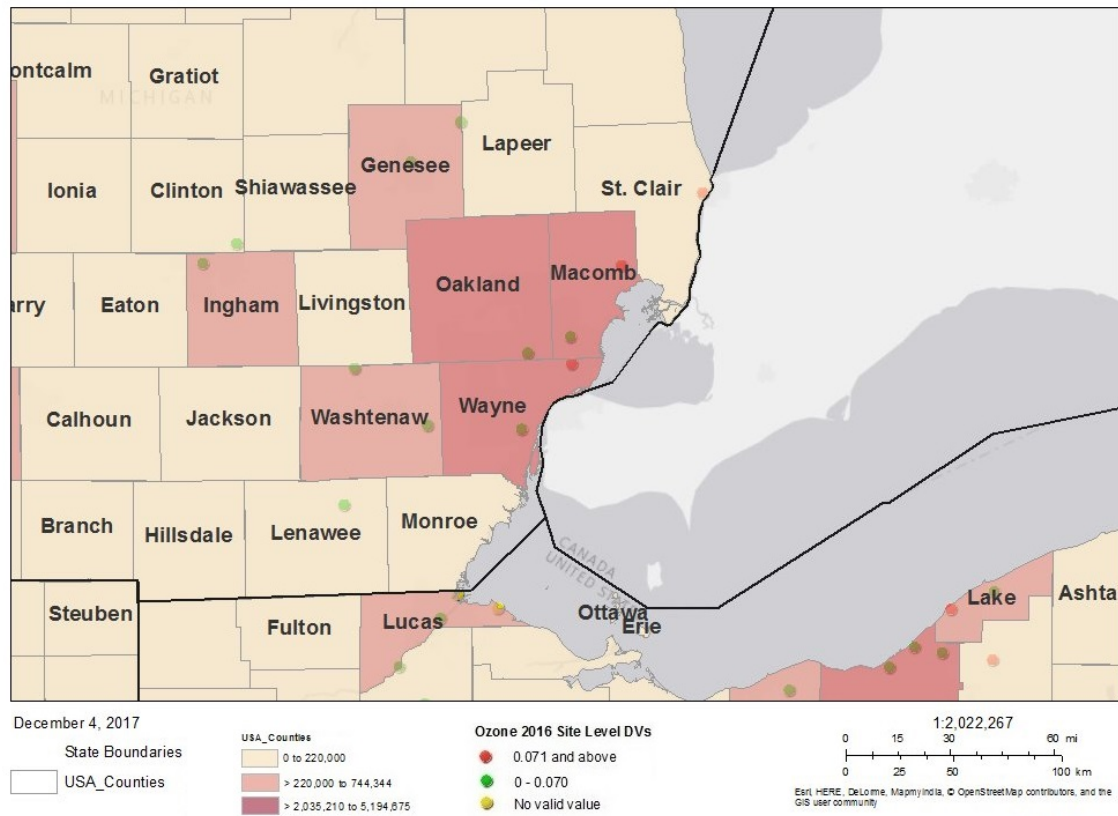
\* For state recommended partial counties, the emissions shown are for the entire county.

Source: U.S. Census Bureau population estimates for 2010 and 2015. [www.census.gov/data.html](http://www.census.gov/data.html)

Wayne and Oakland Counties each have populations exceeding one million and population densities of 2874 and 1432, respectively. While Macomb has a lower, but still high, population of approximately

865,000, it is more densely populated than Oakland County and has a density of 1805. The populations in Genesee and Washtenaw combined are roughly 60 percent of Oakland County’s population and the population densities are about 40 percent of that in Oakland County. The remaining counties are significantly less populous (Figure 4) and less densely populated as well with Lenawee and Lapeer ranking the lowest on both metrics. There has been limited population growth. The highest growth was in Washtenaw and Livingston at 4 percent followed closely by Macomb and Oakland at 3 percent. The remaining counties either experienced a slight decline or, in the case of Lapeer remaining relatively stable.

**Figure 4. County-Level Population.**



**Traffic and Vehicle Miles Travelled (VMT)**

The EPA evaluated the commuting patterns of residents, as well as the total vehicle miles traveled (VMT) for each county in the area of analysis. In combination with the population/population density data and the location of main transportation arteries, this information helps identify the probable location of non-point source emissions. A county with high VMT and/or a high number of commuters is generally an integral part of an urban area and high VMT and/or high number of commuters indicates the presence of motor vehicle emissions that may contribute to violations of the NAAQS. Rapid population or VMT growth in a county on the urban perimeter may signify increasing integration with the core urban area, and thus could indicate that the associated area source and mobile source emissions may be appropriate to include in the nonattainment area. In addition to VMT, the EPA evaluated worker data collected by the

U.S. Census Bureau<sup>11</sup> for the counties in the area of analysis. Table 5 shows the traffic and commuting pattern data, including total VMT for each county in the area of analysis, number of residents who work in each county, number of residents that work in counties with violating monitor(s), and the percent of residents working in counties with violating monitor(s). The data in Table 5 are 2014 data.

**Table 5. Traffic and Commuting Patterns.**

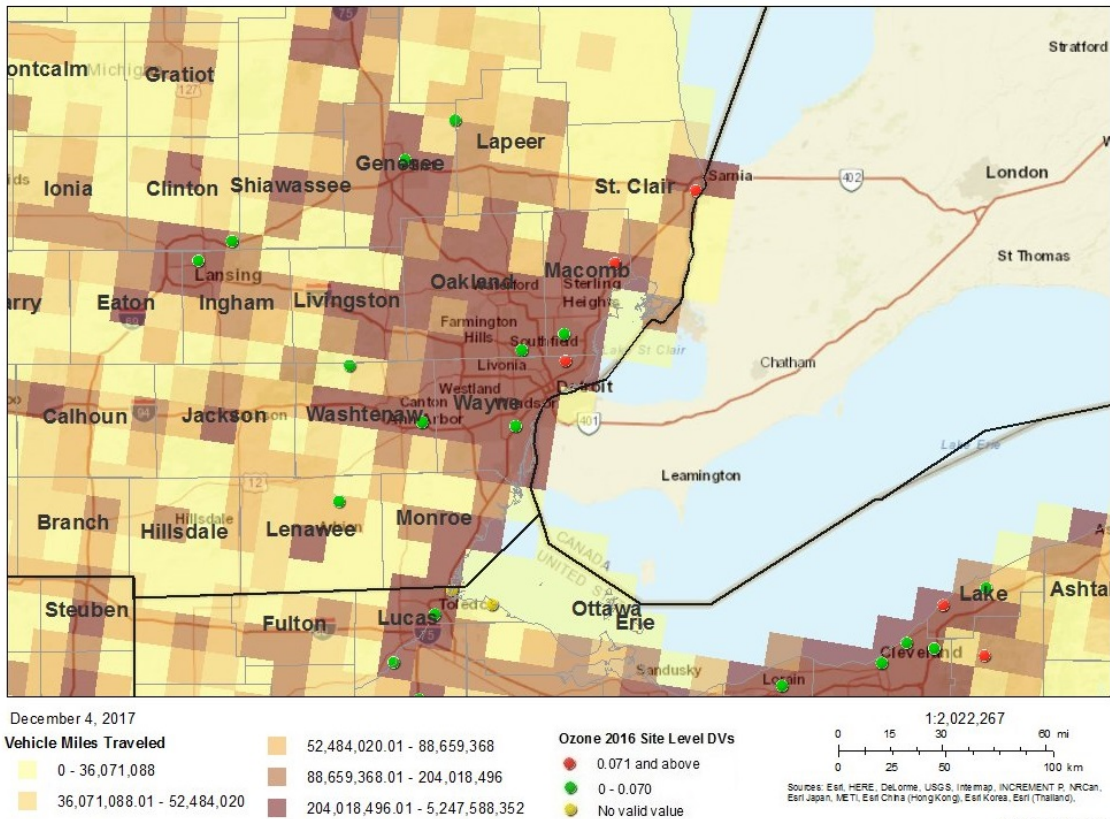
County	State Recommended Nonattainment?	2014 Total VMT (Million Miles)	Number of County Residents Who Work	Number Commuting to or Within Counties with Violating Monitor(s)	Percentage Commuting to or Within Counties with Violating Monitor(s)
<b>Wayne, MI</b>	<b>Yes</b>	<b>15,391</b>	<b>669,091</b>	<b>417,566</b>	<b>62.4%</b>
Oakland, MI	Yes	12,468	567,109	167,915	29.6%
<b>Macomb, MI</b>	<b>Yes</b>	<b>6,373</b>	<b>385,168</b>	<b>236,623</b>	<b>61.4%</b>
Genesee, MI	No	4,982	146,655	13,732	9.4%
Washtenaw, MI	Yes	3,740	152,721	26,557	17.4%
Livingston, MI	Yes	2,169	81,682	12,388	15.2%
Monroe, MI	Yes	1,870	67,262	15,900	23.6%
<b>St. Clair, MI</b>	<b>Yes</b>	<b>1,501</b>	<b>75,085</b>	<b>51,734</b>	<b>68.9%</b>
Lapeer, MI	No	932	37,506	9,560	25.5%
Lenawee, MI	No	858	39,617	3,230	8.2%
Total:		50,284	2,221,896	955,205	43.0%

Counties with a monitor(s) violating the NAAQS are indicated in bold.

To show traffic and commuting patterns, Figure 5 overlays twelve-kilometer gridded VMT from the 2014 NEI with a map of the transportation arteries.

<sup>11</sup> The worker data can be accessed at: <http://onthemap.ces.census.gov/>.

**Figure 5. Twelve Kilometer Gridded VMT (Miles) Overlaid with Transportation Arteries.**



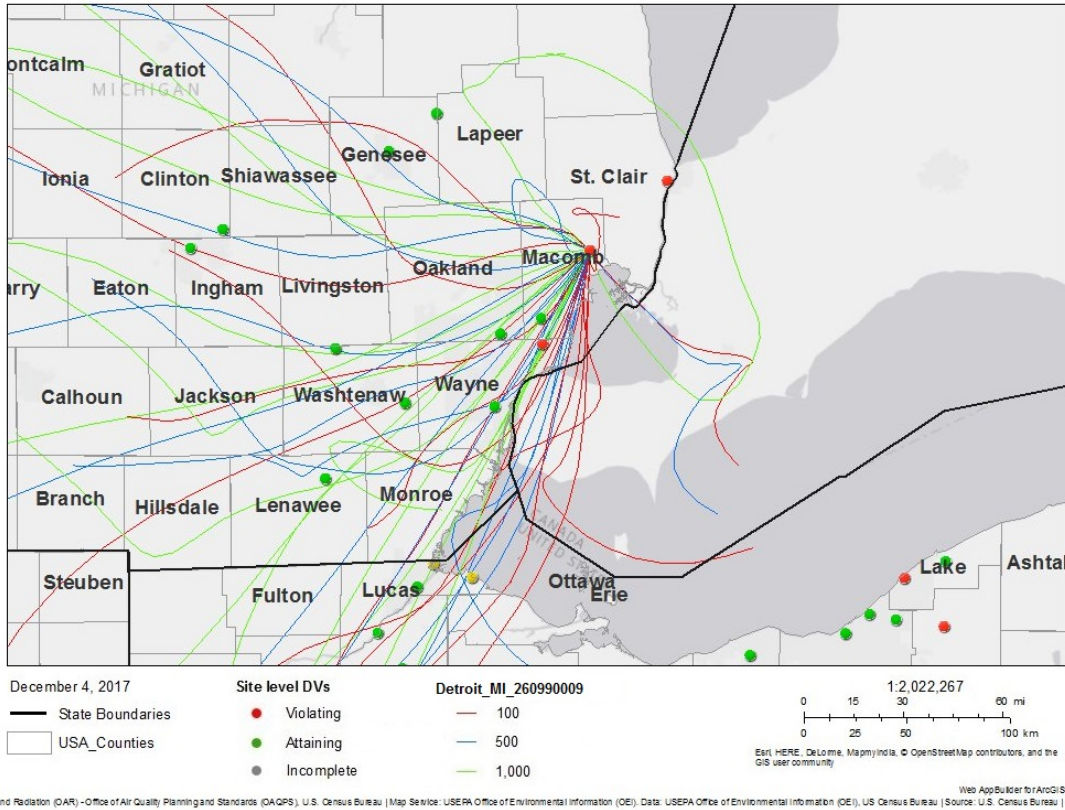
Counties are listed in Table 5 in order of VMT from largest to smallest. The three counties with violating monitors have the first, third and eighth largest VMT of the ten counties in the area of analysis. While Genesee County has the fourth highest VMT, less than 10% of the population in that county commutes to counties with violating monitors (within the area of analysis, only Lawanee County has a lower percentage of residents commuting to counties with violating monitors). The seven counties that EPA intends to designate Nonattainment (Wayne, Oakland, Macomb, Washtenaw, Livingston, Monroe and St. Claire) account for 87% of the VMT in the area of analysis.

**Factor 3: Meteorology**

Evaluation of meteorological data helps to assess the fate and transport of emissions contributing to ozone concentrations and to identify areas potentially contributing to the monitored violations. Results of meteorological data analysis may inform the determination of nonattainment area boundaries. In order to determine how meteorological conditions, including, but not limited to, weather, transport patterns, and stagnation conditions, could affect the fate and transport of ozone and precursor emissions from sources in the area., the EPA evaluated 2014-2016 HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) trajectories at 100, 500, and 1000 meters above ground level (AGL) that illustrate the three-dimensional paths traveled by air parcels to a violating monitor. Figures 6.1-6.3 show the 24-hour HYSPLIT back trajectories for each exceedance day (i.e., daily maximum 8 hour values that exceed the 2015 ozone NAAQS) for the violating monitors.

