WDNR Response to EPA Data Requests – Correction of the Sheboygan County Ozone Nonattainment Area Boundary

January 22, 2014

Background:

On June 27, 2013, the Wisconsin Department of Natural Resources (WDNR) asked the U.S. EPA Region 5 for an adjustment of the Sheboygan County Ozone Nonattainment Area boundary. In this request, WDNR argued that only a narrow strip of land adjacent to Lake Michigan does not attain the ozone NAAQS standard, and the rest of the county is projected to have ozone concentrations below the standard(s). WDNR made these projections based on comparison of concentrations from three monitors that operated from 1999 to 2003 located at varying distances from the lakeshore (Table 1)[1]. During this time period, ozone concentrations at the lakeshore were on average 16.7% higher than those at Sheboygan Falls (5 miles inland; Figure 1; Table 1), and concentrations at Fond du Lac (40 miles inland) were on average 5.9% lower than those at Sheboygan Falls. WDNR assumed these relationships would still hold true and used those comparisons to estimate ozone design values for Sheboygan Falls for the 2008-2012 period (Table 2). This analysis suggested that ozone design values for Sheboygan Falls would be between 67 ppb (2008-2010) and 75 ppb (2010-2012), indicating that Sheboygan Falls should be classified as attainment for both the 1997 and the 2008 ozone standard. WDNR therefore requested that U.S. EPA correct the boundary of the nonattainment area for both standards to include only the easternmost portion of the county nearest Lake Michigan. It is worth noting that the effect of the lake breeze on lakeshore ozone concentrations is a widely recognized phenomenon.

In response, EPA asked WDNR to submit additional information to support the correction of the ozone nonattainment area boundary. These information requests included: (1) ozone modeling results, (2) ozone monitoring and meteorology results, (3), NO_x and VOC emissions data, (4) areas of significant future growth, and (5) recommendation for a boundary based on a roadway. In this package, WDNR is responding to these data requests with significant additional analyses. This response is organized around each of the questions from EPA. The Department's revised recommended boundary is shown in Figure 1 below and represents only a minor modification to the original recommended boundary. This choice of boundary is thoroughly supported by the data, as explained in section 5 below. This response concludes with a justification of the recommended nonattainment boundary using each of EPA's nine factors for determination of nonattainment area boundaries.

[1] There is currently only one ozone monitoring station in Sheboygan County (at Kohler-Andrae State Park on the lakeshore; Figure 1), although a new, special purpose ozone monitor is planned for the county for 2014-2015.

Figure 1. Map of Sheboygan County showing minor civil divisions, including Congressional township boundaries (mostly straight lines) and civil township boundaries (surrounding villages and towns). The recommended ozone nonattainment area boundary is shown in blue. Locations of current, past and future ozone monitors are shown as black symbols.

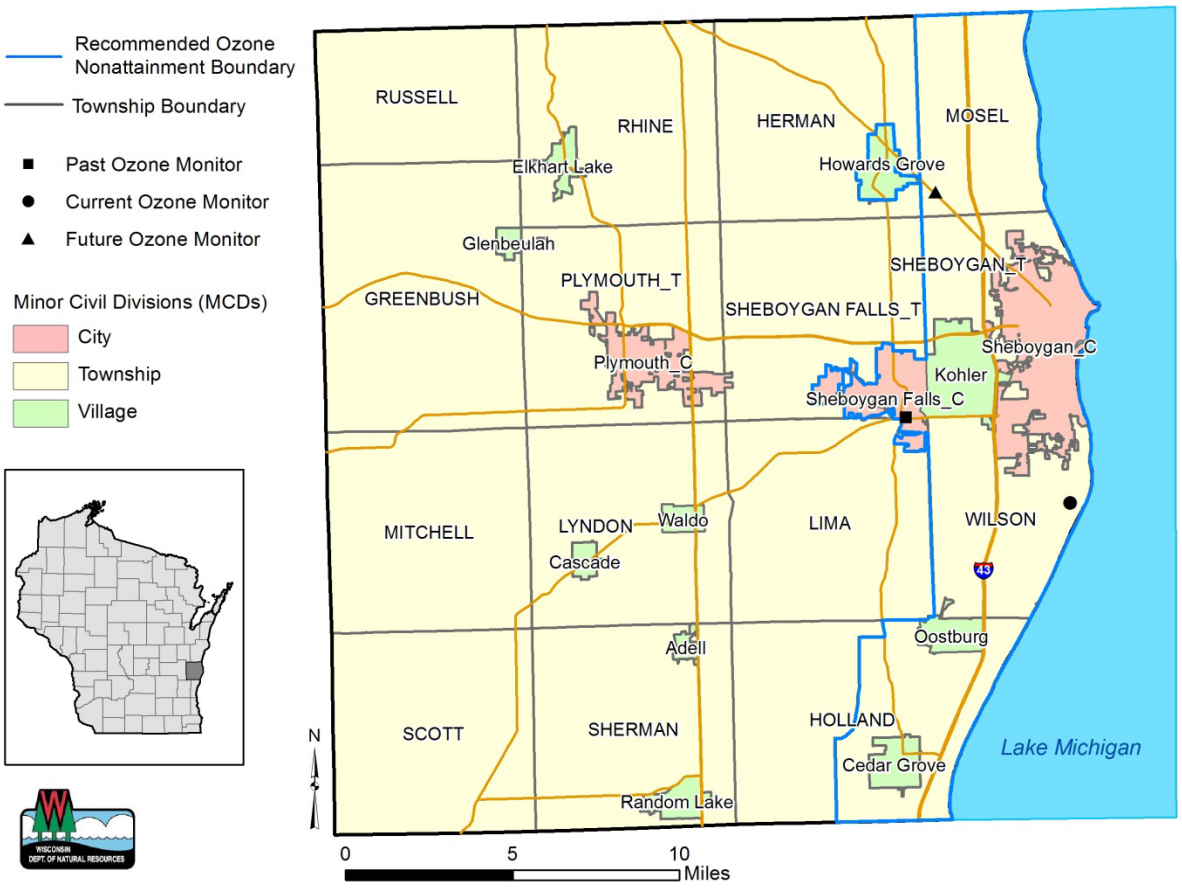


Table 1. Relationships between distance from the Lake Michigan lakeshore and ozone design values at three monitoring locations for the years 1999-2003. Note that the Fond du Lac monitor does not appear on the map above.

Fond du Lac	Sheboygan Falls (S.F.)	Kohler-Andrae State Park
40 miles west of the lakefront	5 miles west of the lakefront	On the lakefront
5.9% lower than S.F. (average) (range: 2.4-8.0%)		16.7% higher than S.F. (average) (range: 14.9%-19.3% higher)

Table 2. Estimated design values for Sheboygan Falls for the years 2008-2012. The values reported in the far right column use the highest of the two estimates for ozone design values.

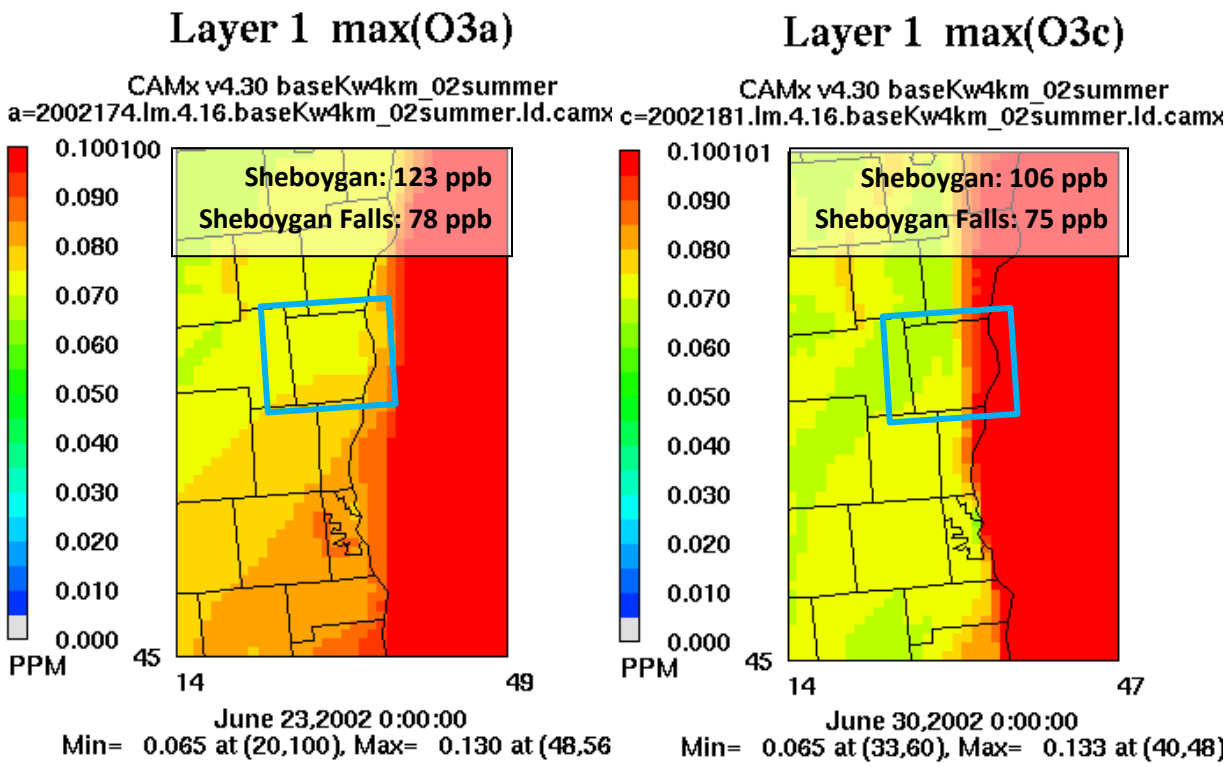
Three Year Period	Estimated Sheboygan Falls Design Values Based on Kohler-Andrae State Park Design Values	Estimated Sheboygan Falls Design Values Based on Fond du Lac Design Values	Highest Estimated Sheboygan Falls Design Values
2008 – 2010	78 ppb – (78 ppb x 16.7%) = **65 ppb**	63 ppb + (63 ppb x 5.9%) = **67 ppb**	**67 ppb**
2009 – 2011	81 ppb – (81 ppb x 16.7%) = **67 ppb**	67 ppb + (67 ppb x 5.9%) = **71 ppb**	**71 ppb**
2010 – 2012	87 ppb – (87 ppb x 16.7%) = **72 ppb**	71 ppb + (71 ppb x 5.9%) = **75 ppb**	**75 ppb**

EPA DATA REQUEST #1: In addition to the estimated ozone design values provided by WDNR, we also need to consider LADCO ozone modeling data for high ozone days in Sheboygan County. This would provide us with a better idea of the area covered by high ozone levels in eastern Sheboygan County.

Results of 4-km grid modeling results: As part of a special project in 2006, LADCO conducted a limited amount of ozone modeling with CAMx using 4-km grid spacing. These runs were conducted using base year meteorology for 2002 for the summer months (June-August). Figure 2 shows modeled one-hour maximum ozone concentrations for two high-ozone days in Sheboygan. Appendix 1 contains figures showing all days on which the monitor at Sheboygan recorded 8-hour concentrations above 100 ppb (with the exception of September 8, 2002, the day with the fourth-highest ozone concentration, which was excluded because the model was not run for September). The monitored ozone concentrations are also provided on the maps for comparison. The plot on the right below shows the deepest modeled penetration of high-ozone air into Sheboygan County, whereas the pattern shown on the left is more typical. **These results show that the model generally predicted that the highest ozone air would be localized very near the lakeshore and would not extend far into the county.** On the day when the model showed the ozone penetrating farthest inland (June 30, shown below), this air was still modeled to be confined to the eastern third to half of the county, whereas on most days, it remained localized within 1-2 grid cells of the lakeshore (4-8 km). These modeling results support the other data submitted by Wisconsin showing that the central and western parts of Sheboygan County are not strongly affected by the high-ozone air from Lake Michigan and should be designated in attainment with the ozone standards.