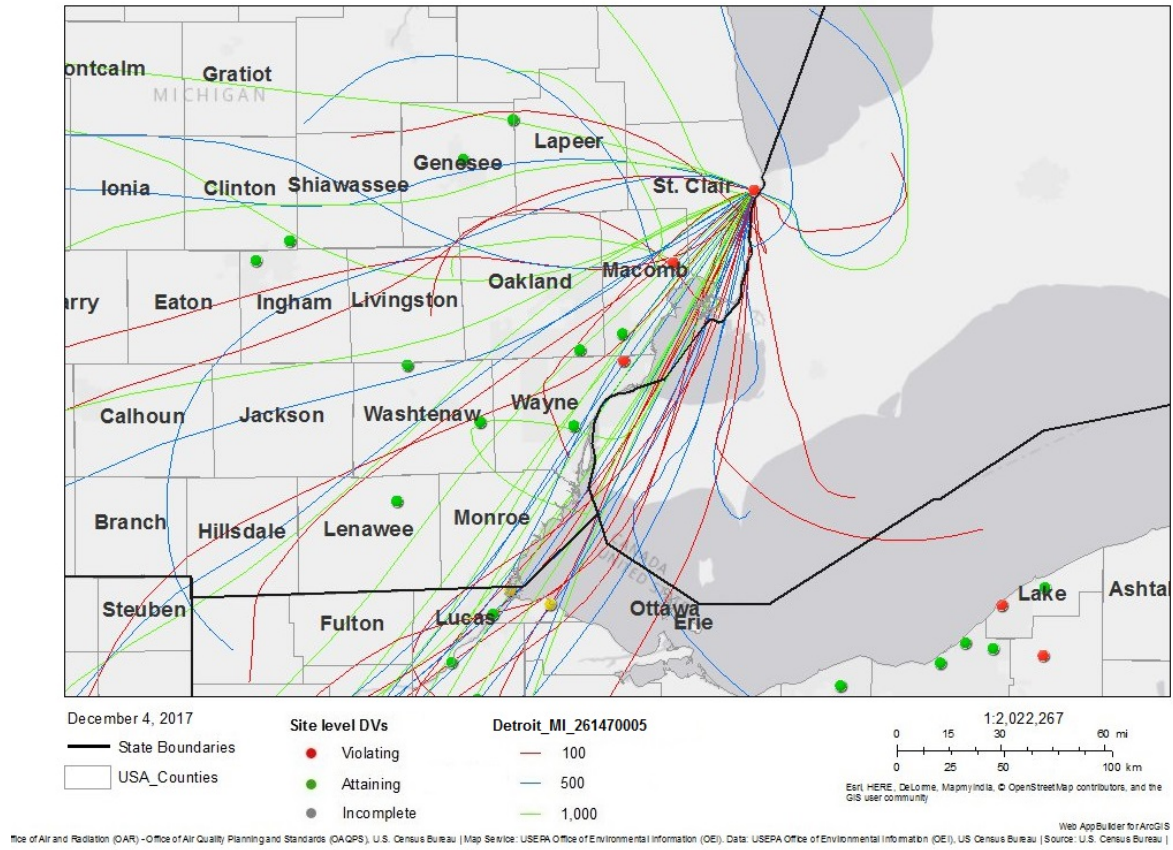


**Figure 6.1 HYSPLIT Back Trajectories for Macomb County Monitor26-099-0009.**

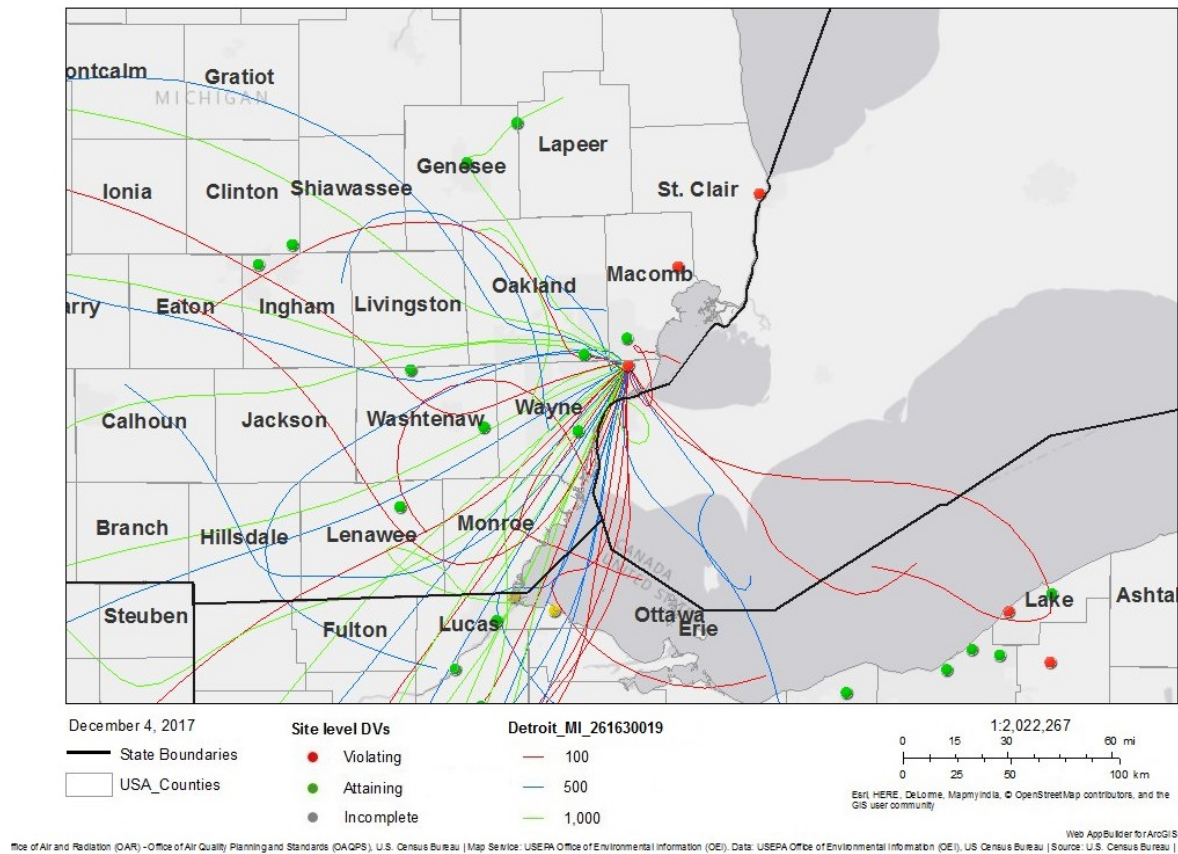




**Figure 6.2 HYSPLIT Back Trajectories for St. Clair County Monitor 26-147-0005.**



**Figure 6.3 HYSPLIT Back Trajectories for Wayne County Monitor 26-163-0019.**



The HYSPLIT results show that the back trajectories for each exceedance day are predominantly from the southwest. The violating monitor in St. Clair County is primarily impacted by transport from St. Clair, Wayne, and Macomb Counties as well as from over Lake Erie. The violating monitor in Macomb County is primarily impacted by transport from Macomb and Wayne Counties as well as from over Lake Erie. The violating Monitor in Wayne County is primarily impacted by transport from Wayne County and over Lake Erie. There are also numerous trajectories over Oakland, Livingston, Washtenaw and Monroe Counties but few over Genesee, Lapeer and Lenawee Counties.

#### **Factor 4: Geography/topography**

Consideration of geography or topography can provide additional information relevant to defining nonattainment area boundaries. Analyses should examine the physical features of the land that might define the airshed. Mountains or other physical features may influence the fate and transport of emissions as well as the formation and distribution of ozone concentrations. The absence of any such geographic or topographic features may also be a relevant consideration in selecting boundaries for a given area.

The EPA used geography/topography analysis to evaluate the physical features of the land that might affect the airshed and, therefore, the distribution of ozone over the area.

The Detroit area does not have any geographical or topographical features significantly limiting air pollution transport within its air shed. Therefore, this factor did not play a role in this evaluation.

#### **Factor 5: Jurisdictional boundaries**

Once the geographic extent of the violating area and the nearby area contributing to violations is determined, the EPA considered existing jurisdictional boundaries for the purposes of providing a clearly defined legal boundary to carry out the air quality planning and enforcement functions for nonattainment areas. In defining the boundaries of the Detroit nonattainment area, the EPA considered existing jurisdictional boundaries, which can provide easily identifiable and recognized boundaries for purposes of implementing the NAAQS. Examples of jurisdictional boundaries include, but are not limited to: counties, air districts, areas of Indian country, metropolitan planning organizations, and existing nonattainment areas. If an existing jurisdictional boundary is used to help define the nonattainment area, it must encompass all of the area that has been identified as meeting the nonattainment definition. Where existing jurisdictional boundaries are not adequate or appropriate to describe the nonattainment area, the EPA considered other clearly defined and permanent landmarks or geographic coordinates for purposes of identifying the boundaries of the designated areas.

The Detroit area has previously established nonattainment boundaries associated with the 1997 ozone NAAQS. This Detroit-Ann Arbor area consisted of Lenawee, Livingston, Macomb, Monroe, Oakland, St. Clair, Washtenaw and Wayne Counties.

#### **Conclusion for Detroit Area**

Based on an assessment of the factors described above, the EPA does not intent to modify the state's recommendation to include the following counties in the Detroit nonattainment area: Livingston, Macomb, Monroe, Oakland, St. Clair, Washtenaw and Wayne Counties. The counties of St. Clair, Macomb, and Wayne are included based on monitors within these counties with 2016 ozone design values violating the 2015 ozone NAAQS. Livingston, Oakland, Washtenaw and Monroe Counties are nearby counties that do not have violating monitors, but the five factor analysis indicates that these areas contribute to the ozone concentrations in violation of the 2015 ozone NAAQS. Specifically, Wayne, Oakland and Macomb Counties have among the highest NO<sub>x</sub> and VOC emissions in the area. Monroe, Livingston, Washtenaw and Livingston Counties have a number of large and small point sources and relatively high levels of VMT. The HYSPLIT trajectories for the St. Clair, Macomb and Wayne County violating monitors also indicate that emissions from Monroe, Livingston, Oakland and Washtenaw counties have the potential to impact the monitors on high ozone days. Finally, all seven counties recommended to be included in the nonattainment areas by the state are also included in the Detroit-Ann Arbor nonattainment area for the 1997 ozone NAAQS.

EPA is not designating Genesee, Lapeer and Lenawee Counties as part of the Detroit nonattainment area. Genesee County is a distinctly separate county with its own jurisdictional boundaries and commuting patterns and ranks seventh out of the ten counties for NO<sub>x</sub> emissions and fourth for VOC emissions.

These emissions are not influencing nonattainment monitors based upon HYSPLIT outputs. While it ranks fourth for total population levels, it suffered the largest percentage loss in the 10-county area of analysis with a decrease of 4 percent. It also ranked fourth for total VMT, but ninth in terms of the number of commuters traveling within or to a county with a violating monitor. Lapeer and Lenawee Counties have very low VOC and NO<sub>x</sub> emissions and also low VMT and population levels. In fact, the emissions, population, and VMT are the lowest in the CSA. Lenawee County has no large point sources, a monitor demonstrating attainment and a very low impact on the violating monitors based on the HYSPLIT trajectories. Lenawee County has only 8.2 percent of its workers commuting to counties with a violating monitor and almost no impact on the nonattainment monitors according to the HYSPLIT trajectories. Together, Genesee, Lapeer, and Lenawee only account for 13% of NO<sub>x</sub> and 13% of VOC emitted in the area of analysis.

### **3.2 Technical Analysis for Western Michigan Areas**

For all of the areas of western Michigan analyzed in this TSD, including Muskegon, Allegan, and Berrien Counties, we note that the meteorological data strongly indicates that the violating monitors in these counties are predominantly affected by the transport of emissions over Lake Michigan. HYSPLIT trajectories from these monitors are from the west and southwest over Lake Michigan. These western Michigan counties are downwind of the Chicago CSA (total reported CSA NO<sub>x</sub> = 274,440 tons, VOC = 206,171 tons) which includes counties in Northeast Illinois, Northwest Indiana and Southeast Wisconsin, and also the Milwaukee CSA (total reported CSA NO<sub>x</sub> = 51,822 tons, VOC = 49,129 tons). These emissions greatly exceed the emissions from the western Michigan counties. The HYSPLIT trajectories indicate that the exceedance day air masses traveled over these upwind areas and Lake Michigan to reach the violating monitors.

The western boundaries of Muskegon, Allegan, and Berrien Counties follow the shoreline of Lake Michigan. Due to their proximity to the lake, these counties have the potential to be impacted by lake breeze meteorology. The land breeze and lake breeze occur when wind blows from the land and lake, respectively, due to air pressure differences caused by the different heating capacities of the land and the water. Land absorbs and loses solar radiation much faster than water. The land breeze typically occurs overnight and in the early morning after air above the relatively warm nighttime water of Lake Michigan heats and rises, setting up an area of low pressure which is filled by the cooler air from the land. The lake breeze typically occurs in the afternoon when the area of low pressure is created by rising air over the heated land, creating winds off the cooler lake. The land/lake breeze is typically more localized than the prevailing (synoptic) winds. Studies indicate the land/lake breeze can trap, stratify, and recirculate offshore air, sometimes in a helical pattern. Daytime inversions over the lake can create shallow, stable layers of precursor plumes, which, on warm sunny days, are conducive to ozone formation. The afternoon lake breeze can carry photochemically-aged, ozone-rich air toward the land from nearby and upwind plumes, to nearby and downwind areas like Muskegon County where violations of the ozone standard can be measured at locations along the shoreline. Additionally, large scale, summertime, stagnant high-pressure systems centered to the south and southeast of Lake Michigan have been implicated in high ozone episodes for areas near the shoreline of Lake Michigan, because they can produce southerly and southeasterly flows over Lake Michigan, which can enhance the flow of photochemically-aged air. The

relative role of each (the land/land breeze and synoptic flow) is episode-specific and not fully understood.<sup>12, 13, 14, 15, 16</sup>

The HYSPLIT trajectories (Figures 12, 18, and 24) indicate that exceedance day air masses generally traveled from the south, southwest, and west prior to being detected at the violating monitors. Scientific studies indicate ozone can be preferentially transported over the Great Lakes relative to the land surface.<sup>17, 18, 19, 20, 21, 22</sup> Any precursor emissions that flow out over the lake with the morning land breeze from upwind areas on the western and southern shore of Lake Michigan have the potential to photochemically react to form ozone, which has the potential to be transported by the afternoon lake breeze to the monitors in western Michigan as corroborated by the studies cited above and by the HYSPLIT trajectories shown in Figures 12, 18, and 24.

The HYSPLIT trajectories are just one piece of evidence corroborating the body of scientific literature on the potential for lake breeze meteorology, and lake breeze meteorology combined with synoptic meteorology, to transport photochemically-aged, ozone-rich air masses from nearby and upwind areas to nearby and downwind areas near the shoreline of Lake Michigan. Evidence of the potential for land/lake breeze and synoptic meteorology to transport ozone to areas along the shoreline of Lake Michigan is documented in the peer-reviewed scientific literature from study data specific to Lake Michigan collected

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<sup>12</sup> Cleary, P. A., Fuhrman, N., Schulz, L., Schafer, J., Fillingham, J., Bootsma, H., McQueen, J., Tang, Y., Langel, T., McKeen, S., Williams, E. J., and Brown, S. S.: Ozone distributions over southern Lake Michigan: comparisons between ferry-based observations, shoreline-based DOAS observations and model forecasts, *Atmos. Chem. Phys.*, 15, 5109–5122, 2015.

<sup>13</sup> Dye, T. S., Roberts, P. T., and Korc, M. E.: Observations of transport processes for ozone and ozone precursors during the 1991 Lake Michigan Ozone Study, *J. Appl. Meteorol.*, 34, 1877–1889, 1995.

<sup>14</sup> Foley, T., Betterton, E. A., Jacko, P. E. R., and Hillery, J.: Lake Michigan air quality: The 1994–2003 LADCO Aircraft Project (LAP), *Atmos. Environ.*, 45, 3192–3202, 2011.

<sup>15</sup> Hanna, S. R. and Chang, J. C.: Relations between meteorology and ozone in the Lake Michigan region, *J. Appl. Meteorol.*, 34, 670–678, 1995.

<sup>16</sup> Lennartson, G. J., and Schwartz, M. D.: A synoptic climatology of surface-level ozone in Eastern Wisconsin, USA, *Climate Research*, 13, 207–220, 1999.

<sup>17</sup> Brook, J. R., Makar, P.A., Sills D. M. L., Hayden, K. L. and McLaren, R. Exploring the nature of air quality over southwestern Ontario: main findings from the Border Air Quality and Meteorology Study, *Atmos. Chem. Phys.*, 13, 10461–10482, 2013.

<sup>18</sup> Lyons, W. A. and Cole, H. S., Fumigation and plume trapping on the shores of Lake Michigan during stable onshore flow, *J. Appl. Meteor.*, 12, 494–510, 1973.

<sup>19</sup> Lyons, W. A. and Cole, H. S.: Photochemical oxidant transport–mesoscale lake breeze and synoptic-scale aspects, *J. Appl. Meteor.*, 15, 733–743, 1976.

<sup>20</sup> Sillman, S., Samson, P. J., and Masters, J. M.: Ozone formation in urban plumes transported over water: photochemical model and case studies in the northeastern and midwestern U.S., *J. Geophys. Res.*, 98, 12687–12699, 1993.

<sup>21</sup> Lyons, W. A., Pielke, R. A., Tremback, C. J., Walko, R. L., Moon, D. A., and Keen, C. S.: Modeling impacts of mesoscale vertical motions upon coastal zone air pollution dispersion, *Atmos. Environ.*, 29, 283–301, 1995a.

<sup>22</sup> Lyons, W. A., Tremback, C. J., and Pielke, R. A.: Applications of the Regional Atmospheric Modeling System (RAMS) to provide input to photochemical grid models for the Lake Michigan Ozone Study (LMOS), *J. Appl. Meteor.*, 34, 1762–1786, 1995b.

mostly in the early 1990's.<sup>37, 38, 39, 40, 41</sup> It is important to reiterate that the relative role of the land/lake breeze and synoptic flow on ozone transport in the Lake Michigan area is episode-specific and not fully understood. The recent 2017 Lake Michigan Ozone Study (LMOS) conducted by many parties, including, but not limited to, Wisconsin DNR, LADCO, EPA, NOAA, NASA, and various academic institutions, seeks to advance the scientific understanding of the relative role of the land/lake breeze and synoptic flow among other factors influencing ozone production and transport in the Lake Michigan area. Specific details on the factors and mechanisms by which a large body of water like Lake Michigan can impact photochemical ozone production are still an active area of research (e.g. changes in precursor mixes, changes in radical concentrations, relative importance of multi-day ozone formation versus same day formation, lake breeze inland penetration distances, the extent to which shallow inversions above the cool lake water prevent vertical mixing, etc.).<sup>23</sup>

While there are still gaps in the peer-reviewed scientific literature on details of the various factors regarding how the local lake breeze (alone or combined with synoptic-scale meteorology) influences ozone production and transport around Lake Michigan, the basic concepts of lake breeze meteorology and its potential to influence ozone production and transport are understood well enough to place great weight on the meteorology factor in our analysis of western Michigan areas. The peer-reviewed results from the Lake Michigan-specific ozone studies and the HYSPLIT trajectories presented here both provide evidence that lake breeze meteorology plays a role in ozone production and transport to western Michigan counties. This factor shows that the violating monitors are mainly affected by emissions coming from the west and southwest over Lake Michigan.

The information above concerning lake breeze effects and subregional/regional ozone transport from upwind areas along the western and southern shore of Lake Michigan is common to and relevant to all of the western Michigan counties evaluated below, and thus is not fully repeated in each of the individual sections.

### **3.3 Technical Analysis for Muskegon Area**

The Muskegon CBSA consists solely of Muskegon County. As indicated in Figure 12, the meteorological data strongly indicates that the violating monitor in Muskegon County is predominantly affected by the transport of emissions over Lake Michigan.

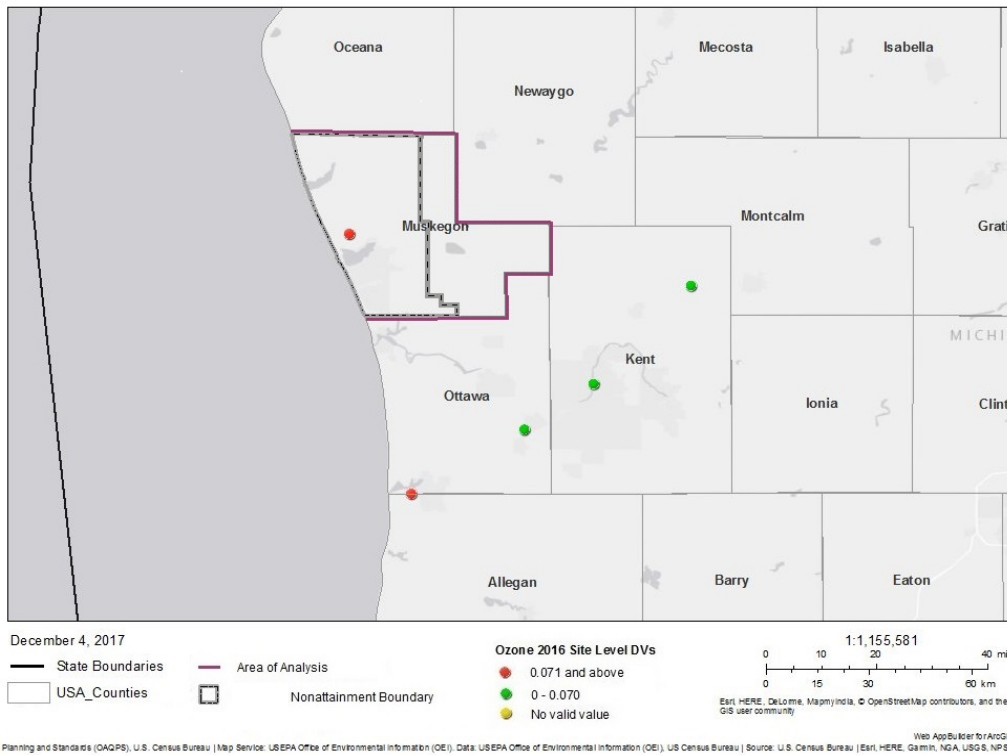
Figure 7 is a map of the EPA's nonattainment boundary for the Muskegon Area. The map shows the location of the ambient air quality monitors, county, and other jurisdictional boundaries

For the 1997 ozone NAAQS, this area was designated nonattainment. The boundary for the nonattainment area for the 1997 ozone NAAQS included all of Muskegon County. For the 2008 ozone NAAQS, Muskegon County was designated attainment.

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<sup>23</sup> Pierce, B., Kaleel, R., Dickens, A., Bertram T., and Stanier, C., Kenski D.: White Paper: Lake Michigan Ozone Study 2017 (LMOS 2017), <http://www.ladco.org/>, 2016.

**Figure 7. EPA's Nonattainment Boundaries for the Muskegon Area**



The EPA must designate as nonattainment any area that violates the NAAQS and any nearby areas that contribute to the violation in the violating area. Muskegon County has a monitor in violation of the 2015 ozone NAAQS, therefore the western part of this county, that contains the violating monitor and is most affected by transport, is included in the nonattainment area. HYSPLIT back-trajectories show that other nearby counties do not contribute to the violating monitor in Muskegon County. The following sections describe the five factor analysis. While the factors are presented individually, they are not independent. The five factor analysis process carefully considers the interconnections among the different factors and the dependence of each factor on one or more of the others, such as the interaction between emissions and meteorology for the area being evaluated.

## Factor Assessment

### Factor 1: Air Quality Data

The EPA considered 8-hour ozone design values in ppm for the air quality monitor in the Muskegon area based on data for the 2014-2016 period (i.e., the 2016 design value, or DV). This is the most recent three-year period with fully-certified air quality data. The design value is the 3-year average of the annual 4<sup>th</sup> highest daily maximum 8-hour average ozone concentration. The 2015 NAAQS are met when the design value is 0.070 ppm or less. Only ozone measurement data collected in accordance with the quality assurance (QA) requirements using approved (FRM/FEM) monitors are used for NAAQS compliance determinations. The EPA uses FRM/FEM measurement data residing in the EPA's Air Quality System (AQS) database to calculate the ozone design values. Individual violations of the 2015 ozone NAAQS



that the EPA determines have been caused by an exceptional event that meets the administrative and technical criteria in the Exceptional Events Rule are not included in these calculations. Whenever several monitors are located in a county (or designated nonattainment area), the design value for the county or area is determined by the monitor with the highest valid design value. The presence of one or more violating monitors (i.e. monitors with design values greater than 0.070 ppm) in a county or other geographic area forms the basis for designating that county or area as nonattainment. The remaining four factors are then used as the technical basis for determining the spatial extent of the designated nonattainment area surrounding the violating monitor(s) based on a consideration of what nearby areas are contributing to a violation of the NAAQS.

The EPA identified a monitor where the most recent design value violates the NAAQS, and examined historical ozone air quality measurement data (including previous design values) to understand the nature of the ozone ambient air quality problem in the area. Eligible monitors for providing design value data generally include State and Local Air Monitoring Stations (SLAMS) that are operated in accordance with 40 CFR part 58, appendix A, C, D and E and operating with an FRM or FEM monitor. These requirements must be met in order to be acceptable for comparison to the 2015 ozone NAAQS for designation purposes. All data from Special Purpose Monitors (SPMs) using an FRM or FEM are eligible for comparison to the NAAQS, subject to the requirements given in the March 28, 2016 Revision to Ambient Monitoring Quality Assurance and Other Requirements Rule (81 FR 17248).

The 2014-2016 design value for Muskegon County is shown in Table 6.

**Table 6. Air Quality Data (all values in ppm)<sup>a</sup>.**

County, State	State Recommended Nonattainment?	AQS Site ID	2014-2016 DV	2014 4 <sup>th</sup> highest daily max value	2015 4 <sup>th</sup> highest daily max value	2016 4 <sup>th</sup> highest daily max value
Muskegon, MI	Yes	261210039	<b>0.075</b>	0.075	0.074	0.076

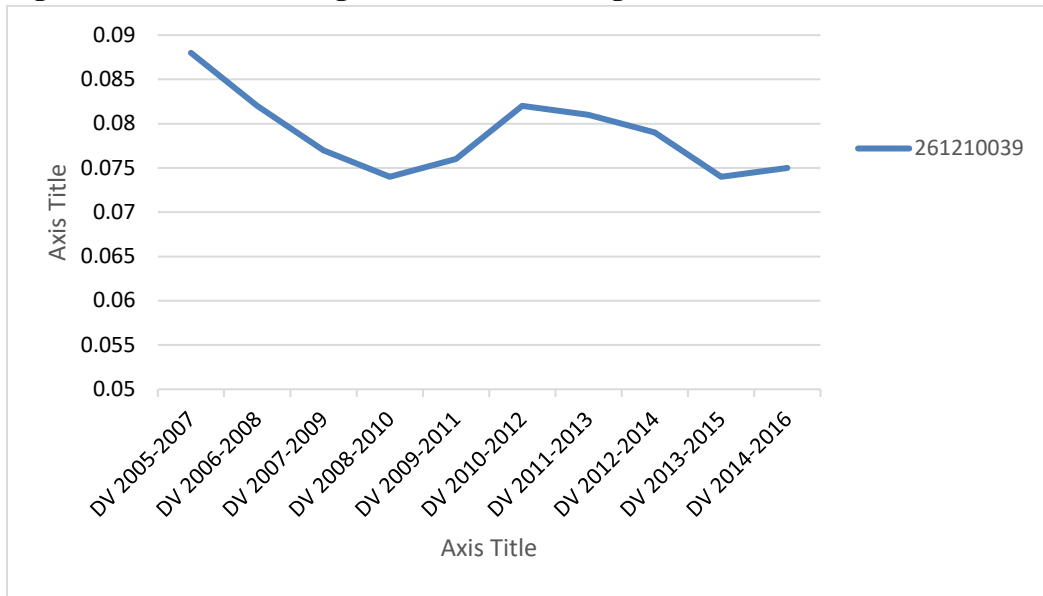
<sup>a</sup>The highest design value in each county is indicated in bold type.

Muskegon County shows a violation of the 2015 ozone NAAQS, therefore part of Muskegon County is included in the nonattainment area.

Figure 7, shown previously, identifies the Muskegon nonattainment area, the CBSA boundary and the violating monitor. Table 6 identifies the design value for the monitor in the area of analysis and Figure 8 shows the historical trend of design values for the violating monitor. As indicated on the map, there is one violating monitor that is located in western Muskegon County, close to Lake Michigan. As shown in Figure 8, with the exception of an increase with the 2012 design value and a slight uptick for the 2016 design value, ozone levels have come down over the last 10 years.



**Figure 8. Three-Year Design Values for Violating Monitor (2007-2016).**



**Factor 2: Emissions and Emissions-Related Data**

The EPA evaluated ozone precursor emissions of nitrogen oxides (NO<sub>x</sub>) and volatile organic compounds (VOC) and other emissions-related data.

**Emissions Data**

The EPA reviewed data from the 2014 National Emissions Inventory (NEI). The EPA examined the magnitude of large sources (NO<sub>x</sub> or VOC emissions greater than 100 tons per year) and small point sources and the magnitude of county-level emissions reported in the NEI. These county-level emissions represent the sum of emissions from the following general source categories: point sources, non-point (i.e., area) sources, non-road mobile, on-road mobile, and fires.

Table 7 provides a county-level emissions summary of NO<sub>x</sub> and VOC (given in tons per year (tpy)) emissions for Muskegon County.

**Table 7. Total County-Level NO<sub>x</sub> and VOC Emissions.**

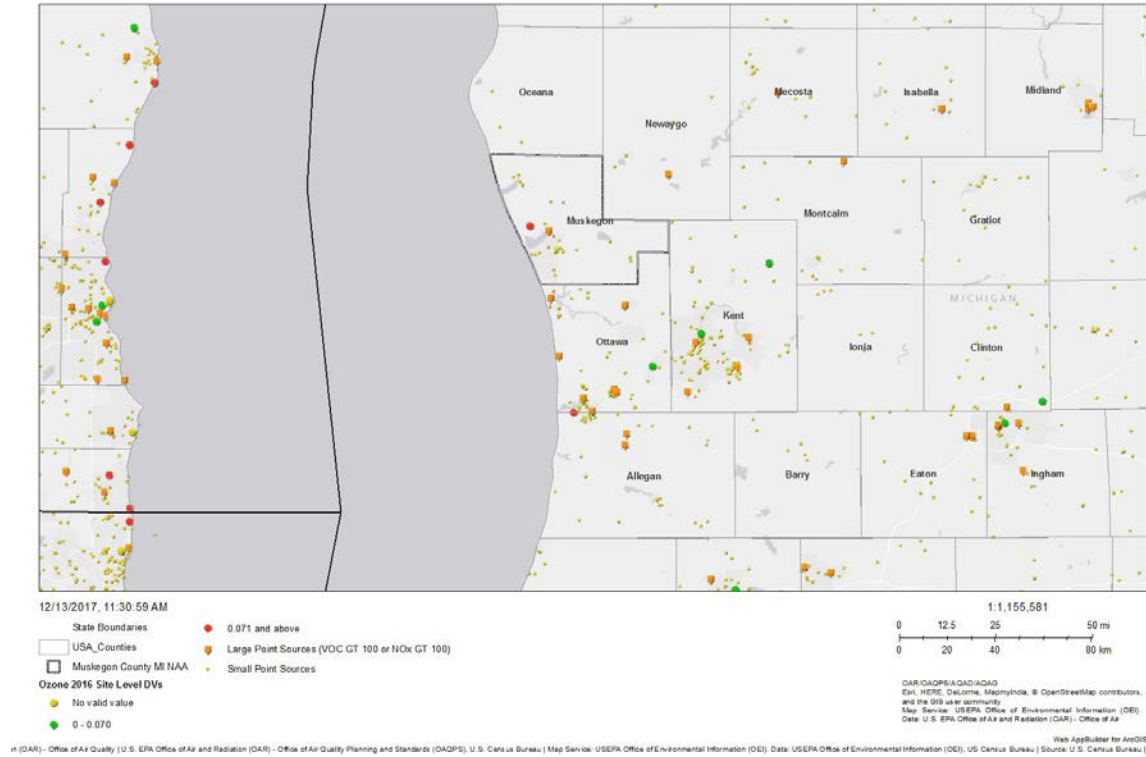
County	State Recommended Nonattainment?	Total NO <sub>x</sub> (tpy)	Total VOC (tpy)
Muskegon, MI	Yes (Partial)*	6,616	5,662

\* For state recommended partial counties, the emissions shown are for the entire county.

In addition to reviewing county-wide emissions of NO<sub>x</sub> and VOC in the area of analysis, the EPA also reviewed emissions from large and small point sources. The location of these sources, together with the other factors, can help inform nonattainment boundaries. There is one large point source in Muskegon County in addition to numerous smaller sources as shown in Figure 9 below. There is a total of 2,484 tpy of NO<sub>x</sub> emissions from point sources in Muskegon County and 99% of these emissions are from within the part of Muskegon County that Michigan recommended to be designated as nonattainment. There is a

total of 213 tpy of VOC emissions from point sources in Muskegon County and 89% of these emissions are from within the part of Muskegon County that Michigan recommended to be designated as nonattainment.

**Figure 9. Large and Small Point Sources in the Area of Analysis.**



**Population density and degree of urbanization**

In this part of the factor analysis, the EPA evaluated the population and vehicle use characteristics and trends of the area as indicators of the probable location and magnitude of non-point source emissions. These include emissions of NO<sub>x</sub> and VOC from on-road and non-road vehicles and engines, consumer products, residential fuel combustion, and consumer services. Areas of dense population or commercial development are an indicator of area source and mobile source NO<sub>x</sub> and VOC emissions that may contribute to violations of the NAAQS. Table 8 shows the population, population density, and population growth information for Muskegon County.