It is important to note that these model runs provide insight into the location and steepness of the concentration gradients in this region but should not be used to represent absolute values.

Figure 2. Modeled 1-hour maximum ozone concentration plots for two high-ozone days in 2002 in Sheboygan. The plot on the left shows the 1-hour maximum ozone modeling for the day with the highest monitored 8-hour ozone concentration at Sheboygan, and the plot on the right shows the day with the third highest 8-hour ozone concentration. Sheboygan County is enclosed in the blue box and the highest monitored 8-hour ozone values are listed in the box at the top. Additional figures are in Appendix 1.



Information from comparison of other lakeshore and inland monitors: We can also address this question from a different direction by comparing monitors placed at different distances from the lakeshore at another location in Wisconsin. At the beginning of the 2013 ozone season, WDNR installed a second monitor in Kenosha County, located about 3.5 miles from the lakeshore. (The original Chiwaukee Prairie Stateline monitor is only a block from the lakefront. For reference, the Sheboygan Falls monitor was about 5 miles from the lakefront.) This can give us insight into how far inland the lake breeze-driven high ozone concentrations extend in another lakefront county. Since the second monitor was installed in 2013, there is only one year of data available for this comparison. In 2013, neither monitor observed 8-hour ozone values exceeding 75 ppb ozone. Table 3 compares ozone concentrations at the two locations on all days on which ozone concentrations exceeded 65 ppb at the lakefront.

Table 3. Difference between Chiwaukee and Kenosha monitors for days with ozone concentrations over 65 ppb, June-August 2013. Values are peak 8-hour values, and the data have not yet been QA'ed.

	CHIWAUKEE PRAIRIE STATELINE (ppb)	KENOSHA-WATER TOWER (ppb)	DIFFERENCE (ppb)	PERCENT DIFFERENCE (higher than inland)
06/09/2013	67	45	22	49%
06/11/2013	68	61	7	11%
06/20/2013	73	68	5	7%
07/05/2013	75	66	9	14%
07/16/2013	73	59	14	24%
07/17/2013	73	44	29	66%
07/22/2013	71	71	0	0%
08/20/2013	70	62	8	13%
Average Difference			11.8	23%

These results show that the ozone concentrations were an average of 23% higher at the lakeshore than they were 3.5 miles inland. This difference is similar to that found when comparing Sheboygan Falls and Sheboygan for 1999-2003 (Table 1), for which lakeshore design values were an average of 16.7% higher than those about five miles inland. This further supports the Department's finding for Sheboygan that the high ozone concentrations due to the lake breeze diminish within 3-5 miles of the lakeshore.

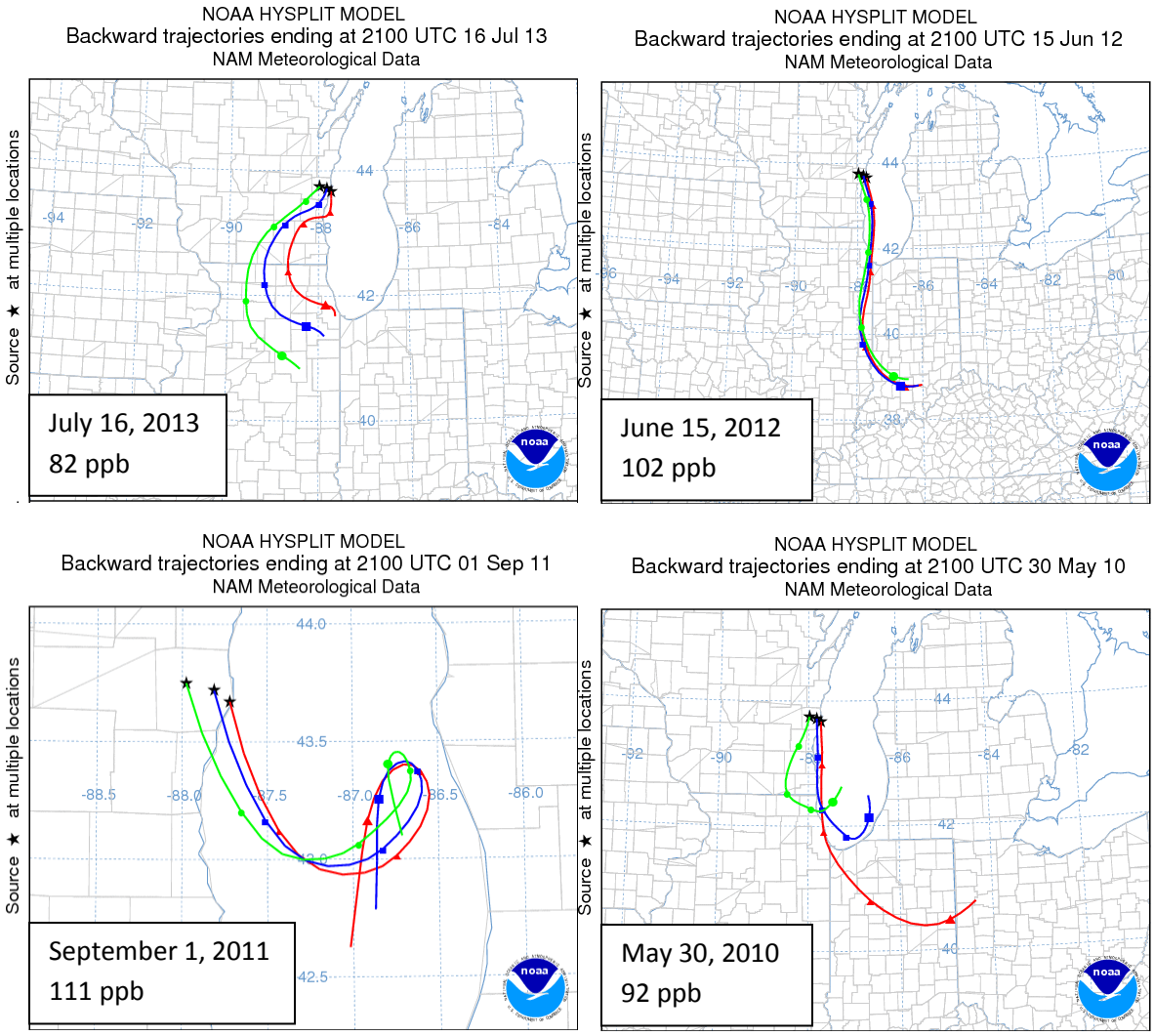
EPA DATA REQUEST #2: Wisconsin should also provide us with ozone monitoring and meteorology for high ozone days to support a record showing that ozone transport over Lake Michigan is truly responsible for the ozone standard violation in Sheboygan County. These data need to be provided for high ozone days under both the 1997 8-hour standard and the 2008 8-hour ozone standard since WDNR is requesting a nonattainment area revision for both of these ozone standards.

To address this request, WDNR is submitting two different kinds of information:

1. HYSPLIT model backward trajectories that trace the location of the air masses reaching three locations in Sheboygan County.
2. Tables showing ozone concentration and wind direction for all days in 2010-2013 on which ozone concentrations exceeded the 1997 or 2008 NAAQS standards.

HYSPLIT models. Complete modeling results are shown in Appendix 2 for the top four highest ozone concentration days for the years 2010-2013. Figure 3 below shows the trajectories for the highest-ozone day (as measured at Kohler Andrae State Park) in each year as examples. Trajectories are shown for Plymouth (in central Sheboygan County, shown in green), for Sheboygan Falls (in east-central Sheboygan County) and for the city of Sheboygan (in eastern Sheboygan County on the lakeshore). These plots show that on some high ozone days, the air masses reaching central and east-central Sheboygan County did not travel over Lake Michigan, in contrast to those reaching the city of Sheboygan, and thus could not be impacted by the high-ozone concentrations that form over the lake. This effect is shown for July 16, 2013. On other days, the air masses may have traveled over the lake but then pass over land for a much longer period than do those reaching Sheboygan, giving the ozone in the lake breeze air more time to decompose or be diluted, as shown for September 1, 2011. Taken together, **these model results suggest that the air in western and central Sheboygan County is much less frequently influenced by Lake Michigan than is that in the eastern part of the county,** supporting the Department's request that these parts of the county be designated "attainment". These trajectories also show that the high-ozone air parcels that impact the City of Sheboygan tend to blow in directly from over Lake Michigan to the south of the city.

Figure 3. HYSPLIT model results for the highest ozone day in each year from 2010-2013. The green trajectory is for Plymouth, the blue for Sheboygan Falls and the red for the city of Sheboygan. These are 24-hour trajectories that end at 9pm. Model results for the four highest ozone days for these years are shown in Appendix 2. The box on each graph lists the highest daily 8-hour concentration.



<u>Ozone concentrations and wind directions</u>. Table 4 below shows the average ozone concentrations and wind direction (shown as compass degrees and as cardinal direction) for days on which the ozone concentration exceeded the 1997 or 2008 standard. Wind directions and concentrations are listed separately for the hours when ozone concentrations exceeded 75 ppb and hours when it was 75 ppb or lower. This data shows that winds during the high-ozone periods usually came over the lake from the south. In contrast during the lower-ozone hours, the winds generally had a larger westerly component, blowing on average from the south-southwest (SSW). Appendix 3 lists the ozone concentrations and wind directions for each day

on which the 8-hour ozone concentration exceeded the standard. The table in Appendix 3 shows that only three of the 40 days with wind direction data had wind that came from a direction other than the south (S) or south-southwest (SSW) during high-ozone hours. During these times, the winds came from the southeast (SE) or south-southeast (SSE) and thus came more from the center of Lake Michigan. **The dominant southerly winds deliver air masses from over Lake Michigan to the Sheboygan monitor** (Figure 1).

Table 4. Ozone concentrations and average wind direction at Sheboygan Kohler-Andrae State Park for days when ozone exceeded the 1997 or 2008 standards for the years 2010-2013. Values are shown for hours during which the 1-hour ozone concentrations exceeded 75 ppb and for those with concentrations of 75 ppb or lower. Note that the days exceeding the 1997 standard also exceeded the 2008 standard and thus were counted in both groups.