**Table 8. Population and Growth.**

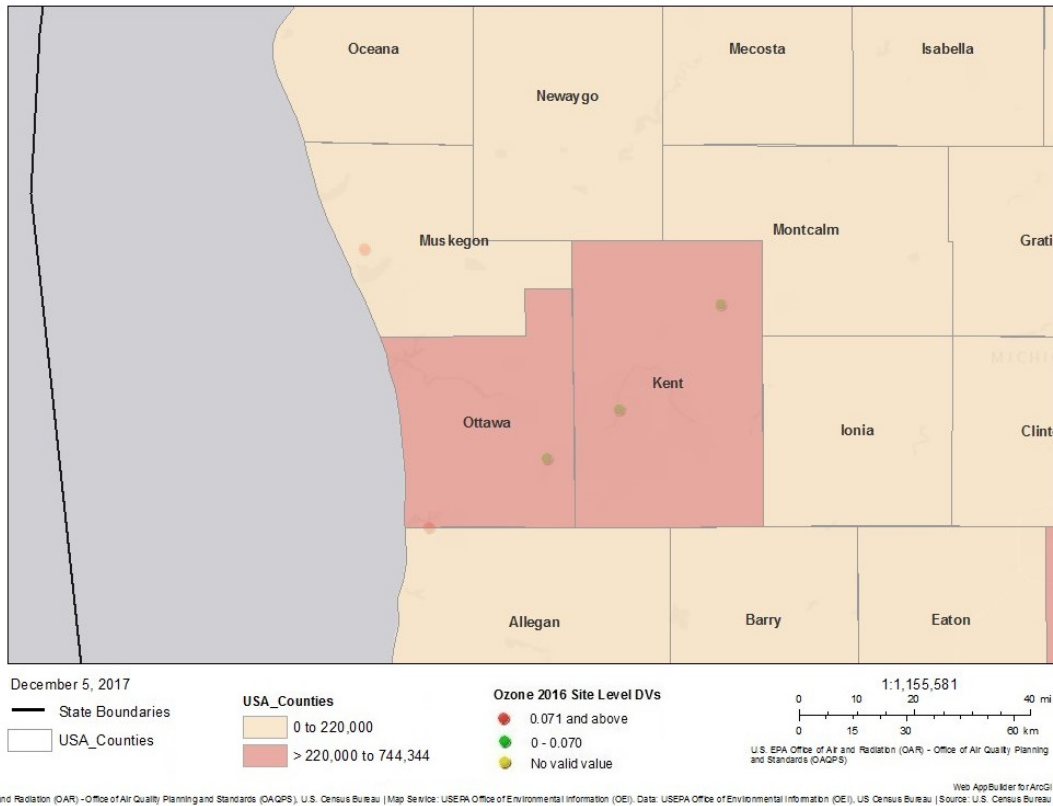
County	State Recommended Nonattainment?	2010 Population	2015 Population	2015 Population Density (per sq. mi.)	Absolute change in population (2010-2015)	Population % change (2010-2015)
Muskegon, MI	Yes (Partial)*	172,188	172,790	346	602	0.3%

\* For state recommended partial counties, the data provided are for the entire county.

Source: U.S. Census Bureau population estimates for 2010 and 2015. [www.census.gov/data.html](http://www.census.gov/data.html).

Muskegon is characterized by rural areas in the eastern portion of the county with most of the county population located along Lake Michigan in the western portion of the county. The population has remained relatively stable. Figure 10 shows the county-level population density for Muskegon county.

**Figure 10. County-Level Population.**



### **Traffic and Vehicle Miles Travelled (VMT)**

The EPA evaluated the commuting patterns of residents, as well as the total vehicle miles traveled (VMT) for each county in the area of analysis. In combination with the population/population density data and the location of main transportation arteries, this information helps identify the probable location of non-point source emissions. A county with high VMT and/or a high number of commuters is generally an integral part of an urban area and high VMT and/or high number of commuters indicates the presence of motor vehicle emissions that may contribute to violations of the NAAQS. Rapid population or VMT growth in a county on the urban perimeter may signify increasing integration with the core urban area, and thus could indicate that the associated area source and mobile source emissions may be appropriate to include in the nonattainment area. In addition to VMT, the EPA evaluated worker data collected by the U.S. Census Bureau<sup>24</sup> for the area of analysis. Table 9 shows the traffic and commuting pattern data, including total VMT for Muskegon County, number of residents who work in the county, number of

<sup>24</sup> The worker data can be accessed at: <http://onthemap.ces.census.gov/>.

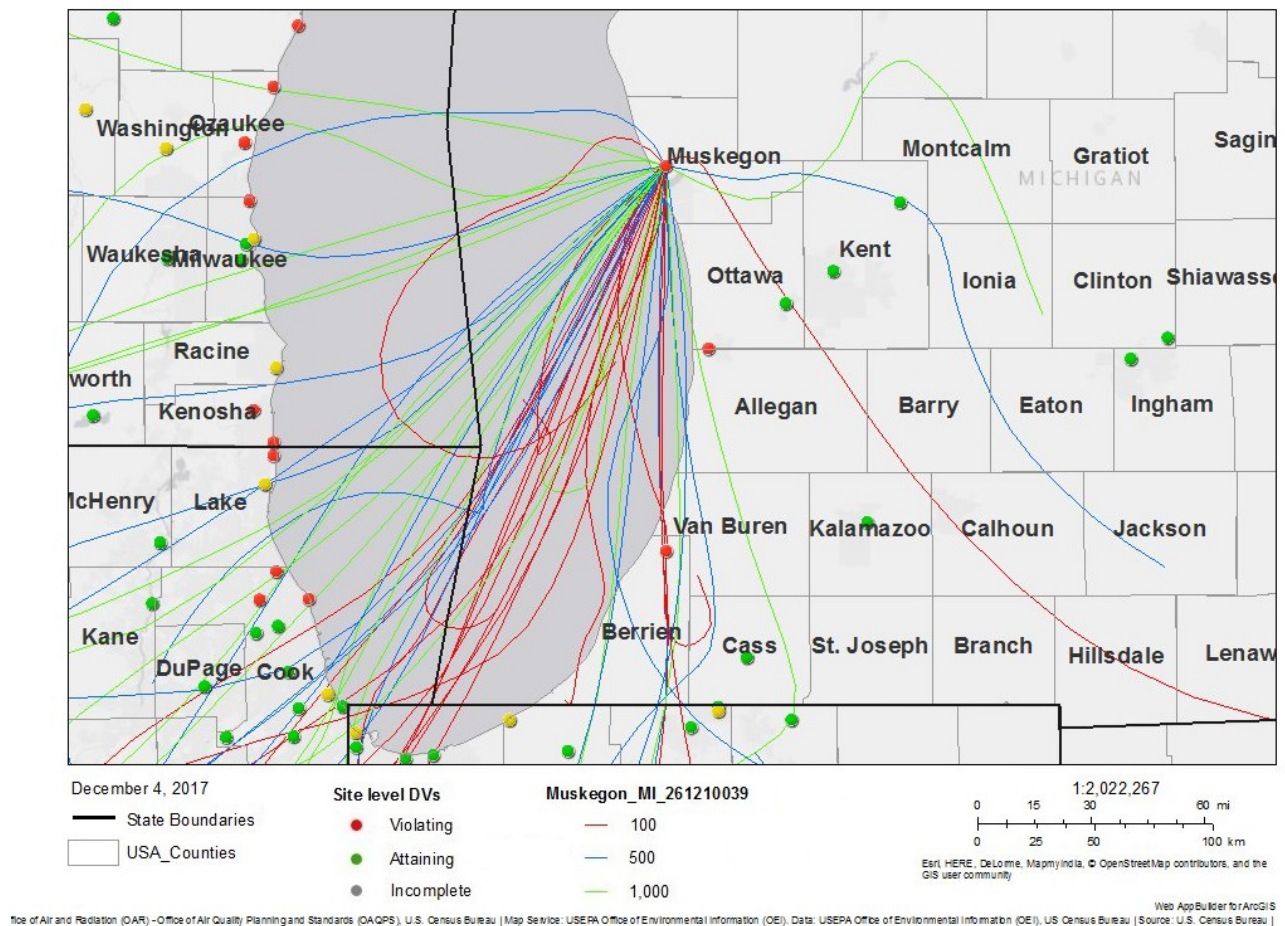




### Factor 3: Meteorology

Evaluation of meteorological data helps to assess the fate and transport of emissions contributing to ozone concentrations and to identify areas potentially contributing to the monitored violations. Results of meteorological data analysis may inform the determination of nonattainment area boundaries. In order to determine how meteorological conditions, including, but not limited to, weather, transport patterns, and stagnation conditions, could affect the fate and transport of ozone and precursor emissions from sources in the area., the EPA evaluated 2014-2016 HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) trajectories at 100, 500, and 1000 meters above ground level (AGL) that illustrate the three-dimensional paths traveled by air parcels to a violating monitor. Figure 12 shows the 24-hour HYSPLIT back trajectories for each exceedance day (i.e., daily maximum 8 hour values that exceed the 2015 ozone NAAQS) for the violating monitor.

**Figure 12. HYSPLIT Back Trajectories for Violating Monitor.**



The HYSPLIT trajectories (Figure 12) indicate that exceedance day air masses generally traveled from the south and southwest prior to being detected at the violating monitor. The HYSPLIT trajectories indicate the exceedance day air masses traveled over upwind areas (such as Chicago and Milwaukee) and Lake Michigan to reach the violating monitor in Muskegon County. The upwind land areas are not located adjacent to Muskegon County, and are evaluated as separate nonattainment areas.

As previously indicated, the peer-reviewed results from the Lake Michigan-specific ozone studies and the HYSPLIT trajectories presented here both provide evidence that lake breeze meteorology plays a role in ozone production and transport to Muskegon County. This factor shows that the violating monitor is mainly affected by emissions coming from the southwest over Lake Michigan.

#### **Factor 4: Geography/topography**

Consideration of geography or topography can provide additional information relevant to defining nonattainment area boundaries. Analyses should examine the physical features of the land that might define the airshed. Mountains or other physical features may influence the fate and transport of emissions as well as the formation and distribution of ozone concentrations. The absence of any such geographic or topographic features may also be a relevant consideration in selecting boundaries for a given area.

The EPA used geography/topography analysis to evaluate the physical features of the land that might affect the airshed and, therefore, the distribution of ozone over the area.

The Muskegon area does not have any geographical or topographical features significantly limiting air pollution transport within the county. However, it is largely affected by lake breeze effects contributing to ozone transport across Lake Michigan.

#### **Factor 5: Jurisdictional boundaries**

Once the geographic extent of the violating area and the nearby area contributing to violations is determined, the EPA considered existing jurisdictional boundaries for the purposes of providing a clearly defined legal boundary to carry out the air quality planning and enforcement functions for nonattainment areas. In defining the boundaries of the Muskegon nonattainment area, the EPA considered existing jurisdictional boundaries, which can provide easily identifiable and recognized boundaries for purposes of implementing the NAAQS. Examples of jurisdictional boundaries include, but are not limited to: counties, air districts, areas of Indian country, metropolitan planning organizations, townships and existing nonattainment areas. If an existing jurisdictional boundary is used to help define the nonattainment area, it must encompass all of the area that has been identified as meeting the nonattainment definition. Where existing jurisdictional boundaries are not adequate or appropriate to describe the nonattainment area, the EPA considered other clearly defined and permanent landmarks or geographic coordinates for purposes of identifying the boundaries of the designated areas.

For the 1997 ozone NAAQS, Muskegon County was designated nonattainment with the county boundary being the boundary of the nonattainment area. Michigan has recommended the following townships, villages and cities in the western portion of Muskegon County be designated as nonattainment for the 2015 ozone NAAQS: White River, Montague, Whitehall, Blue Lake, Fruitland, Dalton, Laketon, Muskegon, Muskegon Heights, North Muskegon, Norton Shores and Fruitport townships

#### **Additional Information:**

Given the unique meteorology described above, we also provide a comparison of emissions from the upwind areas to Muskegon, indicating that source areas on the western and southern shore of Lake Michigan emit 50 times more NO<sub>x</sub> and 45 times more VOC than sources in Muskegon County.

**Table 10. Total County-Level NO<sub>x</sub> and VOC Emissions Comparison to Upwind Areas.**

County	State Recommended Nonattainment?	Total NO <sub>x</sub> (tpy)	Total VOC (tpy)
Muskegon, MI	Yes (Partial)*	6,616	5,662
Chicago and Milwaukee CSAs	n/a	326,262	255,300

\* For state recommended partial counties, the data provided are for the entire county.

## Conclusion for Muskegon Area

The meteorological data strongly indicates that the violating monitor in Muskegon is predominantly affected by the transport of emissions over Lake Michigan. Muskegon County has a population of 172,188 mostly centered in the western portion of the county and has only one large point source of ozone precursor emissions. Over 99% of the point source NO<sub>x</sub> and 89% of point source VOC emissions are from inside the partial county nonattainment area, the eastern boundary of which ranges from about 9 to 17 miles from the shore. This is consistent with the distance from the shore that the ozone monitors in western Michigan start to show attainment. The EPA is designating the following western townships, villages and cities as the Muskegon area nonattainment area: White River, Montague, Whitehall, Blue Lake, Fruitland, Dalton, Laketon, Muskegon, Muskegon Heights, North Muskegon, Norton Shores and Fruitport townships

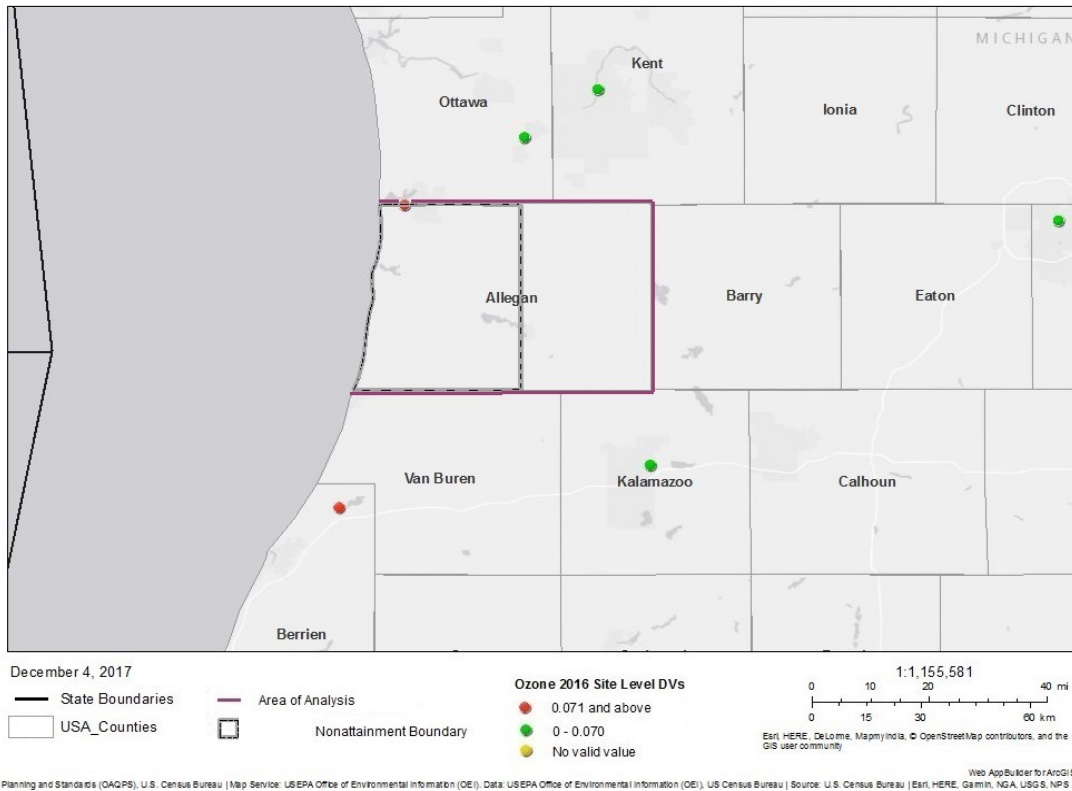
### 3.4 Technical Analysis for Allegan Area

Allegan County is the only county comprising the Holland CBSA. Meteorological data strongly indicates that the violating monitor in Allegan County is predominantly affected by the transport of emissions over Lake Michigan. As shown in Figure 18, the majority of HYSPLIT trajectories on high ozone days are from the southwest and west over Lake Michigan. Allegan County is also downwind of neighboring Van Buren County on high ozone days. However, Van Buren County has less than 6,000 tons combined NO<sub>x</sub> and VOC emissions and is therefore not expected to contribute to the violating monitor. The HYSPLIT trajectories indicate that the exceedance day air masses traveled from upwind urban areas across Lake Michigan and similarly longer-range locations to the south of Michigan to reach the violating monitor in Allegan County.

Figure 13 is a map of the EPA's nonattainment boundary for the Allegan Area. The map shows the location of the ambient air quality monitors, county, and other jurisdictional boundaries.

For the 1997 ozone NAAQS, this area was designated nonattainment. The boundary for the nonattainment area for the 1997 ozone NAAQS included all of Allegan County. For the 2008 ozone NAAQS, Allegan County was designated attainment.

**Figure 13. EPA's Nonattainment Boundaries for the Allegan Area**



The EPA must designate as nonattainment any area that violates the NAAQS and any nearby areas that contribute to the violation in the violating area. Allegan County has a monitor in violation of the 2015 ozone NAAQS, therefore the western part of this county that contains the violating monitor and is most affected by transport is included in the nonattainment area. The EPA determined that no other nearby counties contribute to the violating monitor in Allegan County. The following sections describe the five factor analysis. While the factors are presented individually, they are not independent. The five factor analysis process carefully considers the interconnections among the different factors and the dependence of each factor on one or more of the others, such as the interaction between emissions and meteorology for the area being evaluated.

## Factor Assessment

### Factor 1: Air Quality Data

The EPA considered 8-hour ozone design values in ppm for the air quality monitor in the Allegan area based on data for the 2014-2016 period (i.e., the 2016 design value, or DV). This is the most recent three-year period with fully-certified air quality data. The design value is the 3-year average of the annual 4<sup>th</sup> highest daily maximum 8-hour average ozone concentration. The 2015 NAAQS are met when the design value is 0.070 ppm or less. Only ozone measurement data collected in accordance with the quality assurance (QA) requirements using approved (FRM/FEM) monitors are used for NAAQS compliance determinations. The EPA uses FRM/FEM measurement data residing in the EPA's Air Quality System



(AQS) database to calculate the ozone design values. Individual violations of the 2015 ozone NAAQS that the EPA determines have been caused by an exceptional event that meets the administrative and technical criteria in the Exceptional Events Rule are not included in these calculations. Whenever several monitors are located in a county (or designated nonattainment area), the design value for the county or area is determined by the monitor with the highest valid design value. The presence of one or more violating monitors (i.e. monitors with design values greater than 0.070 ppm) in a county or other geographic area forms the basis for designating that county or area as nonattainment. The remaining four factors are then used as the technical basis for determining the spatial extent of the designated nonattainment area surrounding the violating monitors based on a consideration of what nearby areas are contributing to a violation of the NAAQS.

The EPA identified a monitor where the most recent design value violates the NAAQS, and examined historical ozone air quality measurement data (including previous design values) to understand the nature of the ozone ambient air quality problem in the area. Eligible monitors for providing design value data generally include State and Local Air Monitoring Stations (SLAMS) that are operated in accordance with 40 CFR part 58, appendix A, C, D and E and operating with an FRM or FEM monitor. These requirements must be met in order to be acceptable for comparison to the 2015 ozone NAAQS for designation purposes. All data from Special Purpose Monitors (SPMs) using an FRM or FEM are eligible for comparison to the NAAQS, subject to the requirements given in the March 28, 2016 Revision to Ambient Monitoring Quality Assurance and Other Requirements Rule (81 FR 17248).

The 2014-2016 design value for Allegan County is shown in Table 11.

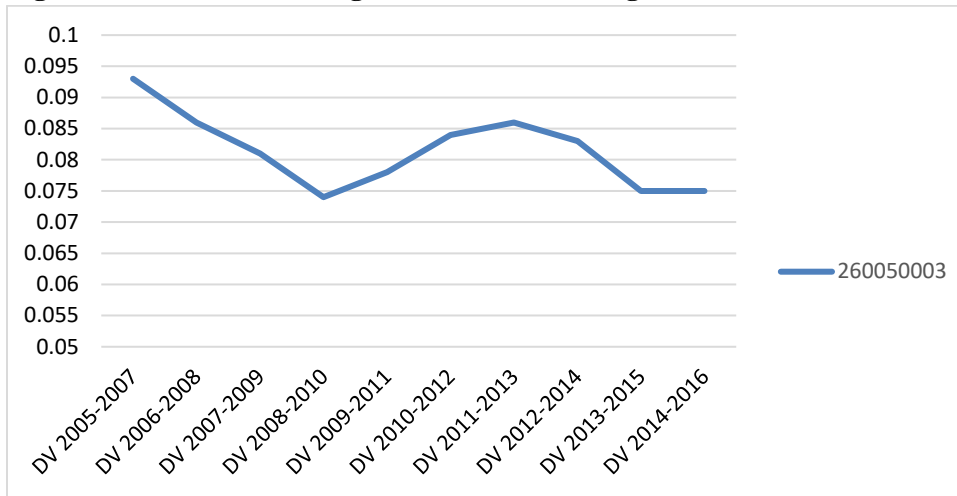
**Table 11. Air Quality Data (all values in ppm).<sup>a</sup>**

County, State	State Recommended Nonattainment?	AQS Site ID	2014-2016 DV	2014 4 <sup>th</sup> highest daily max value	2015 4 <sup>th</sup> highest daily max value	2016 4 <sup>th</sup> highest daily max value
Allegan, MI	Yes (Partial)	260050003	<b>0.075</b>	0.077	0.072	0.076

<sup>a</sup>The highest design value in each county is indicated in bold type.

Allegan County shows a violation of the 2015 ozone NAAQS, therefore part of Allegan County is included in the nonattainment area. Figure 13, shown previously, identifies the Allegan nonattainment area, the CBSA boundary and the violating monitor. Table 11 identifies the design value for the monitor in the area of analysis and Figure 14 shows the historical trend of design values for the violating monitors. As indicated on the map, there is one violating monitor that is located at the Northwest corner of Allegan County, close to Lake Michigan. As shown in Figure 14, with the exception of an increase for the 2012 and 2013 design values, overall, ozone levels have come down over the last 10 years but have remained fairly steady over the last few years.

**Figure 14. Three-Year Design Values for Violating Monitors (2007-2016).**



**Factor 2: Emissions and Emissions-Related Data**

The EPA evaluated ozone precursor emissions of nitrogen oxides (NO<sub>x</sub>) and volatile organic compounds (VOC) and other emissions-related data that provide information on areas contributing to violating monitors.

**Emissions Data**

The EPA reviewed data from the 2014 National Emissions Inventory (NEI). For each county in the area of analysis, the EPA examined the magnitude of large sources (NO<sub>x</sub> or VOC emissions greater than 100 tons per year) and small point sources and the magnitude of county-level emissions reported in the NEI. These county-level emissions represent the sum of emissions from the following general source categories: point sources, non-point (i.e., area) sources, non-road mobile, on-road mobile, and fires. Significant emissions levels from sources in a nearby area indicate the potential for the area to contribute to monitored violations.

Table 12 provides a county-level emissions summary of NO<sub>x</sub> and VOC (given in tons per year (tpy)) emissions for Allegan County.

**Table 12. Total County-Level NO<sub>x</sub> and VOC Emissions.**

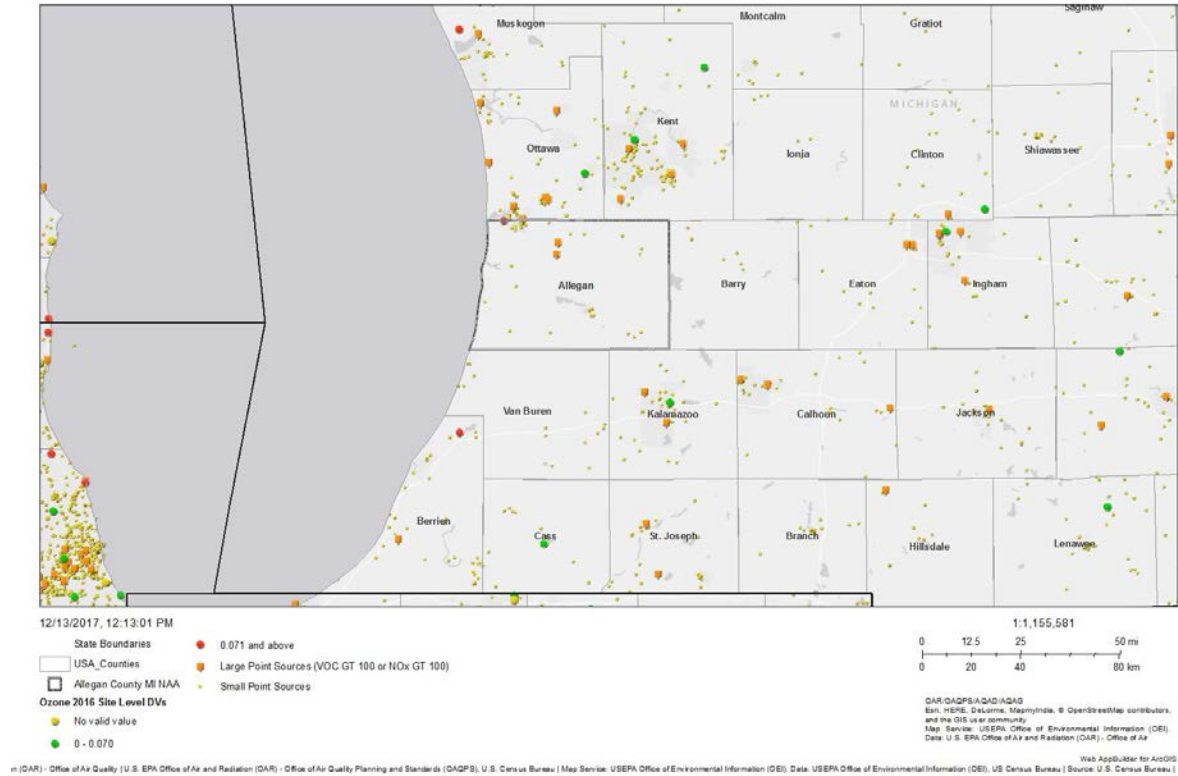
County	State Recommended Nonattainment?	Total NO <sub>x</sub> (tpy)	Total VOC (tpy)
Allegan, MI	Yes (Partial)*	4,764	5,165

\* For state recommended partial counties, the emissions shown are for the entire county.

In addition to reviewing county-wide emissions of NO<sub>x</sub> and VOC in the area of analysis, the EPA also reviewed emissions from large and small point sources. The location of these sources, together with the other factors, can help inform nonattainment boundaries. There are three large point sources in Allegan County as well as several smaller sources as shown in Figure 15 below. There is a total of 767 tpy of NO<sub>x</sub> emissions from point sources in Allegan County and 83% of these emissions are from within the western

part of Allegan County that Michigan recommended to be designated as nonattainment. There is a total of 346 tpy of VOC emissions from point sources in Allegan County and 81% of these emissions are from within the western part of Allegan County that Michigan recommended to be designated as nonattainment.

**Figure 15. Large and Small Point Sources in the Area of Analysis.**



**Population density and degree of urbanization**

In this part of the factor analysis, the EPA evaluated the population and vehicle use characteristics and trends of the area as indicators of the probable location and magnitude of non-point source emissions. These include emissions of NO<sub>x</sub> and VOC from on-road and non-road vehicles and engines, consumer products, residential fuel combustion, and consumer services. Areas of dense population or commercial development are an indicator of area source and mobile source NO<sub>x</sub> and VOC emissions that may contribute to violations of the NAAQS. Table 13 shows the population, population density, and population growth information for Allegan County. Figure 16 shows the county-level population density for the area.

**Table 13. Population and Growth.**

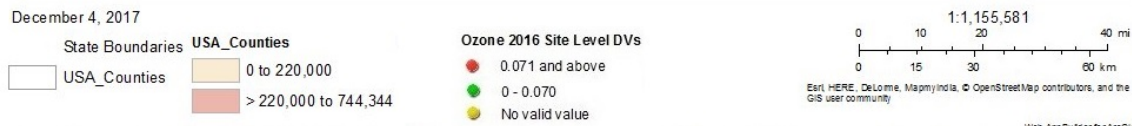
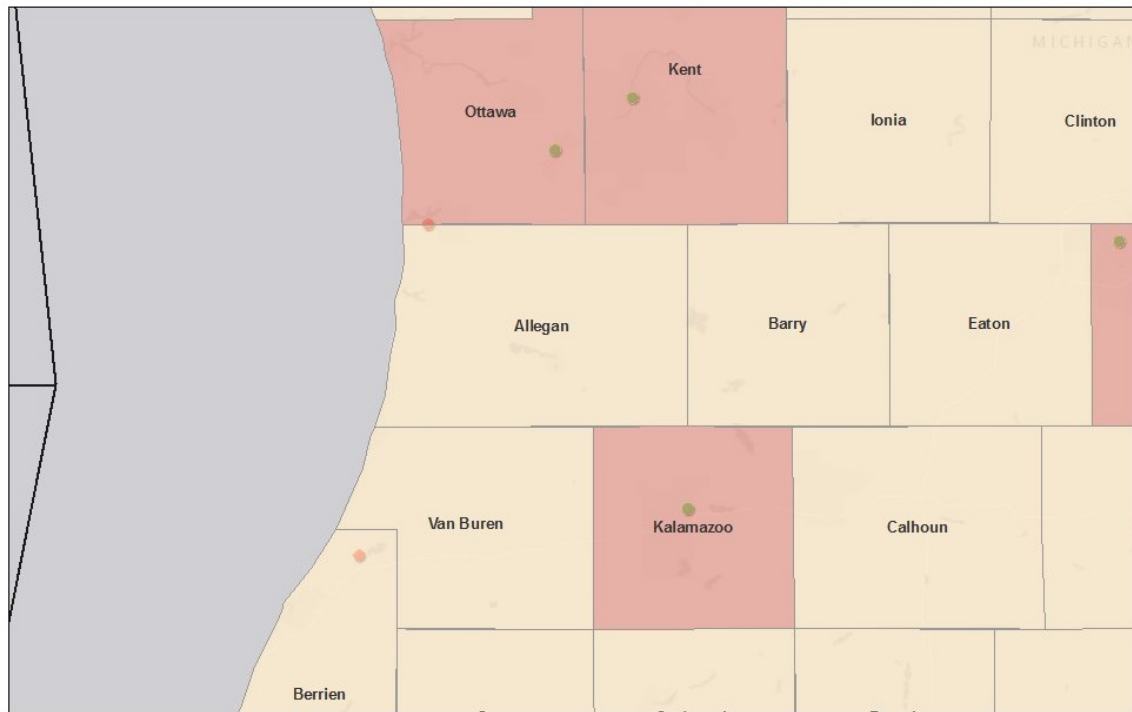
County	State Recommended Nonattainment?	2010 Population	2015 Population	2015 Population Density (per sq. mi.)	Absolute change in population (2010-2015)	Population % change (2010-2015)
Allegan, MI	Yes (Partial)*	111,408	114,625	139	3217	3

\* For state recommended partial counties, the data provided are for the entire county.

Source: U.S. Census Bureau population estimates for 2010 and 2015. [www.census.gov/data.html](http://www.census.gov/data.html).

Allegan County has a population of approximately 115,000 and a population density of 139 people per square mile. Allegan county includes several small cities all with populations of less than 5,000 residents as well as the southern portion of Holland, MI, a city with a population around 33,000.

**Figure 16. County-Level Population.**



Air Quality Planning and Standards (OAQPS), U.S. Census Bureau | Map Service: USEPA Office of Environmental Information (OEI), Data: USEPA Office of Environmental Information (OEI), US Census Bureau | Source: U.S. Census Bureau | Esri, HERE, Garmin, NGA, USGS, NPS |

**Traffic and Vehicle Miles Travelled (VMT)**

The EPA evaluated the commuting patterns of residents, as well as the total vehicle miles traveled (VMT) for each county in the area of analysis. In combination with the population/population density data and the location of main transportation arteries, this information helps identify the probable location of non-

point source emissions. A county with high VMT and/or a high number of commuters is generally an integral part of an urban area and high VMT and/or high number of commuters indicates the presence of motor vehicle emissions that may contribute to violations of the NAAQS. Rapid population or VMT growth in a county on the urban perimeter may signify increasing integration with the core urban area, and thus could indicate that the associated area source and mobile source emissions may be appropriate to include in the nonattainment area. In addition to VMT, the EPA evaluated worker data collected by the U.S. Census Bureau<sup>25</sup> for the Allegan County area. Table 14 shows the traffic and commuting pattern data, including total VMT for each county, number of residents who work in each county, number of residents that work in the counties with a violating monitor, and the percent of residents working in counties with a violating monitor. The data in Table 14 are 2014 data.

**Table 14. Traffic and Commuting Patterns.**

County	State Recommended Nonattainment?	2014 Total VMT (Million Miles)	Number of County Residents Who Work	Number Commuting to or Within Counties with Violating Monitor(s)	Percentage Commuting to or Within Counties with Violating Monitor(s)
Allegan, MI	Yes*	1,486	54,689	14,862	27.2%

\* For state recommended partial counties, the data provided are for the entire county.