			High O_3 Hours (>75 ppb)		Low O_3 Hours (≤75 ppb)	
	# of days	Peak 8-hour Ozone (ppb)	Wind Direction (°)	Cardinal Direction	Wind Direction (°)	Cardinal Direction
Average (2008 std)	43	85	183	S	197	SSW
Average (1997 std)	17	92	178	S	197	SSW

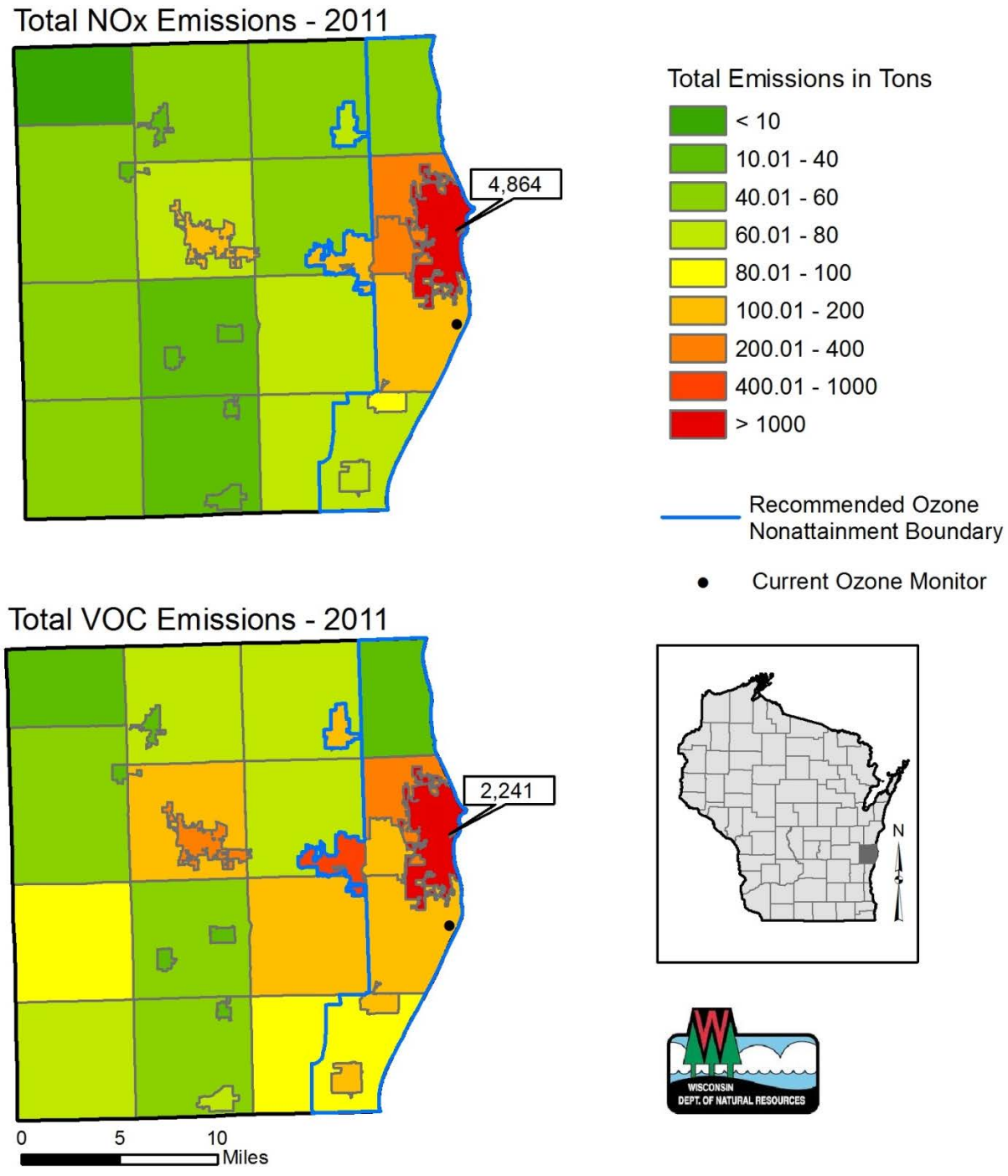
EPA DATA REQUEST #3: Since EPA policy requires that ozone nonattainment areas include the significant source areas along with the ozone standard violation areas, we will also need NOx and VOC emissions data by location resolved at the sub-county level. WDNR should provide us with gridded area source emissions data, the locations and levels of point source emissions, and zonal or major roadway mobile source emissions. We will need to establish which portions of Sheboygan County contribute most of the emissions. For Kenosha County, we were able to establish that the eastern townships in Kenosha County contributed approximately 90 percent of the NOx and VOC emissions in the county.

Figure 4 below shows the distribution of total NOx and VOC emissions in Sheboygan County, and Table 5 summarizes the emissions for the entire county and for the recommended nonattainment area. From the maps, it is apparent that **the revised recommended nonattainment area encompasses all major source areas.** The only significant source area that is not included in the recommended area is the town of Plymouth and some lower VOC emissions from the surrounding township. Overall, the recommended nonattainment area contains 88% of total NOx emissions and 74% of total VOC emissions. Appendix 4 parses these emission sources by source category (point, non-point, on-road and nonroad) and by geographic area, and Appendix 5 provides a detailed list of the point sources. Table 5 shows that the recommended nonattainment area contains 99% of point source emissions of NOx and 89% of point source VOC emissions. It is also worth noting that overall NOx and VOC emissions from Sheboygan County are very low relative to concentrated area/population sources locations in the region. As WDNR stated in the original request, U.S. EPA analysis done for CSAPR found that the entire state of Wisconsin only contributed 10.2% of the ozone observed in Sheboygan County. Given the relatively small number of sources in the county and the fact that most of the county sources are downwind of the monitor, the contribution from sources within Sheboygan County is likely to be much smaller than 10%.

Table 5. Distribution of NOx and VOC emissions, population and expected population growth for all of Sheboygan County and for the recommended nonattainment area. The percent of emissions in the recommended nonattainment area is shown for both total emissions and emissions from point sources. Additional information on the types and sources of emissions is in Appendices 4 and 5.

		Total NO_x Emissions (tons)	Total VOC Emissions (tons)	Population (2010)	Population Growth (2010-2045)
Entire County		6858	5063	115,507	19,485
Recommended Nonattainment Area		6019	3768	79,855	15,463
% in Recommended Nonattainment Area	**Total**	**88%**	**74%**	**69%**	**79%**
	Point	**99%**	**89%**		

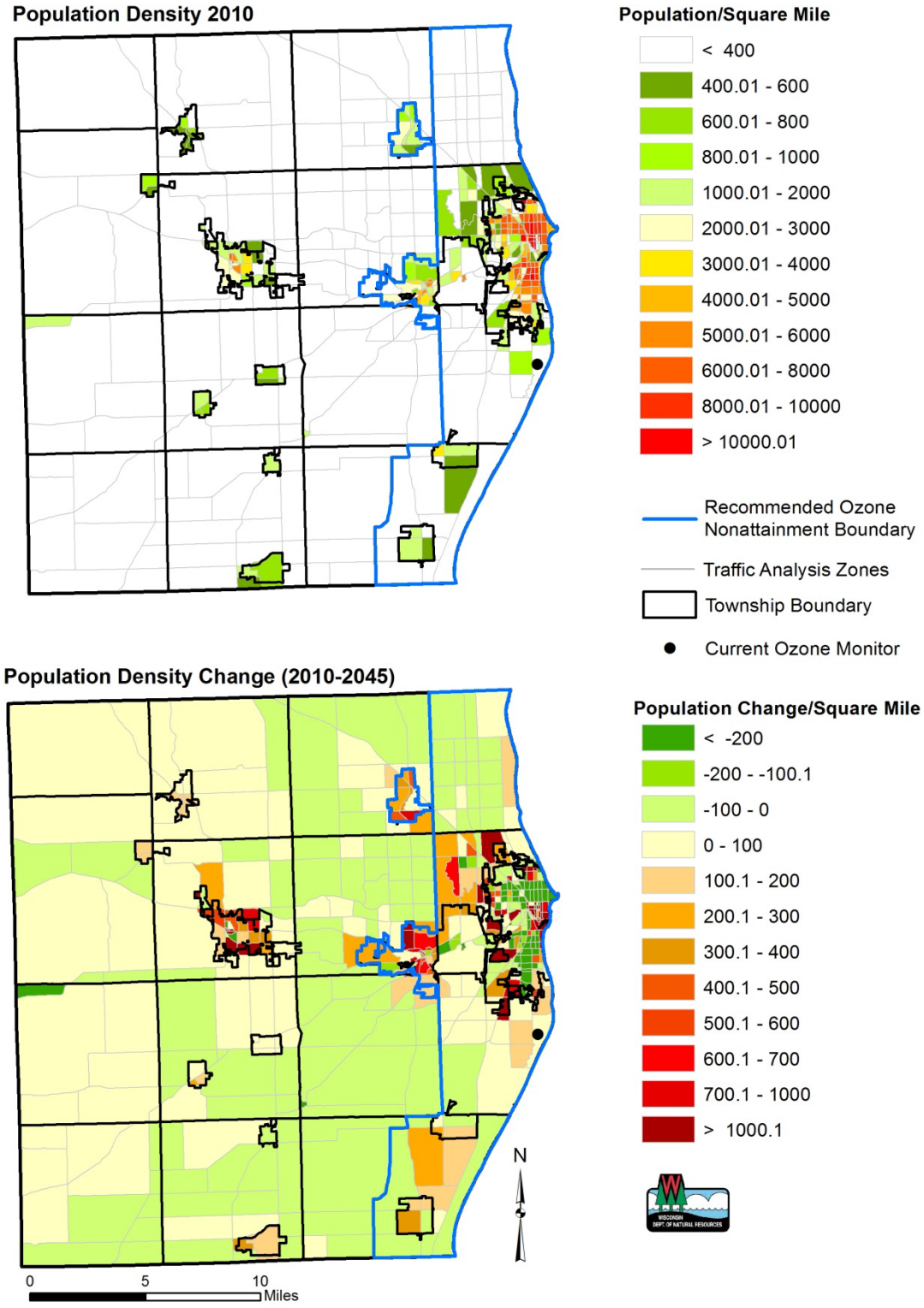
Figure 4. Total NO_x (top) and VOC (bottom) emissions for 2011 from Sheboygan County. These numbers combine emissions from four source categories (point, nonpoint, on-road and non-road). Appendix 4 shows the distribution of emissions from these four source categories in the county, and Appendix 5 identifies the point sources. Note the non-linear scale.



EPA DATA REQUEST #4: We note here that the revised ozone nonattainment area boundary for Sheboygan County recommended by the WDNR is very complicated and may not be fixed in time. In addition, the recommended boundary does not provide for the inclusion of areas just outside of the recommended boundary that may be expected to experience significant source growth in the future. Since EPA's ozone designation policy also recommends the inclusion of significant source growth areas within nonattainment areas, we also need to consider such areas for Sheboygan County. For this reason, **we need the WDNR to provide us with maps and data accounting for areas of significant source growth, particularly in the eastern half of Sheboygan County.**

Figure 5 maps the current (2010) population density of Sheboygan County, as well as where population growth is projected to occur through 2045. The growth projections are based on analysis done by the Bay-Lake Regional Planning Commission and the Wisconsin Department of Transportation. The map shows that the recommended ozone nonattainment area includes all major population centers and major areas of anticipated growth in the county other than the town of Plymouth. Table 5 (above) totals the population and population growth for the total county and the recommended nonattainment area. **The recommended boundary encompasses 69% of the current population and 79% of the anticipated population growth.**

Figure 5. Population density in 2010 (top) and projected growth in population density from 2010 to 2045 (bottom) plotted for Sheboygan County. Note the nonlinear scales. Population data are from the 2010 U.S. Census and growth projections were provided by the Bay-Lake Regional Planning Commission.



EPA DATA REQUEST #5: The WDNR-recommended nonattainment boundary would be very hard to define other than in terms of boundaries of villages, towns, and cities, which are not permanent and not easy to plot on maps for the public record. In addition, as noted above the state-recommended boundary would exclude potential source growth areas. **We would recommend that a major north-south roadway be selected in Sheboygan County as a western boundary for a revised ozone nonattainment area.**

The boundary WDNR recommends is strongly supported by the modeling and monitoring data, which both show that ozone concentrations west of this boundary should fall below the NAAQS standard. Further, the majority of NOx and VOC emissions sources, population and projected population growth fall to the east of this boundary. The Department has revised the southernmost section of the recommended boundary to more closely align with the area in which ozone concentrations may be elevated due to the lake breeze. This revised portion of the recommended boundary follows roadways as requested by EPA.