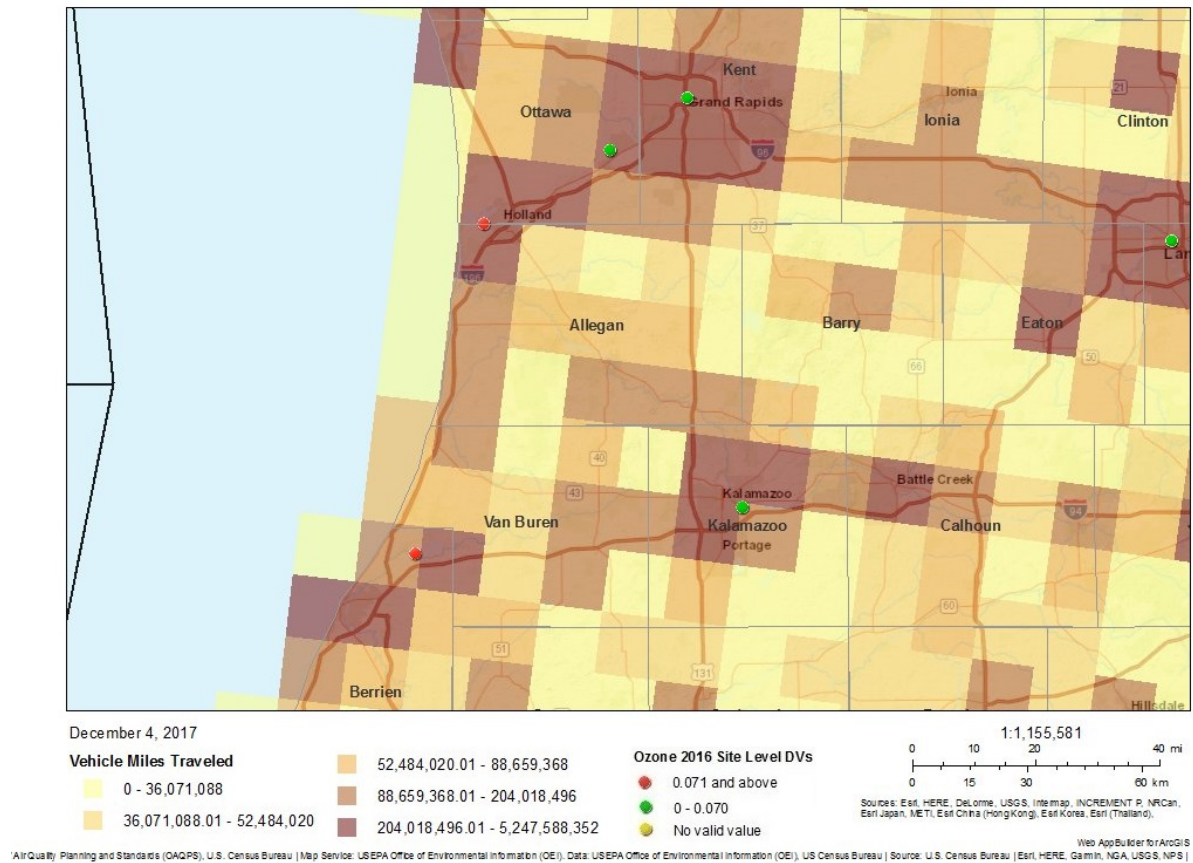
Counties with a monitor(s) violating the NAAQS are indicated in bold.

To show traffic and commuting patterns, Figure 17 overlays twelve-kilometer gridded VMT from the 2014 NEI with a map of the transportation arteries.

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<sup>25</sup> The worker data can be accessed at: <http://onthemap.ces.census.gov/>.

**Figure 17. Twelve Kilometer Gridded VMT (Miles) Overlaid with Transportation Arteries.**



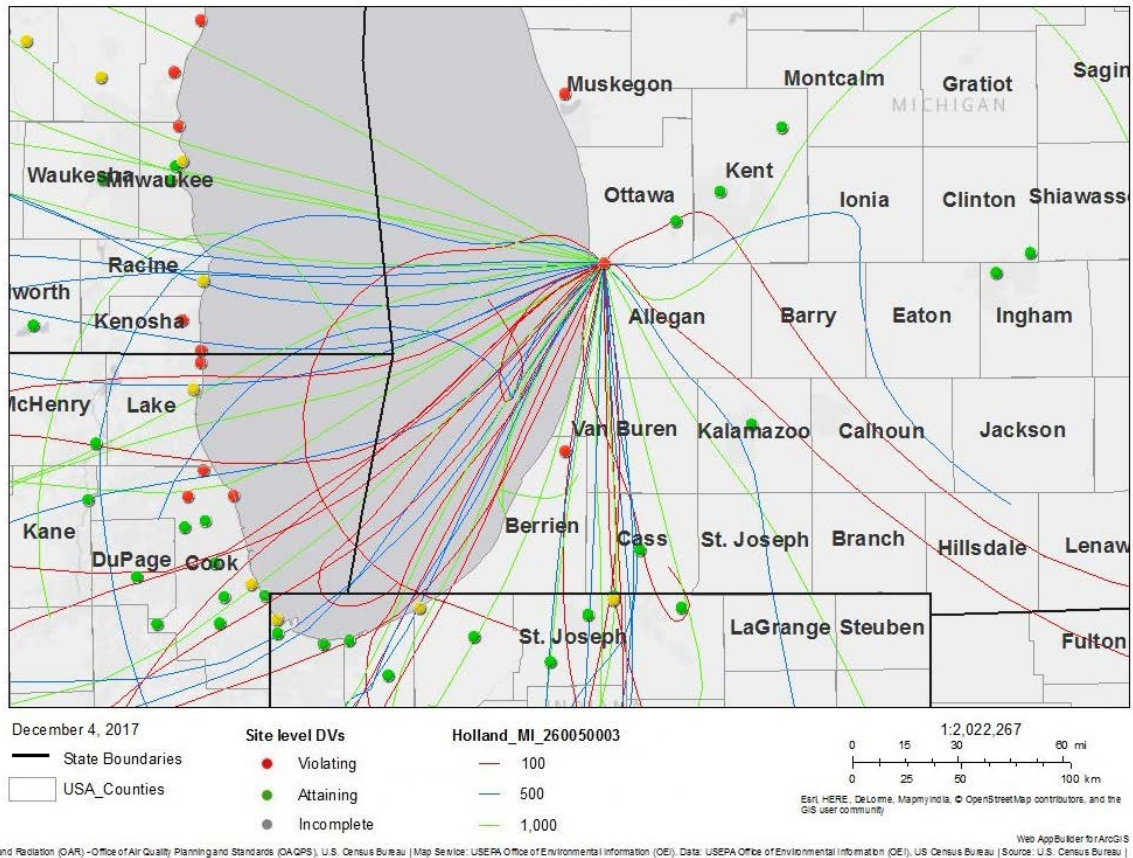
Allegan County has less than 2 billion VMT and less than 15,000 county residents commuting to or within Allegan County.

### Factor 3: Meteorology

Evaluation of meteorological data helps to assess the fate and transport of emissions contributing to ozone concentrations and to identify areas potentially contributing to the monitored violations. Results of meteorological data analysis may inform the determination of nonattainment area boundaries. In order to determine how meteorological conditions, including, but not limited to, weather, transport patterns, and stagnation conditions, could affect the fate and transport of ozone and precursor emissions from sources in the area., the EPA evaluated 2014-2016 HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) trajectories at 100, 500, and 1000 meters above ground level (AGL) that illustrate the three-dimensional paths traveled by air parcels to a violating monitor. Figure 18 shows the 24-hour HYSPLIT back trajectories for each exceedance day (i.e., daily maximum 8 hour values that exceed the 2015 ozone NAAQS) for the violating monitor.



**Figure 18. HYSPLIT Back Trajectories for Violating Monitor.**



The western boundary of Allegan County follows the shoreline of Lake Michigan. Due to its proximity to the lake, Allegan County has the potential to be impacted by lake breeze meteorology. The HYSPLIT trajectories (Figure 18) indicate that exceedance day air masses generally traveled from the south, southwest, and west prior to being detected at the violating monitor. The HYSPLIT trajectories indicate the exceedance day air masses traveled over upwind areas (such as Chicago and Milwaukee) and Lake Michigan to reach the violating monitor, as well as over land in nearby Van Buren County (which has few emissions sources). The upwind areas across Lake Michigan are not located adjacent to Muskegon County, and are evaluated as separate nonattainment areas.

As previously indicated, the peer-reviewed results from the Lake Michigan-specific ozone studies and the HYSPLIT trajectories presented here both provide evidence that lake breeze meteorology plays a role in ozone production and transport to Allegan County. In combination with information on the location of emissions sources, this factor shows that the violating monitor is mainly affected by emissions coming from the southwest and west over Lake Michigan.

#### **Factor 4: Geography/topography**

Consideration of geography or topography can provide additional information relevant to defining nonattainment area boundaries. Analyses should examine the physical features of the land that might define the airshed. Mountains or other physical features may influence the fate and transport of emissions as well as the formation and distribution of ozone concentrations. The absence of any such geographic or topographic features may also be a relevant consideration in selecting boundaries for a given area.

The EPA used geography/topography analysis to evaluate the physical features of the land that might affect the airshed and, therefore, the distribution of ozone over the area.

The Allegan area does not have any geographical or topographical features significantly limiting air pollution transport within its air shed. However, it is largely affected by lake breeze effects contributing to ozone transport across Lake Michigan.

#### **Factor 5: Jurisdictional boundaries**

Once the geographic extent of the violating area and the nearby area contributing to violations is determined, the EPA considered existing jurisdictional boundaries for the purposes of providing a clearly defined legal boundary to carry out the air quality planning and enforcement functions for nonattainment areas. In defining the boundaries of the Allegan nonattainment area, the EPA considered existing jurisdictional boundaries, which can provide easily identifiable and recognized boundaries for purposes of implementing the NAAQS. Examples of jurisdictional boundaries include, but are not limited to: counties, air districts, areas of Indian country, metropolitan planning organizations, townships and existing nonattainment areas. If an existing jurisdictional boundary is used to help define the nonattainment area, it must encompass all of the area that has been identified as meeting the nonattainment definition. Where existing jurisdictional boundaries are not adequate or appropriate to describe the nonattainment area, the EPA considered other clearly defined and permanent landmarks or geographic coordinates for purposes of identifying the boundaries of the designated areas.

For the 1997 ozone NAAQS, Allegan County was designated nonattainment with the county boundary being the boundary of the nonattainment area. Michigan has recommended the following townships, villages and cities in the western half of Allegan County be designated as nonattainment for the 2015 ozone NAAQS: Casco, Cheshire, Clyde, Douglas, Fillmore, Ganges, Heath, Holland (only the part in Allegan County), Laketown, Lee, Manilus, Overisel, Sagatuck and Valley.

#### **Additional Information:**

Given the unique meteorology described above, we also provide a comparison of emissions from the upwind areas to Allegan in Table 15, indicating that source areas on the western and southern shore of Lake Michigan emit 68 times more NO<sub>x</sub> and nearly 45 times more VOC than sources in Allegan County. In addition, we provide information on neighboring Van Buren County. As shown in Figure 15 there are no large point sources in Van Buren County. Comparisons of VMT between Allegan and Van Buren County shown in Table 16 show that Van Buren County has substantially lower VMT than Allegan.



**Table 15. Total County-Level NO<sub>x</sub> and VOC Emissions Comparison to Upwind and Neighboring Areas.**

County	State Recommended Nonattainment?	Total NO <sub>x</sub> (tpy)	Total VOC (tpy)
Allegan, MI	Yes (Partial)*	4,764	5,165
Van Buren, MI	No	2,732	3,095
Chicago and Milwaukee CSAs	n/a	326,262	255,300

\* For state recommended partial counties, the data provided are for the entire county.

**Table 16. Traffic and Commuting Patterns comparison to Neighboring Areas.**

County	State Recommended Nonattainment?	2014 Total VMT (Million Miles)	Number of County Residents Who Work	Number Commuting to or Within Counties with Violating Monitor(s)	Percentage Commuting to or Within Counties with Violating Monitor(s)
Allegan, MI	Yes (Partial)*	1,486	54,689	14,862	27.2%
Van Buren, MI	No	954	30,464	1,413	5%

\* For state recommended partial counties, the data provided are for the entire county.

Counties with a monitor(s) violating the NAAQS are indicated in bold.

## Conclusion for Allegan Area

The violating monitor in Allegan County is affected on high ozone days by the transport of emissions over Lake Michigan. This is supported by the HYSPLIT back-trajectories over Lake Michigan. Although there are a number of back-trajectories on high ozone days from neighboring Van Buren County, this county has less than 6,000 tons combined NO<sub>x</sub> and VOC emissions and would therefore not be expected to contribute to the violating monitor in Allegan County. Allegan County's low population, low NO<sub>x</sub> and VOC emissions and low VMT further support transport as being the main reason for the violation in Allegan County. Eighty-three percent (83%) of the point source NO<sub>x</sub> and 81% of point source VOC emissions are from inside the partial county nonattainment area, the eastern boundary of which ranges from about 16 to 19 miles from the shore. This is consistent with the distance from the shore that the ozone monitors in western Michigan start to show attainment. The EPA is designating the following western townships, villages and cities as the Muskegon area nonattainment area: Casco, Cheshire, Clyde, Douglas, Fillmore, Ganges, Heath, Holland (only the part in Allegan County), Laketown, Lee, Manilus, Overisel, Sagatuck and Valley.

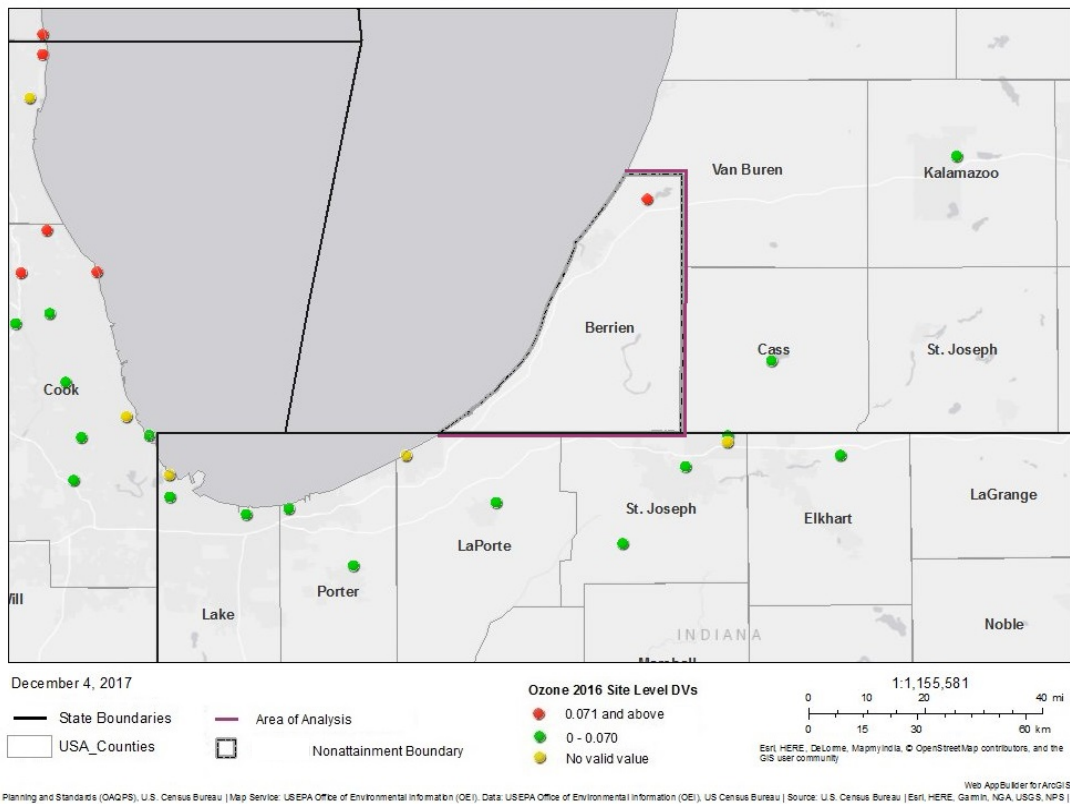
### 3.5 Technical Analysis for Berrien County

Berrien County is the only county comprising the Niles-Benton Harbor CBSA. Meteorological data strongly indicates that the violating monitor in Berrien County is predominantly affected by the transport

of emissions over Lake Michigan and similarly far reaching areas of Indiana. As shown in Figure 24, the majority of HYSPLIT trajectories are from the southwest and west over Lake Michigan and the south from Indiana. Although there are back-trajectories crossing Cass County, MI and St. Joseph, La Porte and Elkhart counties in Indiana, these counties have relatively few emissions compared to the upwind Chicago area and are therefore not expected to contribute to the violating monitor.