The recommended boundary (Figure 1) follows the western Congressional township lines of Mosel, Sheboygan and Wilson townships. Congressional townships were established in the early 1800s and can only be changed by an act of Congress. These borders are therefore easy to define and permanent. The nonattainment area defined by this boundary would also encompass the entire villages of Howards Grove and Oostburg and the city of Sheboygan Falls. These village/city borders are civil borders which may change as the town or city grows. However, these borders are permanent in that there will always be a specified boundary for these villages and cities. This approach is also advantageous in that the nonattainment area would grow as the village or city grows, without any additional action required by U.S. EPA or WDNR. The southernmost section of the boundary follows roadways because no north-south Congressional township boundaries were convenient. This boundary skirts the village of Oostburg and travels west along the Congressional township border between Lima and Holland townships until it intersects Highway 32. The boundary then travels briefly south on Highway 32 to County Road A, which it follows west to County Road KW. The boundary then follows County Road KW south to the county border. As with the Congressional township boundaries, these roadways are unlikely to change and thus represent permanent and unambiguously defined boundaries.

Recommended Municipalities for Ozone Nonattainment (outlined in blue in Figure 1)

Township of Mosel
Township of Sheboygan
Township of Wilson
Township of Holland (eastern part, as defined above)
Village of Cedar Grove
Village of Howards Grove
Village of Kohler
Village of Oostburg
City of Sheboygan
City of Sheboygan Falls

SUMMARY AND CONCLUSION.

To summarize, we organized the information supporting the Department's request according to the nine factors EPA has established for determination of nonattainment area boundaries in designations for the 2008 ozone NAAQS.

Factor 1: Air Quality Data

As described in the original submission to EPA, spatial trends in ozone concentrations suggest that ozone concentrations in Sheboygan Falls should currently meet both the 1997 and 2008 NAAQS standards (Table 2). Additionally, Figure 2 above shows that the CAMx model also projects that, on days when ozone concentrations exceed the NAAQS, the high-ozone air in Sheboygan County is confined to a narrow strip of land near the lakeshore, leaving most of the county with much lower ozone concentrations.

Factor 2: Emissions Data

Detailed emissions data is presented above in Table 5 and Figure 4. This data shows that a large majority of the NOx (88%) and VOC (74%) emissions from the county derive from within the recommended ozone nonattainment area. Even more of the point source emissions (99% and 89%, respectively) originate from this area.

Factor 3: Current population density and degree of urbanization

Population density for the county is plotted in Figure 5 and listed in Table 5. The majority (69%) of the county's current population lives within the recommended ozone nonattainment area.

Factor 4: Traffic and commuting patterns

The major roadway within the county, Interstate 43, is entirely contained within the recommended ozone nonattainment area (Figure 1). Additionally, as shown in Appendix 4, most on-road (78% for NOx and 70% for VOC) and nonroad (69% for both NOx and VOC) emissions originate within the recommended nonattainment area.

Factor 5: Growth rates and patterns

Figure 5 and Table 5 show that 79% of population growth by 2045 is projected to occur within the recommended ozone nonattainment area.

Factor 6: Meteorology

The meteorological data presented above (Figure 3 and Table 3) demonstrate that the air reaching Sheboygan on high-ozone days was heavily impacted by the lake breeze and by pollution transported from the south (i.e., from Chicago). In contrast, the inland locations are less frequently affected by the lake breeze, and the air reaching Plymouth and Sheboygan Falls on these same days less frequently passes over Lake Michigan and thus would be expected to have significantly lower ozone concentrations than those measured on the lakefront.

Factor 7: Geography/topography

WDNR submitted information about the geography and topography of eastern Wisconsin in the original submission (February 27, 2009). Because the topography is predominantly flat, it is unlikely to directly impact ozone transport in the region. The original submission also discussed the role of the lake breeze in driving ozone concentrations in eastern Wisconsin.

Factor 8: Jurisdictional boundaries

The recommended boundary is defined by jurisdictional boundaries, except for the southernmost portion, which does not divide any heavily populated jurisdictions.

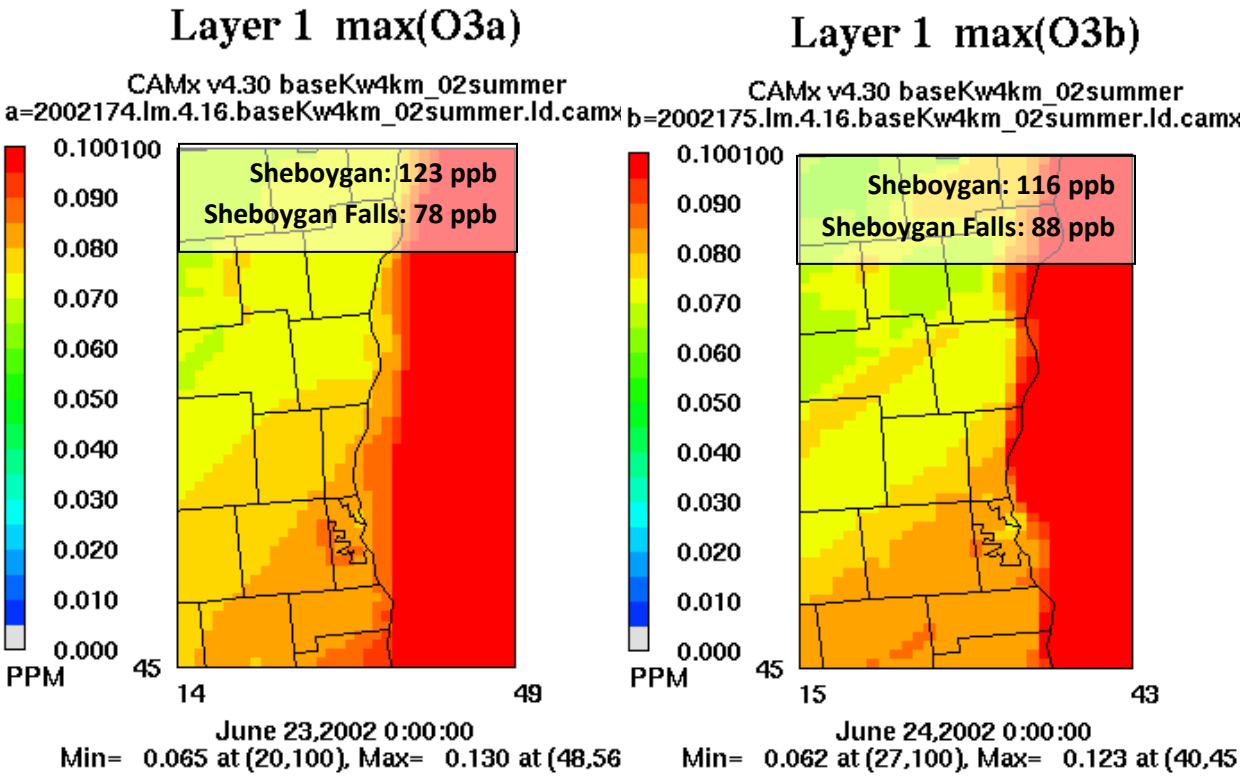
Factor 9: Level of control of emission sources

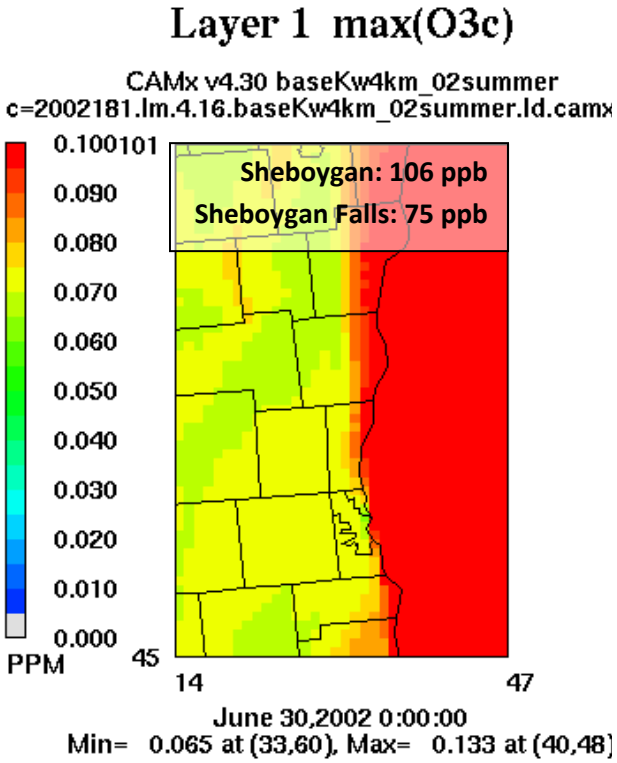
Prospectively, emission sources outside the corrected nonattainment area would be subject to the same major source applicability criteria for permitting as are sources in the majority of the state.

In summary, all nine factors laid out by EPA support a correction to the designation of the central and western parts of Sheboygan County as unclassifiable/attainment for both the 1997 and the 2008 ozone NAAQS standards.

APPENDIX 1. CAMx model results using a 4-km grid cell for high ozone days in 2002.

Model results are shown for the highest ozone days in Sheboygan (e.g., the days on which the Sheboygan monitor recorded maximum 8-hour concentrations above 100 ppb). The fourth-highest ozone day (September 8; 105 ppb) is not shown because the model was only run for June-August. Monitored maximum 8-hour ozone concentrations for Sheboygan and Sheboygan Falls are shown at the top of each figure.