For the 1997 ozone NAAQS, this area was designated nonattainment. The nonattainment area for the 1997 ozone NAAQS included all of Berrien County. For the 2008 ozone NAAQS, Berrien County was designated attainment.

**Figure 19. EPA's Nonattainment Boundaries for the Berrien Area**



The EPA must designate as nonattainment any area that violates the NAAQS and any nearby areas that contribute to the violation in the violating area. Berrien County has a monitor in violation of the 2015 ozone NAAQS, therefore this county is included in the nonattainment area. The EPA determined, based upon HYSPLIT back-trajectories and emissions from neighboring counties that no other nearby counties contribute to the violating monitor in Berrien County. The following sections describe the five factor analysis. While the factors are presented individually, they are not independent. The five factor analysis process carefully considers the interconnections among the different factors and the dependence of each factor on one or more of the others, such as the interaction between emissions and meteorology for the area being evaluated.

## Factor Assessment

### Factor 1: Air Quality Data

The EPA considered 8-hour ozone design values in ppm for the air quality monitor in the Berrien area based on data for the 2014-2016 period (i.e., the 2016 design value, or DV). This is the most recent three-year period with fully-certified air quality data. The design value is the 3-year average of the annual 4<sup>th</sup> highest daily maximum 8-hour average ozone concentration. The 2015 NAAQS are met when the design value is 0.070 ppm or less. Only ozone measurement data collected in accordance with the quality assurance (QA) requirements using approved (FRM/FEM) monitors are used for NAAQS compliance determinations. The EPA uses FRM/FEM measurement data residing in the EPA's Air Quality System (AQS) database to calculate the ozone design values. Individual violations of the 2015 ozone NAAQS that the EPA determines have been caused by an exceptional event that meets the administrative and technical criteria in the Exceptional Events Rule are not included in these calculations. Whenever several monitors are located in a county (or designated nonattainment area), the design value for the county or area is determined by the monitor with the highest valid design value. The presence of one or more violating monitors (i.e. monitors with design values greater than 0.070 ppm) in a county or other geographic area forms the basis for designating that county or area as nonattainment. The remaining four factors are then used as the technical basis for determining the spatial extent of the designated nonattainment area surrounding the violating monitor(s) based on a consideration of what nearby areas are contributing to a violation of the NAAQS.

The EPA identified a monitor where the most recent design value violates the NAAQS, and examined historical ozone air quality measurement data (including previous design values) to understand the nature of the ozone ambient air quality problem in the area. Eligible monitors for providing design value data generally include State and Local Air Monitoring Stations (SLAMS) that are operated in accordance with 40 CFR part 58, appendix A, C, D and E and operating with an FRM or FEM monitor. These requirements must be met in order to be acceptable for comparison to the 2015 ozone NAAQS for designation purposes. All data from Special Purpose Monitors (SPMs) using an FRM or FEM are eligible for comparison to the NAAQS, subject to the requirements given in the March 28, 2016 Revision to Ambient Monitoring Quality Assurance and Other Requirements Rule (81 FR 17248).

The 2014-2016 design value for Berrien County is shown in Table 17.

**Table 17. Air Quality Data (all values in ppm).<sup>a</sup>**

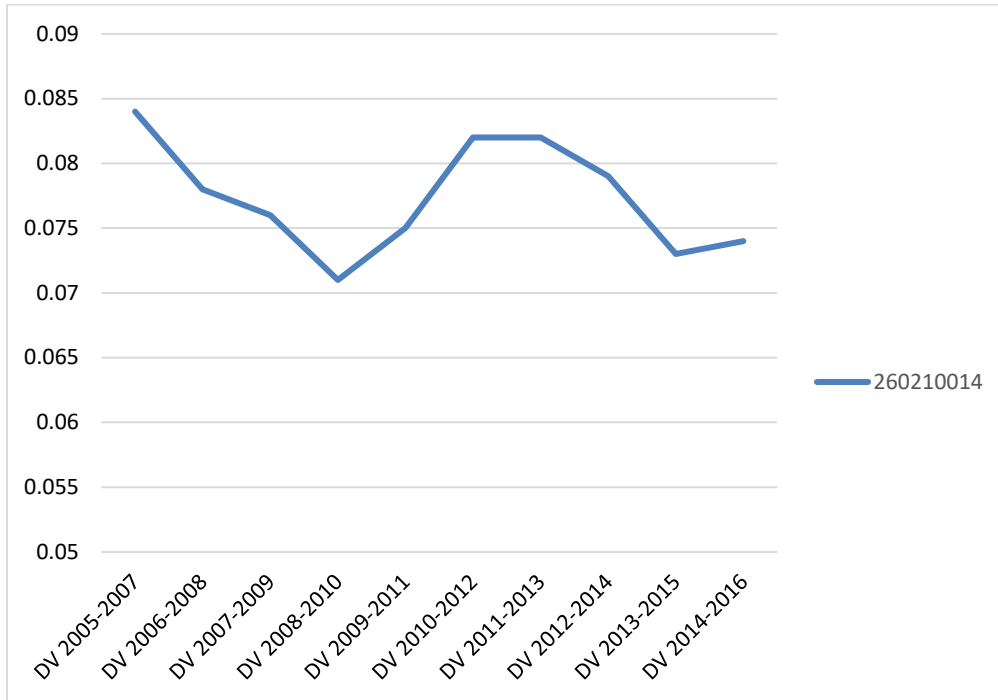
County, State	State Recommended Nonattainment?	AQS Site ID	2014-2016 DV	2014 4 <sup>th</sup> highest daily max value	2015 4 <sup>th</sup> highest daily max value	2016 4 <sup>th</sup> highest daily max value
Berrien, MI	Yes	26021004	<b>0.074</b>	0.073	0.072	0.078

<sup>a</sup>The highest design value in each county is indicated in bold type.

Berrien County shows a violation of the 2015 ozone NAAQ therefore it is included in the nonattainment area. Figure 19, shown previously, identifies the Berrien nonattainment area, the CBSA boundary and the violating monitor. Table 17 identifies the design value for the monitor in the area of analysis and Figure 20 shows the historical trend of design values for the violating monitors. As indicated on the map, there is one violating monitor that is located at the Northwest corner of Berrien County, close to Lake Michigan.

As shown in Figure 20, with the exception of 2012 and 2013 design values, ozone levels have come down over the last 10 years but have remained fairly steady over the last few years.

**Figure 20. Three-Year Design Values for Violating Monitors (2007-2016).**



**Factor 2: Emissions and Emissions-Related Data**

The EPA evaluated ozone precursor emissions of nitrogen oxides (NO<sub>x</sub>) and volatile organic compounds (VOC) and other emissions-related data that provide information on areas contributing to violating monitors.

**Emissions Data**

The EPA reviewed data from the 2014 National Emissions Inventory (NEI). For each county in the area of analysis, the EPA examined the magnitude of large sources (NO<sub>x</sub> or VOC emissions greater than 100 tons per year) and small point sources and the magnitude of county-level emissions reported in the NEI. These county-level emissions represent the sum of emissions from the following general source categories: point sources, non-point (i.e., area) sources, non-road mobile, on-road mobile, and fires. Significant emissions levels from sources in a nearby area indicate the potential for the area to contribute to monitored violations.

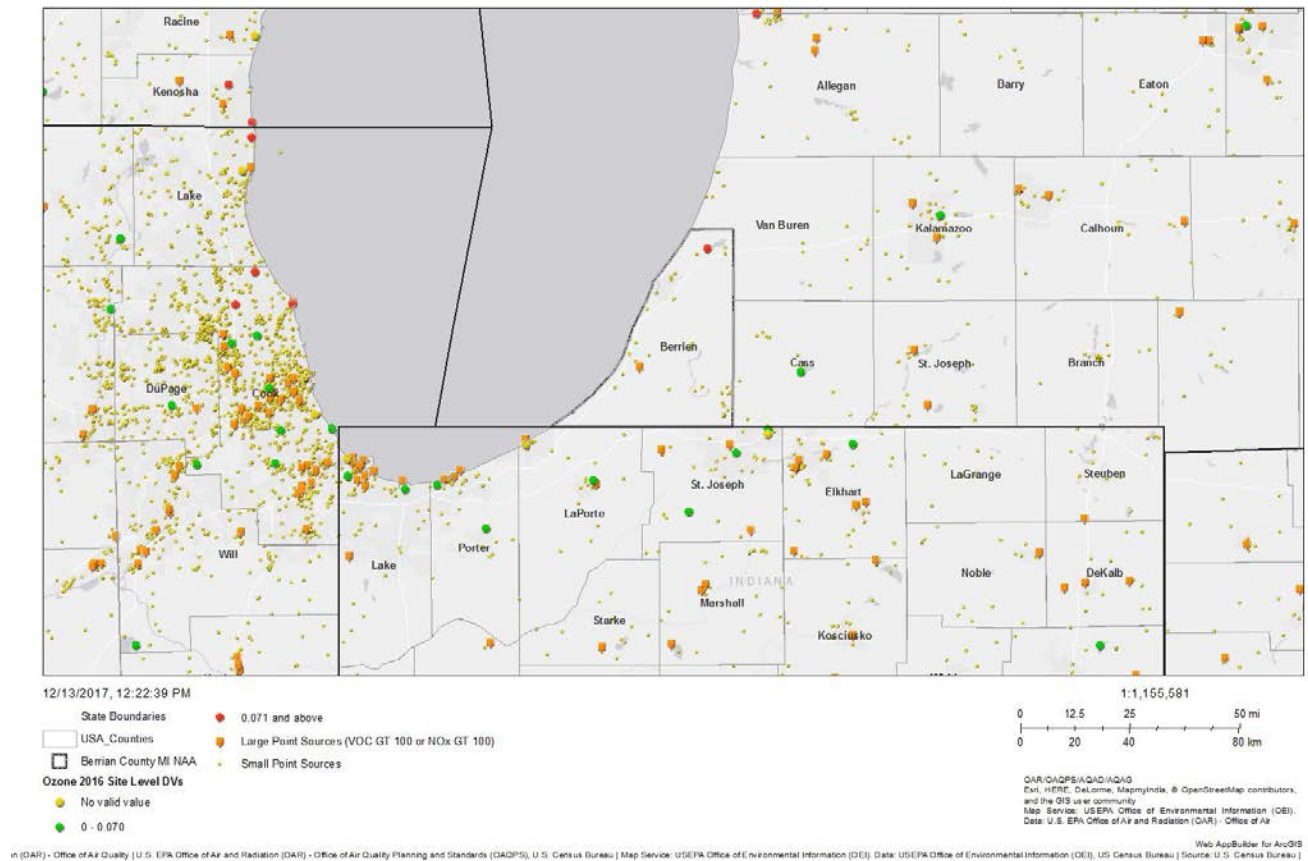
Table 18 provides a county-level emissions summary of NO<sub>x</sub> and VOC (given in tons per year (tpy)) emissions for Berrien County.

**Table 18. Total County-Level NO<sub>x</sub> and VOC Emissions.**

County	State Recommended Nonattainment?	Total NO <sub>x</sub> (tpy)	Total VOC (tpy)
Berrien, MI	Yes	5,609	6,351

In addition to reviewing county-wide emissions of NO<sub>x</sub> and VOC in the area of analysis, the EPA also reviewed emissions from large and small point sources. The location of these sources, together with the other factors, can help inform nonattainment boundaries. There is one large point source in Berrien County in addition to numerous smaller sources as shown in Figure 21 below.

**Figure 21. Large and Small Point Sources in the Area around Berrien County.**



**Population density and degree of urbanization**

In this part of the factor analysis, the EPA evaluated the population and vehicle use characteristics and trends of the area as indicators of the probable location and magnitude of non-point source emissions. These include emissions of NO<sub>x</sub> and VOC from on-road and non-road vehicles and engines, consumer products, residential fuel combustion, and consumer services. Areas of dense population or commercial development are an indicator of area source and mobile source NO<sub>x</sub> and VOC emissions that may contribute to violations of the NAAQS. Table 19 shows the population, population density, and population growth information for the area around Berrien County. Figure 22 shows the county-level population density for this area.

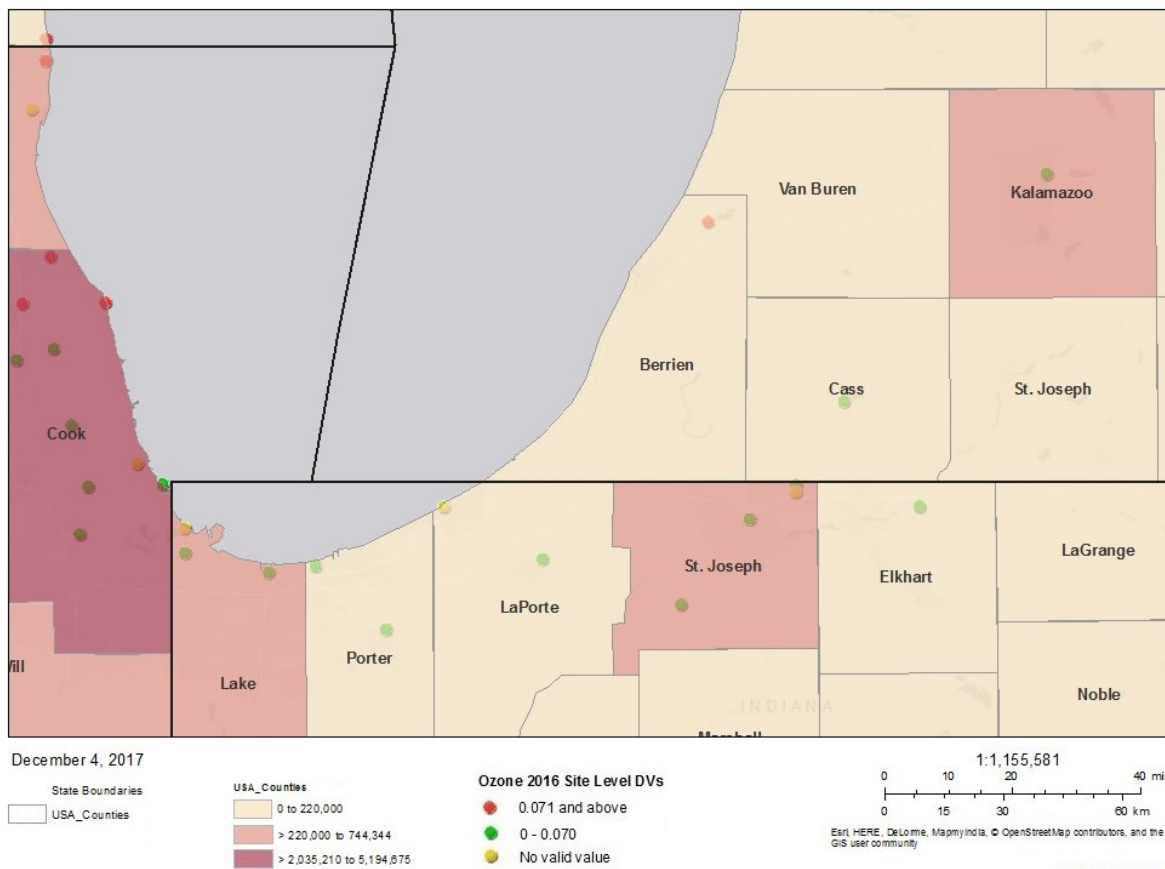
**Table 19. Population and Growth.**

County	State Recommended Nonattainment?	2010 Population	2015 Population	2015 Population Density (per sq. mi.)	Absolute change in population (2010-2015)	Population % change (2010-2015)
Berrien, MI	Yes	156,813	154,636	272	-2,177	-1

Source: U.S. Census Bureau population estimates for 2010 and 2015. <https://www.census.gov/popest/data/>

Berrien County has a shrinking population of 154,636 and a population density of 272 people per square mile.