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Sheboygan: 106 ppb
Sheboygan Falls: 75 ppb
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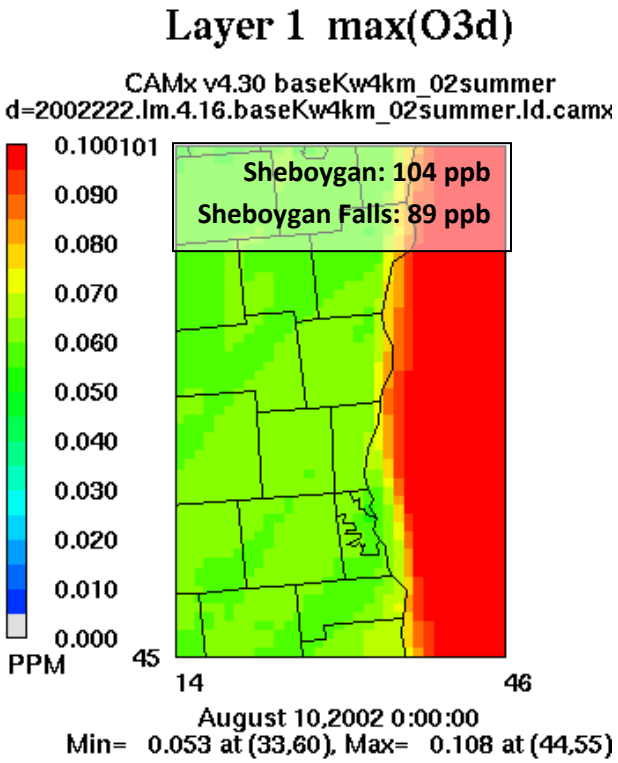
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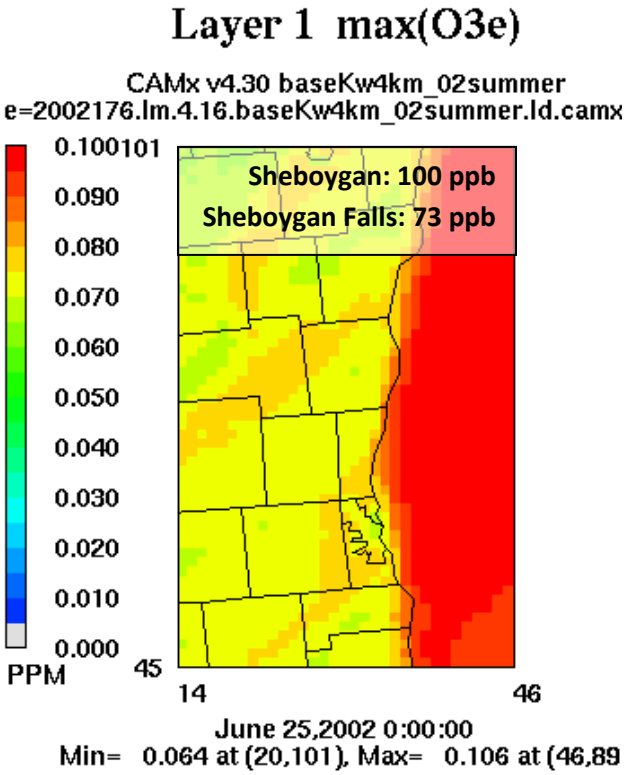
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Sheboygan Falls: 73 ppb
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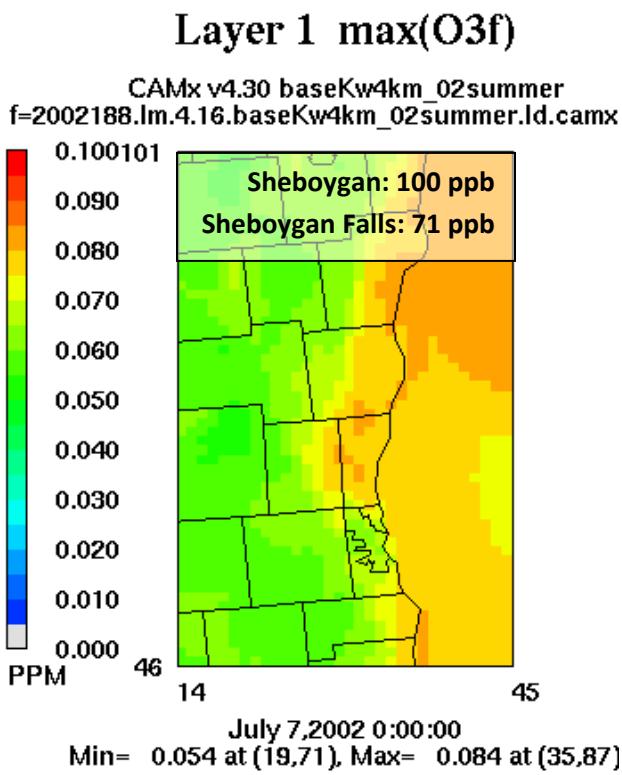
Min= 0.064 at (20,101), Max= 0.106 at (46,89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PPM
Sheboygan: 100 ppb
Sheboygan Falls: 71 ppb
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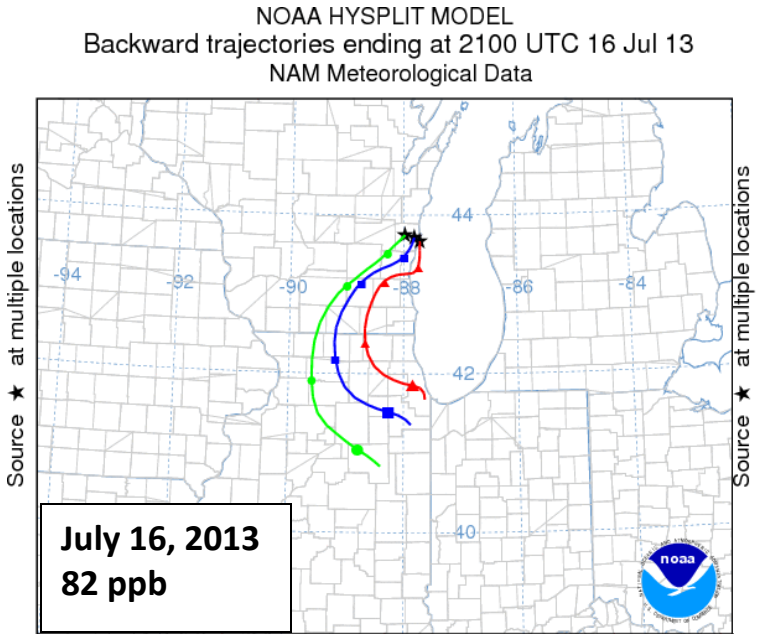
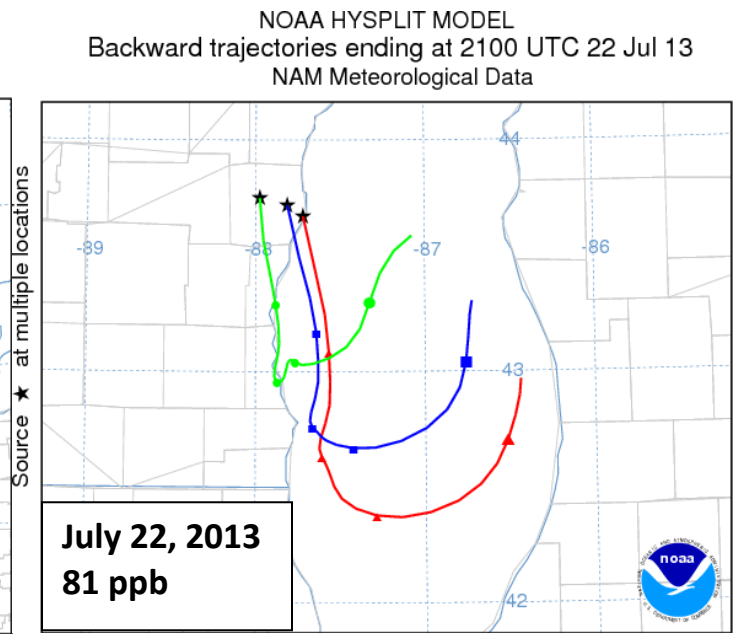
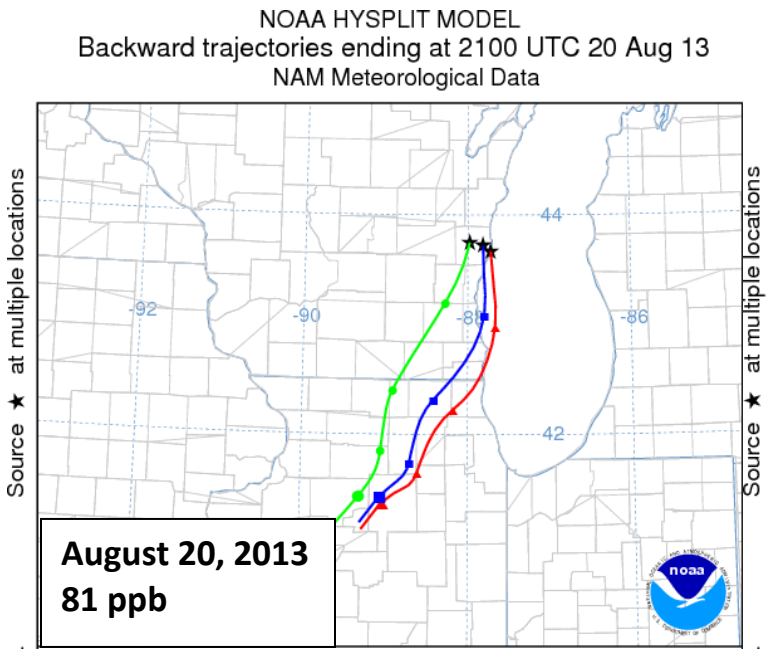
July 7,2002 0:00:00
Min= 0.054 at (19,71), Max= 0.084 at (35,87)

APPENDIX 2. HYSPLIT Model results for the top four ozone concentration days each year in Sheboygan, 2010-2013.

The green trajectory is for Plymouth, the blue for Sheboygan Falls and the red for the city of Sheboygan. These are 24-hour trajectories that end at 9pm. These graphs demonstrate that the air parcels reaching the western parts of Sheboygan County have often followed significantly different trajectories that expose the air parcels less frequently to intermixing with the high-ozone air present over Lake Michigan under conditions conducive to high ozone episodes. The box on each graph contains the highest daily 8-hour concentration.


NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 16 Jul 13
NAM Meteorological Data
Source ★ at multiple locations
July 16, 2013
82 ppb


NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 22 Jul 13
NAM Meteorological Data
Source ★ at multiple locations
July 22, 2013
81 ppb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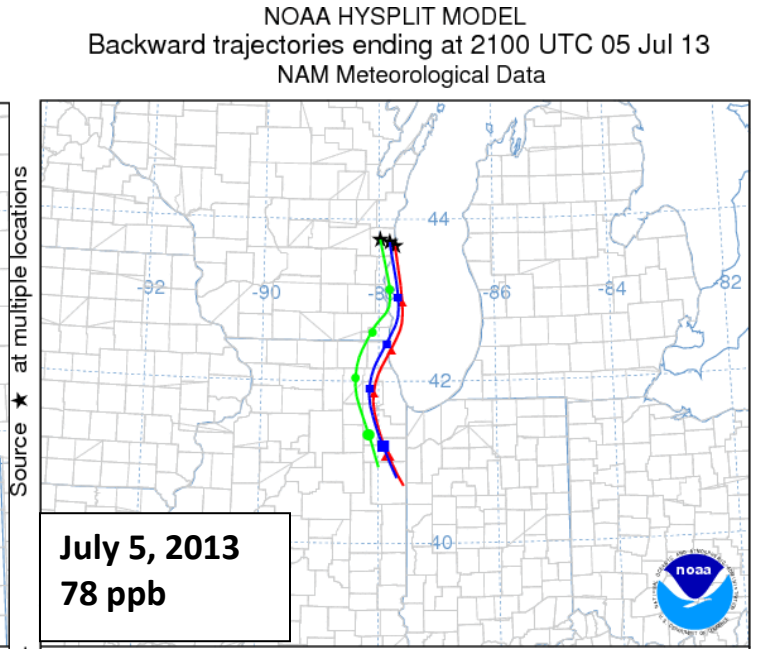
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July 5, 2013
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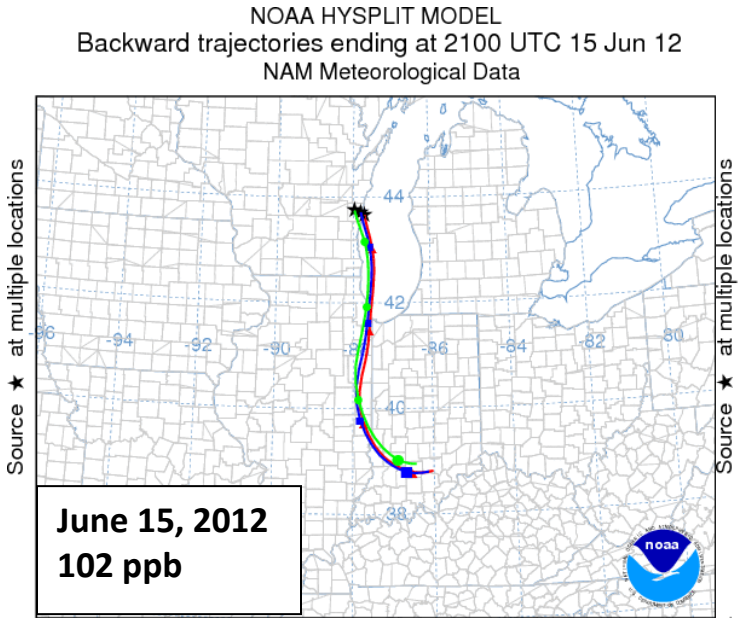
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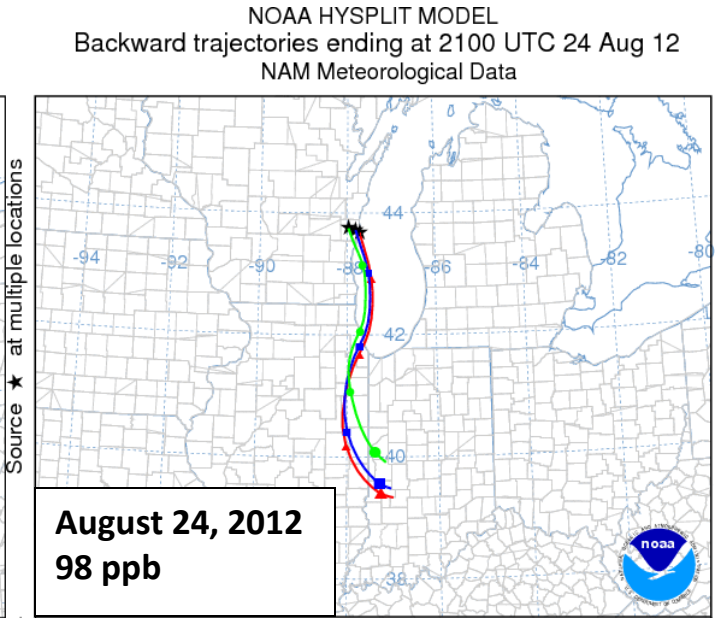
Source ★ at multiple locations
June 15, 2012
102 ppb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Source ★ at multiple locations
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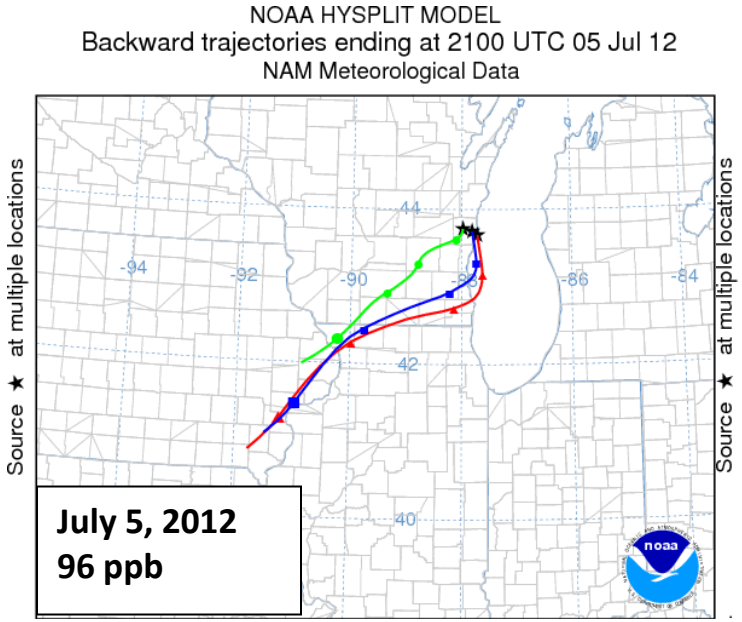
98 ppb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Source ★ at multiple locations
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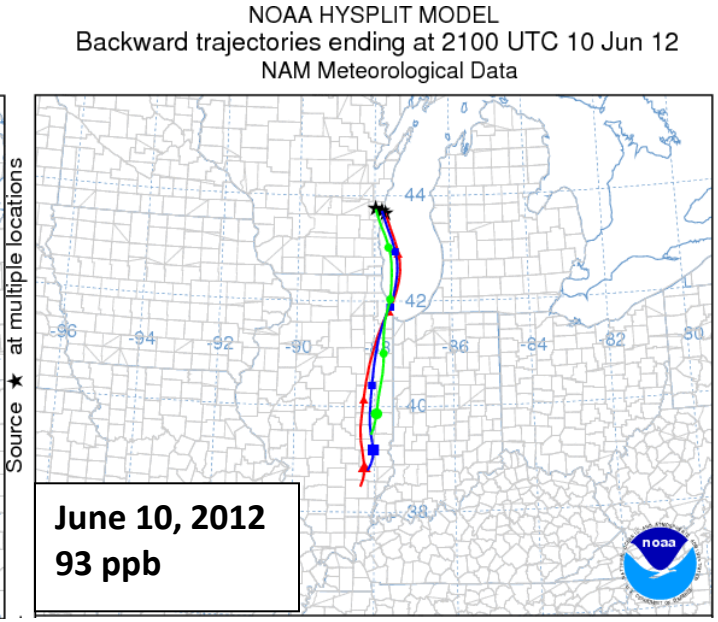
96 ppb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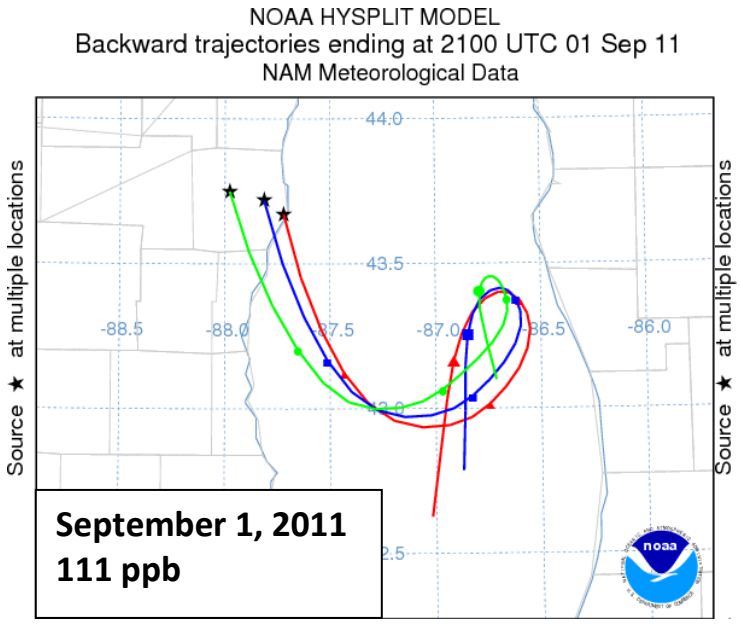
Backward trajectories ending at 2100 UTC 10 Jun 12
NAM Meteorological Data
Source ★ at multiple locations
June 10, 2012
93 ppb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Backward trajectories ending at 2100 UTC 01 Sep 11
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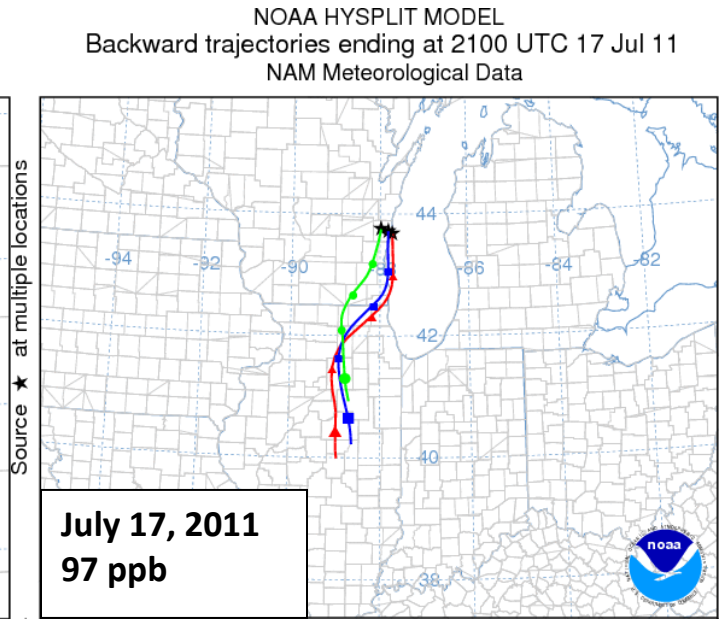
Source ★ at multiple locations
September 1, 2011
111 ppb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Backward trajectories ending at 2100 UTC 17 Jul 11
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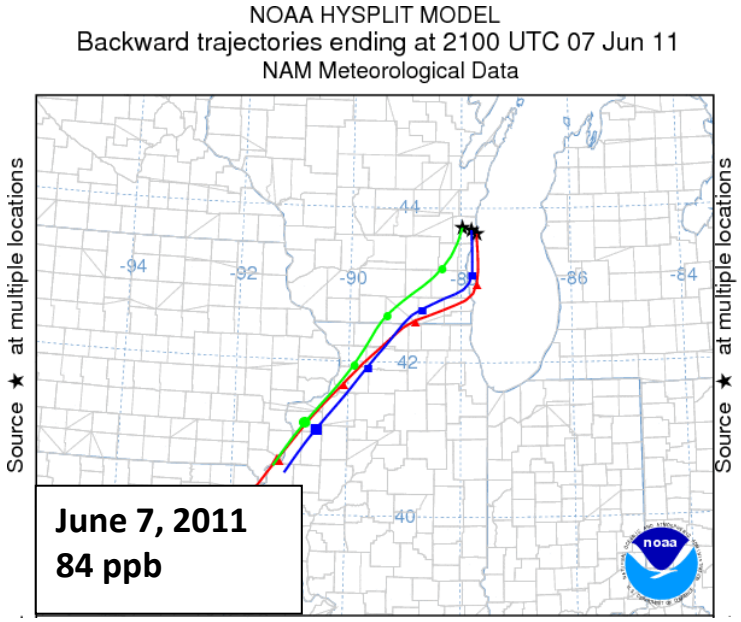
Source ★ at multiple locations
July 17, 2011
97 ppb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Backward trajectories ending at 2100 UTC 07 Jun 11
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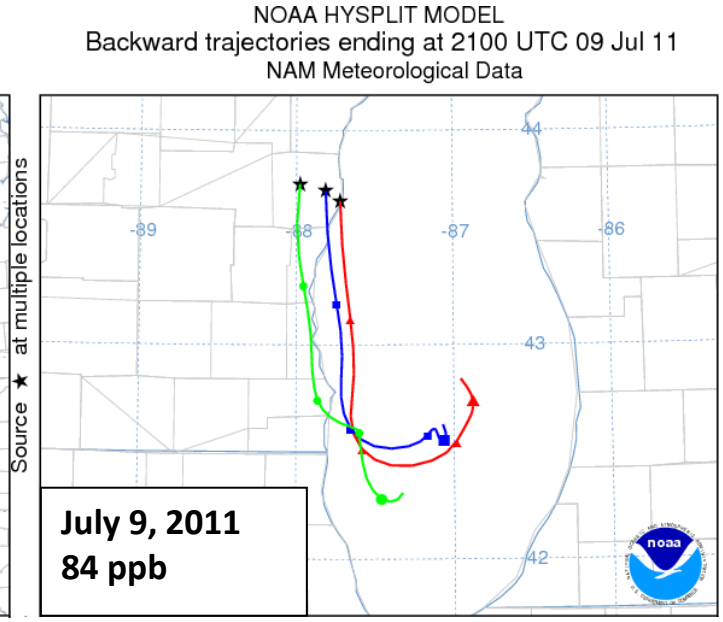
Source ★ at multiple locations
June 7, 2011
84 ppb


NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 09 Jul 11
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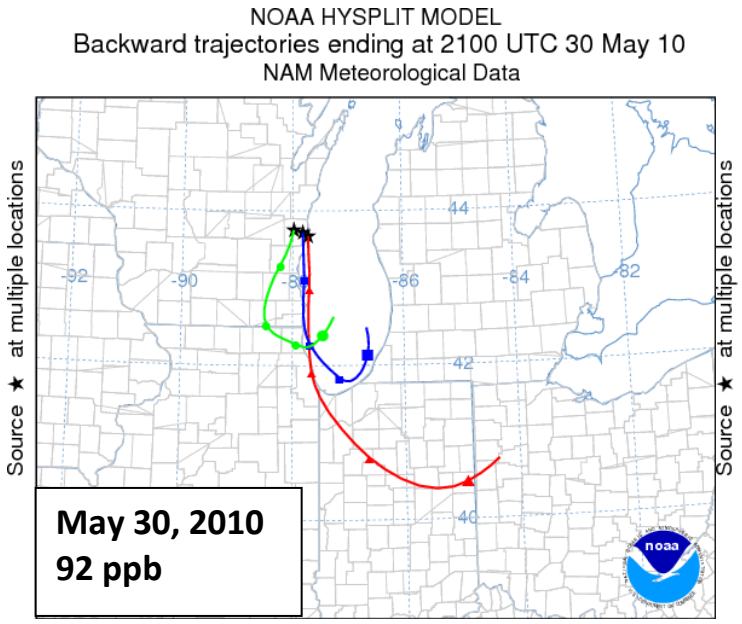
Source ★ at multiple locations
July 9, 2011
84 ppb


NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 30 May 10
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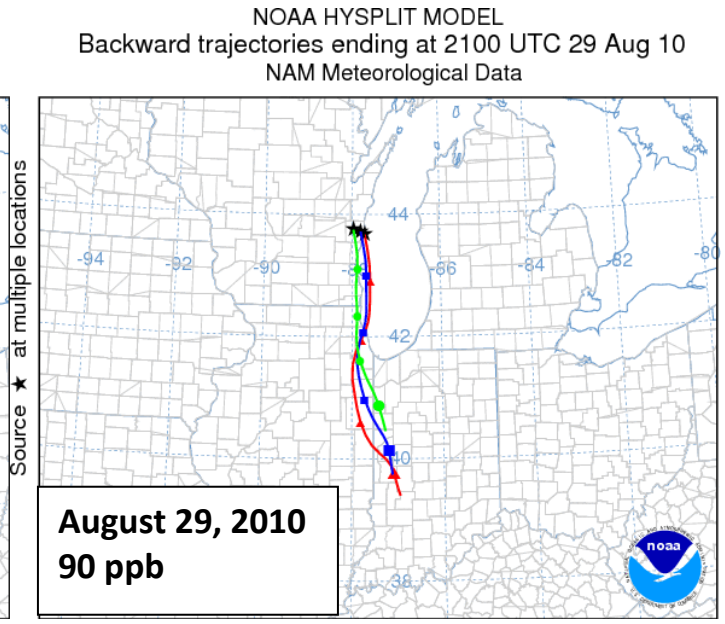
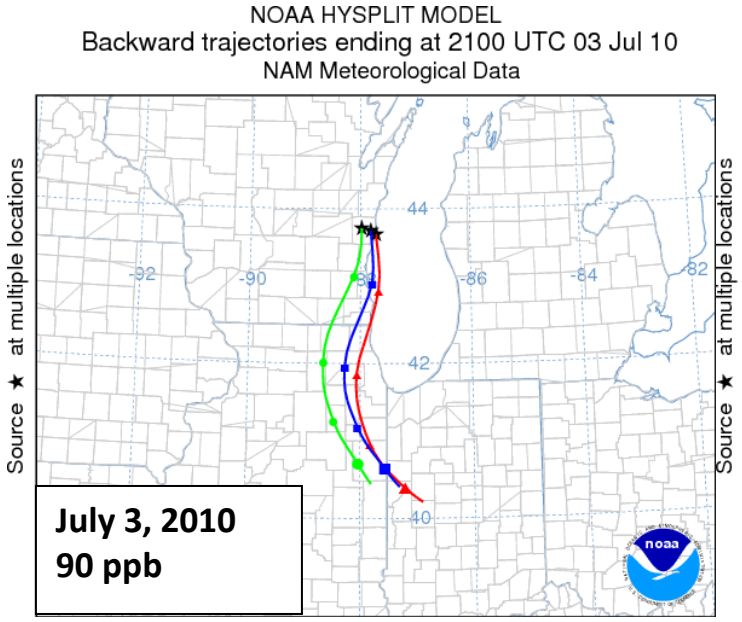
Source ★ at multiple locations
May 30, 2010
92 ppb


NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 29 Aug 10
NAM Meteorological Data
Source ★ at multiple locations
August 29, 2010
90 ppb


NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 03 Jul 10
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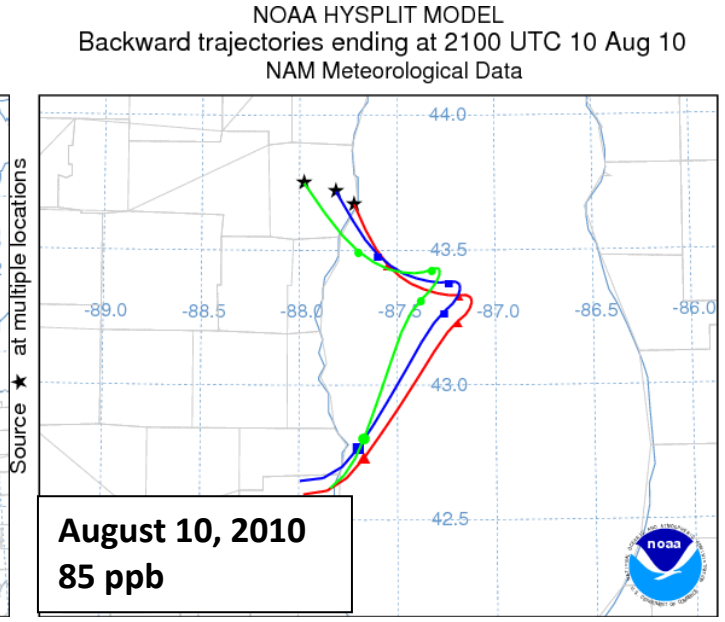
Source ★ at multiple locations
July 3, 2010
90 ppb


NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 10 Aug 10
NAM Meteorological Data
Source ★ at multiple locations
August 10, 2010
85 ppb

APPENDIX 3. Ozone concentrations and average wind direction at Sheboygan Kohler-Andrae State Park for days when 8-hour ozone concentrations exceeded the 1997 (bold) and 2008 NAAQS standards for the years 2010-2013. Values are shown separately for hours during which the 1-hour ozone concentration exceeded 75 ppb and for those with concentrations of 75 ppb or lower.

			High O_3 Hours (>75 ppb)		Low O_3 Hours (≤75 ppb)	
	DATE	Ozone (ppb)	Wind Direction (°)	Cardinal Direction	Wind Direction (°)	Cardinal Direction
2010	**05/30/2010**	**92**	**185**	**S**	**200**	**SSW**
	06/25/2010	79	181	S	190	S
	07/03/2010	**90**	**185**	**S**	**202**	**SSW**
	07/27/2010	79	187	S	204	SSW
	08/10/2010	**85**	**158**	**S**	**195**	**SSW**
	08/28/2010	81	191	S	202	SSW
	08/29/2010	**90**	**188**	**S**	**208**	**SSW**
2011	06/03/2011	76	no data		no data	
	06/06/2011	81	no data		no data	
	06/07/2011	84	no data		no data	
	07/09/2011	84	193	SSW	206	SSW
	07/10/2011	84	191	SSW	195	SSW
	07/16/2011	77	187	S	189	S
	07/17/2011	**97**	**190**	**S**	**200**	**SSW**
	07/20/2011	80	186	S	206	SSW
	09/01/2011	**111**	**173**	**S**	**211**	**SSW**
2012	05/18/2012	77	195	SSW	186	S
	05/19/2012	**91**	**190**	**S**	**177**	**S**
	05/20/2012	82	191	SSW	221	SW
	05/24/2012	84	178	S	186	**S**
	05/27/2012	83	189	S	84	E
	06/09/2012	**90**	**189**	**S**	**223**	**SW**
	06/10/2012	**93**	**188**	**S**	**186**	**S**
	06/15/2012	**102**	**205**	**SSW**	**190**	**S**
	06/16/2012	**85**	**130**	**SE**	**147**	**SSE**
	06/19/2012	78	189	S	186	**S**
	06/27/2012	**85**	**186**	**S**	**191**	**SSW**
	06/28/2012	**85**	**127**	**SE**	**209**	**SSW**
	07/02/2012	83	190	S	202	SSW
	07/05/2012	**96**	**166**	**SSE**	**222**	**SW**
	07/13/2012	78	176	S	196	SSW
	07/14/2012	76	180	S	215	SW
	07/16/2012	78	183	S	215	SW
	07/30/2012	**92**	**184**	**S**	**205**	**SSW**

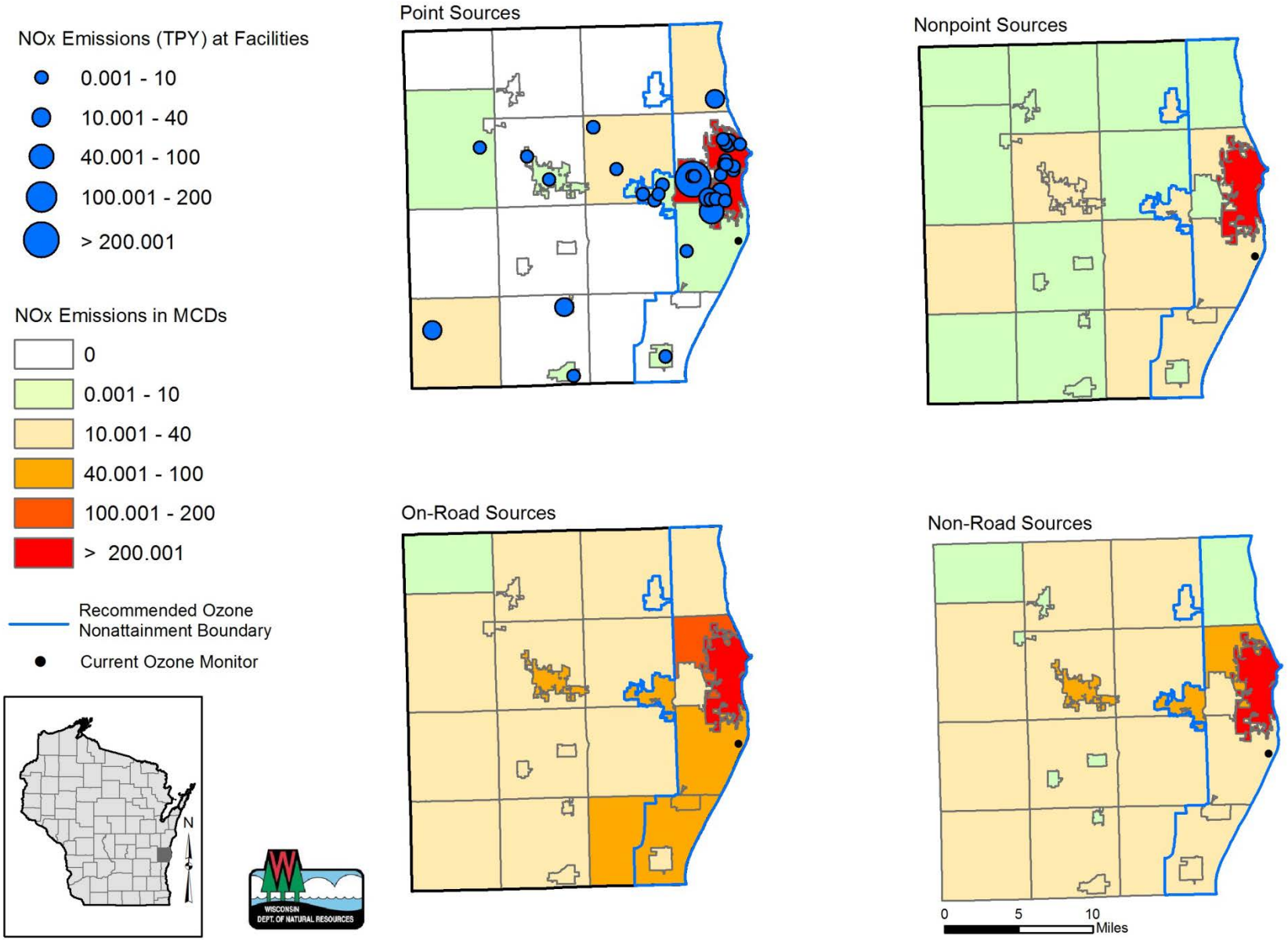
	08/23/2012	81	189	S	203	SSW
	08/24/2012	**98**	**187**	**S**	**185**	**S**
	08/25/2012	**90**	**191**	**SSW**	**203**	**SSW**
	08/30/2012	78	189	S	197	SSW
	09/12/2012	80	189	S	239	WSW
2013	07/05/2013	78	189	S	199	SSW
	07/16/2013	82	192	SSW	183	S
	07/22/2013	81	193	SSW	207	SSW
	08/20/2013	81	191	S	224	SW
Average (> 2008 std)		85	183	S	197	SSW
Average (> 1997 std)		92	178	S	197	SSW