**Figure 22. County-Level Population.**



**Traffic and Vehicle Miles Travelled (VMT)**

The EPA evaluated the commuting patterns of residents, as well as the total vehicle miles traveled (VMT) for each county in the area of analysis. In combination with the population/population density data and the location of main transportation arteries, this information helps identify the probable location of non-

point source emissions. A county with high VMT and/or a high number of commuters is generally an integral part of an urban area and high VMT and/or high number of commuters indicates the presence of motor vehicle emissions that may contribute to violations of the NAAQS. Rapid population or VMT growth in a county on the urban perimeter may signify increasing integration with the core urban area, and thus could indicate that the associated area source and mobile source emissions may be appropriate to include in the nonattainment area. In addition to VMT, the EPA evaluated worker data collected by the U.S. Census Bureau<sup>26</sup> for the area around Berrien County. Table 20 shows the traffic and commuting pattern data, including total VMT for the county, number of residents who work in the county, number of residents that work in the county with the violating monitor, and the percent of residents working in the county with violating monitor. The data in Table 20 are 2014 data.

**Table 20. Traffic and Commuting Patterns.**

County	State Recommended Nonattainment?	2014 Total VMT (Million Miles)	Number of County Residents Who Work	Number Commuting to or Within Counties with Violating Monitor(s)	Percentage Commuting to or Within Counties with Violating Monitor(s)
<b>Berrien, MI</b>	<b>Yes</b>	<b>2,066</b>	<b>64,803</b>	<b>39,265</b>	<b>60.6%</b>

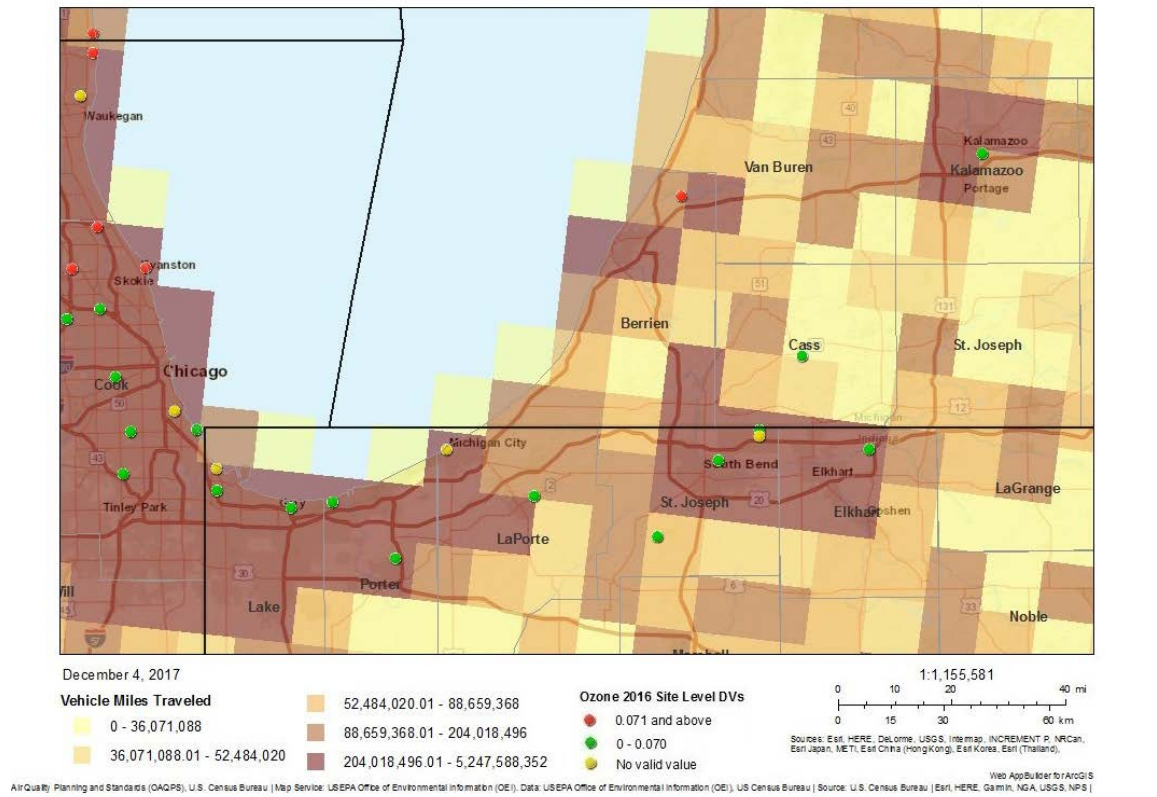
Counties with a monitor(s) violating the NAAQS are indicated in bold.

To show traffic and commuting patterns, Figure 23 overlays twelve-kilometer gridded VMT from the 2014 NEI with a map of the transportation arteries.

<sup>26</sup> The worker data can be accessed at: <http://onthemap.ces.census.gov/>.



**Figure 23. Twelve Kilometer Gridded VMT (Miles) Overlaid with Transportation Arteries.**



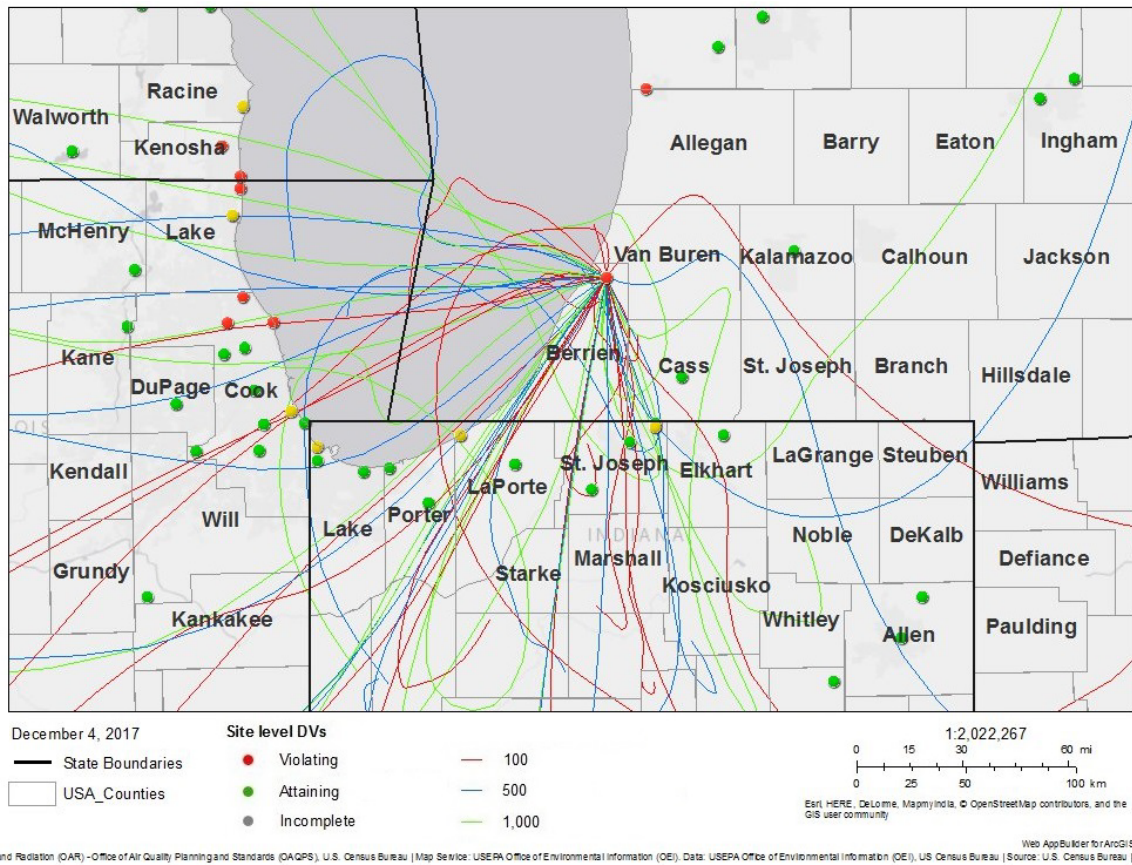
Berrien County has only about 2 billion VMT and less than 40,000 county residents commuting to or within Berrien County.

**Factor 3: Meteorology**

Evaluation of meteorological data helps to assess the fate and transport of emissions contributing to ozone concentrations and to identify areas potentially contributing to the monitored violations. Results of meteorological data analysis may inform the determination of nonattainment area boundaries. In order to determine how meteorological conditions, including, but not limited to, weather, transport patterns, and stagnation conditions, could affect the fate and transport of ozone and precursor emissions from sources in the area., the EPA evaluated 2014-2016 HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) trajectories at 100, 500, and 1000 meters above ground level (AGL) that illustrate the three-dimensional paths traveled by air parcels to a violating monitor. Figure 24 shows the 24-hour HYSPLIT back trajectories for each exceedance day (i.e., daily maximum 8 hour values that exceed the 2015 ozone NAAQS) for the violating monitor.



**Figure 24. HYSPLIT Back Trajectories for Violating Monitor**



The western boundary of Berrien County follows the shoreline of Lake Michigan. Due to its proximity to the lake, Berrien County has the potential to be impacted by lake breeze meteorology.

The HYSPLIT trajectories (Figure 24) indicate that exceedance day air masses generally traveled from the west, southwest and south prior to being detected at the violating monitor. Berrien County is downwind of the Chicago CSA (total 2014 reported CSA NO<sub>x</sub> = 274,440 tons, VOC= 206,171 tons) which includes counties in Northeast Illinois, Northwest Indiana and Southeast Wisconsin. Although there are a number of back-trajectories that cross Cass, MI and St. Joseph, La Porte and Elkhart counties in Indiana, due to the low emissions levels in these counties relative to Chicago (Cass County has about 4,000 tons combined NO<sub>x</sub> and VOC emissions, St. Joseph County, IN has less than 15,000 tons combined NO<sub>x</sub> and VOC emissions, La Porte county has less than 13,000 tons combined NO<sub>x</sub> and VOC emissions and Elkhart County, IN has about 16,000 tons combined NO<sub>x</sub> and VOC emissions) these counties are not expected to contribute to the violating monitor in Berrien County. The HYSPLIT trajectories indicate many exceedance day air masses traveled over Lake Michigan to reach the violating monitor in Berrien County. Any precursor emissions that flow out from upwind areas (i.e. Chicago) over the lake with the morning land breeze have the potential to photochemically react to form ozone, which has the potential to be transported by the afternoon lake breeze to the violating monitor in Berrien County. The Chicago area is evaluated as separate nonattainment area as it is in a separate CSA.

As previously indicated, the peer-reviewed results from the Lake Michigan-specific ozone studies and the HYSPLIT trajectories presented here all provide evidence that lake breeze meteorology plays a role in ozone production and transport to Berrien County. In combination with information on the location and magnitude of emissions sources, this factor shows that the violating monitor is often affected by emissions coming from the west and southwest over Lake Michigan.

#### **Factor 4: Geography/topography**

Consideration of geography or topography can provide additional information relevant to defining nonattainment area boundaries. Analyses should examine the physical features of the land that might define the airshed. Mountains or other physical features may influence the fate and transport of emissions as well as the formation and distribution of ozone concentrations. The absence of any such geographic or topographic features may also be a relevant consideration in selecting boundaries for a given area.

The EPA used geography/topography analysis to evaluate the physical features of the land that might affect the airshed and, therefore, the distribution of ozone over the area.

The Berrien area does not have any geographical or topographical features significantly limiting air pollution transport within its air shed. It is, however, largely affected by ozone transport up the coast of Lake Michigan.

#### **Factor 5: Jurisdictional boundaries**

Once the geographic extent of the violating area and the nearby area contributing to violations is determined, the EPA considered existing jurisdictional boundaries for the purposes of providing a clearly defined legal boundary to carry out the air quality planning and enforcement functions for nonattainment areas. In defining the boundaries of the Berrien nonattainment area, the EPA considered existing jurisdictional boundaries, which can provide easily identifiable and recognized boundaries for purposes of implementing the NAAQS. Examples of jurisdictional boundaries include, but are not limited to: counties, air districts, areas of Indian country, metropolitan planning organizations, and existing nonattainment areas. If an existing jurisdictional boundary is used to help define the nonattainment area, it must encompass all of the area that has been identified as meeting the nonattainment definition. Where existing jurisdictional boundaries are not adequate or appropriate to describe the nonattainment area, the EPA considered other clearly defined and permanent landmarks or geographic coordinates for purposes of identifying the boundaries of the designated areas.

For the 1997 ozone NAAQS, Berrien County was designated nonattainment with the county boundary being the boundary of the nonattainment area. The Berrien area has previously established nonattainment boundaries associated with the 1997 ozone NAAQS. Michigan has recommended the same boundary for the 2015 ozone NAAQS.

### **Additional Information:**

Given the unique meteorology described above, we also provide a comparison of emissions from the upwind areas to Allegan in Table 21, indicating that source areas on the western and southern shore of Lake Michigan (including the Chicago CSA) emit 35 times more NO<sub>x</sub> and at least 28 times more VOC than sources in Berrien County. In addition, we provide information on neighboring counties in the South Bend CSA. There are no large point sources in Cass County, and few large point sources in St. Joseph County located more than 50 km from the violating monitor in Berrien County

**Table 21. Total County-Level NO<sub>x</sub> and VOC Emissions Comparison to Upwind and Neighboring Areas.**

County	State Recommended Nonattainment?	Total NO <sub>x</sub> (tpy)	Total VOC (tpy)
Berrien, MI	Yes	5,609	6,351
Cass, MI	No	1,576	2,436
St. Joseph, IN	No	7,803	7,115
Chicago CSA	n/a	274,440	206,171

A Comparison of population information in Berrien and neighboring areas is provided in Table 22. There is a greater population in St. Joseph County than in Berrien, but as shown in the VMT analysis below, only a small fraction of this population commutes into Berrien County. Cass County has substantially fewer people but a larger population density than Berrien County.

**Table 22. Population and Growth Comparison to Neighboring Areas.**

County	State Recommended Nonattainment?	2010 Population	2015 Population	2015 Population Density (per sq. mi.)	Absolute change in population (2010-2015)	Population % change (2010-2015)
Berrien, MI	Yes	156,813	154,636	272	-2,177	-1
Cass, MI	No	52,293	51,657	586	1,510	1
St. Joseph, IN	No	266,931	268,441	105	-636	-1

Source: U.S. Census Bureau population estimates for 2010 and 2015. <https://www.census.gov/popest/data/>

Table 23 compares traffic and commuting patterns between Berrien and neighboring counties. Cass and St. Joseph counties have relatively fewer commuters into Berrien County than Berrien County itself. The upwind Chicago area CSA and LaPorte County, IN are not located in the same CSA as Berrien County, and thus by definition have a very low level of economic integration measured by commuting patterns.



**Table 23. Traffic and Commuting Patterns Comparison with Neighboring Areas.**

County	State Recommended Nonattainment?	2014 Total VMT (Million Miles)	Number of County Residents Who Work	Number Commuting to or Within Counties with Violating Monitor(s)	Percentage Commuting to or Within Counties with Violating Monitor(s)
<b>Berrien, MI</b>	<b>Yes</b>	<b>2,066</b>	<b>64,803</b>	<b>39,265</b>	<b>60.6%</b>
Cass, MI	No	477	22,634	1,455	6
St. Joseph, IN	No	2,788	118,307	5,443	5

Counties with a monitor(s) violating the NAAQS are indicated in bold.

### **Conclusion for Berrien Area**

The violating monitor in Berrien County is affected by the transport of emissions over Lake Michigan and Indiana. This is supported by the HYSPLIT back-trajectories. Although there are a number of back-trajectories from Cass County, MI and St. Joseph, La Porte and Elkhart counties in Indiana, Cass County has about 4,000 tons combined NOx and VOC emissions, St. Joseph County, IN has less than 15,000 tons combined NOx and VOC emissions, La Porte county has less than 13,000 tons combined NOx and VOC emissions and Elkhart County, IN has about 16,000 tons combined NOx and VOC emissions and these counties are therefore not expected to contribute to the violating monitor in Berrien County. Berrien County's low population and VMT further support transport over Lake Michigan as being the main reason for the violation in Berrien County. EPA is designating Berrien County as the Berrien nonattainment area.