APPENDIX 4. NOx and VOC emissions for Sheboygan County grouped by source category.

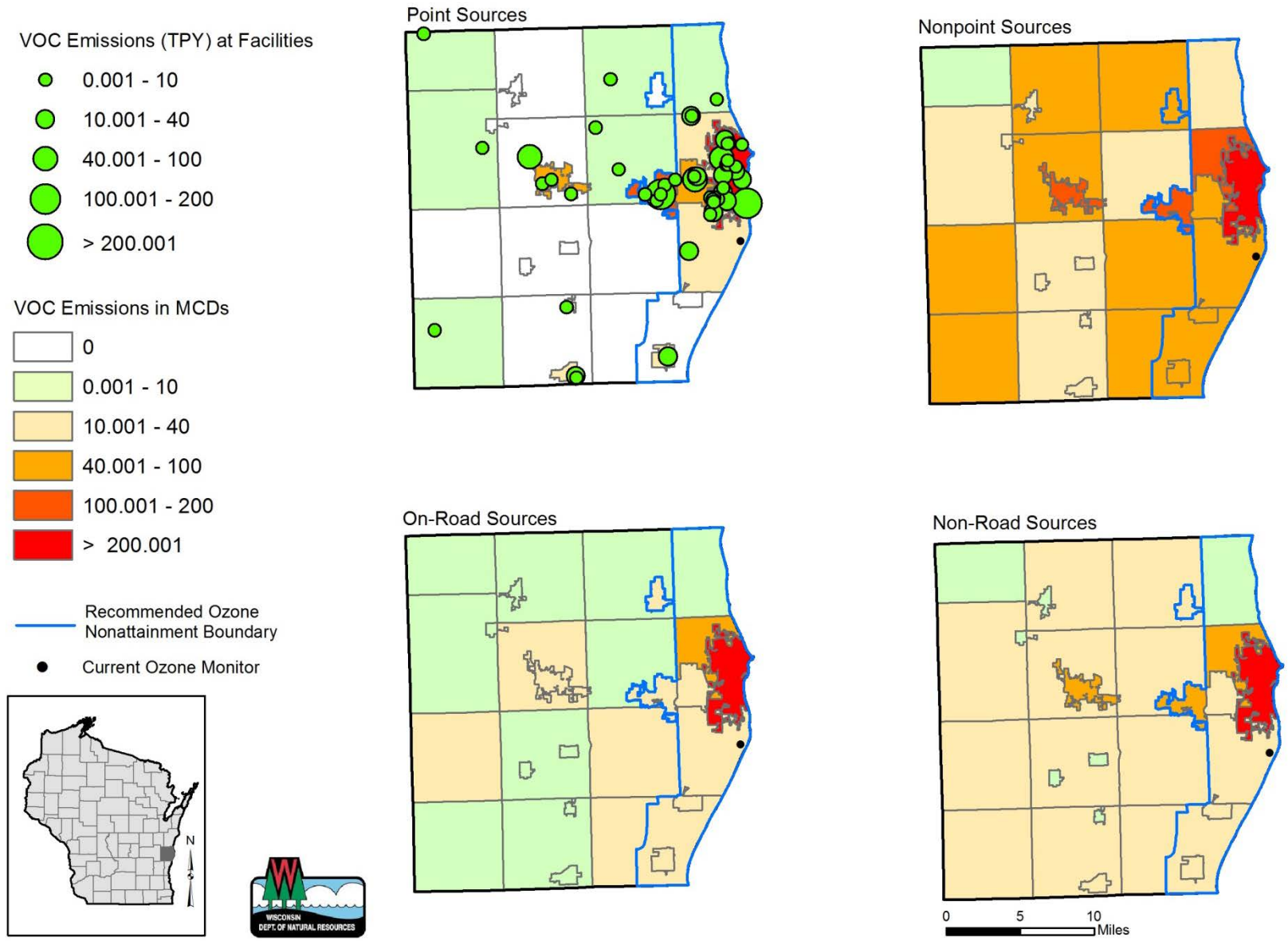
Sub-county level NOx and VOC emissions in Sheboygan County for 2011 shown in a table and plotted on maps for four source categories: point, non-point, on-road and non-road emissions. For the maps, emissions are plotted per minor civil division (MCD), which includes cities, towns and townships. Data are from the 2011 National Emission Inventory (NEI). To achieve a sub-county level spatial resolution of the NOx and VOC emissions, nonpoint and non-road emissions were allocated to MCDs based on the population statistics as of the 2010 US Census data. The on-road emissions were assigned for MCDs based on interstate, urban and rural contributions and the population data as well.

	Point Sources	Non-Point Sources	On-Road Sources	Nonroad Sources	Total
			NOx Emissions (tons)		
Entire County	3726	526	1747	859	6858
Recommended Nonattainment Area	3675	369	1373	602	6019
% in Recommended Nonattainment Area	99%	70%	79%	70%	88%
			VOC Emissions (tons)		
Entire County	770	2582	747	964	5063
Recommended Nonattainment Area	688	1811	593	676	3768
% in Recommended Nonattainment Area	89%	70%	79%	70%	74%

Sub-county Level NOx Emissions in Sheboygan - 2011



Sub-county Level VOC Emissions in Sheboygan - 2011



APPENDIX 5. NOx and VOC emissions from point sources in Sheboygan County for the year 2011.

FACILITY_NAME	CITY	NO_x Emissions (tons)	VOC Emissions (tons)
WPL - EDGEWATER GENERATING STATION	SHEBOYGAN	3297.64	110.32
KOHLER CO-METALS PROCESSING COMPLEX	KOHLER	231.39	56.78
J.L. FRENCH CORPORATION, GATEWAY PLANT	SHEBOYGAN	49.50	18.03
KOHLER CO - TOWN OF MOSEL PLANT	MOSEL	23.80	9.42
ANR PIPELINE CO.(KEWASKUM COMP. STATION)	ADELL	17.52	0.34
MOMENTIVE SPECIALTY CHEMICALS INC	SHEBOYGAN	15.79	22.87
PLASTICS ENGINEERING CO N 15TH ST PLANT	SHEBOYGAN	15.49	7.43
ADELL CORPORATION	ADELL	11.79	0.72
J. L. FRENCH CORP.	SHEBOYGAN	10.17	4.09
JOHNSONVILLE FOODS	SHEBOYGAN FALLS	7.90	5.24
KOHLER COMPANY - VITREOUS PLANT	KOHLER	6.73	0.43
SHEBOYGAN CO HIGHWAY COMMISSION	GREENBUSH	6.46	0.44
THE VOLLRATH COMPANY, LLC	SHEBOYGAN	4.10	0.23
BEMIS MFG. CO. PLANT B	SHEBOYGAN FALLS	3.78	171.05
WPL - SHEBOYGAN FALLS ENERGY FACILITY	PLYMOUTH	3.44	0.31
AURORA SHEBOYGAN MEMORIAL MEDICAL CENTER	SHEBOYGAN	3.02	0.17
KOHLER CO-ENGINE PLANT	KOHLER	2.96	23.07
GEORGIA-PACIFIC CORRUGATED LLC	SHEBOYGAN	2.85	3.82
PLYMOUTH FOAM INCORPORATED	PLYMOUTH	2.41	54.17
WILLMAN INDUSTRIES	CEDAR GROVE	1.94	25.71
TIMES PRINTING CO INC	RANDOM LAKE	1.26	12.26
BEMIS MFG. CO. - PLANT D	SHEBOYGAN FALLS	1.22	5.61
NEMSCHOFF CHAIRS INC	SHEBOYGAN	1.17	14.36
AURORA MEDICAL SYSTEM - VALLEY VIEW MEDICAL	PLYMOUTH	0.70	0.04
THE MAYLINE CO.(STEEL PLANT)	SHEBOYGAN	0.58	17.30
THE MAYLINE CO.(WOOD PLANT)	SHEBOYGAN	0.45	0.44
CURT G. JOA, INCORPORATED	SHEBOYGAN FALLS	0.40	3.34
PEMCO INC.	SHEBOYGAN	0.38	2.55
RICHARDSON YACHT INTERIORS	SHEBOYGAN FALLS	0.36	4.39
MANNING LIGHTING, INC.	SHEBOYGAN	0.33	0.45
AMERICAN EXCELSIOR	SHEBOYGAN	0.17	9.07
LAKESHORE DISPLAY CO., INC.	SHEBOYGAN	0.16	16.61
AUSTIN GRAY IRON FOUNDRY	SHEBOYGAN	0.15	2.99
BEMIS WOOD FLOUR MILL	SHEBOYGAN FALLS	0.09	0.01
NEMSCHOFF CHAIRS, INC.	SHEBOYGAN	0.08	11.74
ALDRICH CHEMICAL COMPANY	SHEBOYGAN FALLS	0.01	23.80
SHEBOYGAN PAINT CO.	SHEBOYGAN	0	57.50
SHEBOYGAN PAPERBOX CO.	SHEBOYGAN	0	27.71
FRANZEN LITHOSCREEN INC.	SHEBOYGAN	0	11.19

SACO POLYMERS INC	SHEBOYGAN	0	7.45
WESTSHORE INDUSTRIES	SHEBOYGAN	0	6.43
UNIVERSAL LITHOGRAPHERS	SHEBOYGAN	0	3.99
CERTAIN TEED	PLYMOUTH	0	3.30
POLY VINYL COMPANY INC	SHEBOYGAN FALLS	0	3.24
OLD WISCONSIN SAUSAGE CO PLANT 2	SHEBOYGAN	0	2.67
AJS & ASSOCIATES, INC	RANDOM LAKE	0	2.40
LAKELAND SPORTS CENTER	PLYMOUTH	0	2.15
KIEFFER & CO., INC.	SHEBOYGAN	0	2.11
LAKELAND COLLEGE	PLYMOUTH	0	0.10
BREMER MANUFACTURING	ELKHART LAKE	0	0.02