

# **APPENDIX B**

## **INDIANA 1-HOUR SULFUR DIOXIDE BACKGROUND DETERMINATION**

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## Indiana's 1-Hour SO<sub>2</sub> Background Determination

U.S. EPA revised the SO<sub>2</sub> National Ambient Air Quality Standard (NAAQS) by instituting a 1-hour standard of 75 parts per billion (ppb). Therefore, an analysis was necessary to determine ambient 1-hour SO<sub>2</sub> background concentrations representative for all regions in the state. This determination is needed in order to make attainment designations and attainment demonstrations and perform New Source Review (NSR) and Prevention of Significant Deterioration (PSD) modeling. Indiana has reviewed the 1-hour SO<sub>2</sub> monitoring and meteorological data from 2011 through 2013 to calculate representative ambient 1-hour SO<sub>2</sub> background concentrations. U.S. EPA's "Guidance for 1-Hour SO<sub>2</sub> Nonattainment Area SIP Submissions, April 2014" was followed to calculate the background concentrations in order to eliminate overly conservative cumulative impacts from nearby major SO<sub>2</sub> emission sources when performing air quality dispersion modeling.

### Overview

Indiana has twenty-one SO<sub>2</sub> monitors located throughout the state. As of the end of the 2013 monitoring season, six of the SO<sub>2</sub> monitors recorded 1-hour design values (99<sup>th</sup> percentile) above the 1-hour SO<sub>2</sub> NAAQS of 75 ppb. These six monitors reside in the following five counties: Daviess, Marion, Morgan, Pike and Vigo. Vigo County has two SO<sub>2</sub> monitors which measured concentrations above the 1-hour SO<sub>2</sub> NAAQS. For this analysis, the Vigo County controlling monitor (Fort Harrison Road) was analyzed. Table 1 shows the 99<sup>th</sup> percentile values for the years 2011, 2012 and 2013 and the 2011-2013 1-hour SO<sub>2</sub> design values.

**Table 1**  
**1-Hour SO<sub>2</sub> Design Values for All SO<sub>2</sub> Monitors in Indiana 2011-2013**

<b>County</b>	<b>Monitor ID</b>	<b>2011 99<sup>th</sup> Percentile</b>	<b>2012 99<sup>th</sup> Percentile</b>	<b>2013 99<sup>th</sup> Percentile</b>	<b>2011-2013 Design Value</b>
Daviess	18-027-0002	<b>100</b>	<b>78</b>	<b>150</b>	<b>109</b>
Marion	18-097-0057	63	<b>92</b>	<b>78</b>	<b>78</b>
Marion	18-097-0073	60	56	42	53
Marion	18-097-0078	60	61	70	64
Morgan	18-109-1001	<b>96</b>	<b>82</b>	64	<b>81</b>
Pike	18-125-0005	<b>119</b>	<b>140</b>	<b>169</b>	<b>143</b>
Vigo	18-167-0018	<b>95</b>	73	<b>79</b>	<b>82</b>
Vigo	18-167-1014	<b>139</b>	<b>128</b>	<b>103</b>	<b>123</b>

N/O Not operational

N/A Not available

## Data Retrieval

Monitoring data for all the SO<sub>2</sub> monitors in the state were retrieved from U.S. EPA's AirData database. The concentration data was supplied for each hour and day of every month from 2011 through 2013. In the event that a monitor was moved during the retrieval period, the data from each site was used to determine ambient background concentrations. Meteorological data was collected in order to correlate the wind directions and concentrations for each hour of each day of every month. Meteorological data was either collected at the SO<sub>2</sub> monitor, a monitor near the monitoring site or the nearest National Weather Service (NWS) station or Automated Surface Observation Station (ASOS). This data was collected and distributed by the Midwest Regional Climate Center (mrcc.isws.illinois.edu). The nearest meteorological data site to each of the SO<sub>2</sub> monitor in the state is summarized below.

**Table 2**  
**Locations of SO<sub>2</sub> Monitors and Meteorological Stations for Background Analysis**

County	Monitor ID	Monitor Location	Meteorological Station	Station Location	Distance
Daviess	18-027-0002	38.57° N 87.21° W	Evansville - NWS station	38.05° N 87.52° W	39.6 miles
Marion	18-097-0057	39.75° N 86.19° W	Harding St. monitor and meteorological station	39.75° N 86.19° W	0 mile
Marion	18-097-0073	39.79° N 86.06° W	Harding St. monitor and meteorological station	39.75° N 86.19° W	7.4 miles
Marion	18-097-0078	39.81° N 86.11° W	Harding St. monitor and meteorological station	39.75° N 86.19° W	5.9 miles
Morgan	18-109-1001	39.52° N 86.39° W	Indianapolis NWS station	39.73° N 86.27° W	15.8 miles
Pike	18-125-0005	38.52° N 87.25° W	Evansville NWS station	38.05° N 87.52° W	35.6 miles
Vigo	18-167-0018	39.51° N 87.41° W	Terre Haute NWS station	39.46° N 87.30° W	6.8 miles
Vigo	18-167-1014	39.49° N 87.40° W	Terre Haute NWS station	39.46° N 87.30° W	5.7 miles

### Methodology for Determining Ambient SO<sub>2</sub> Background Concentrations

Each set of SO<sub>2</sub> data was paired with the corresponding meteorological conditions for every hour of the year in order to determine the wind direction for each hour that SO<sub>2</sub> concentrations were recorded. Initially, data was processed in chronological order with daily and seasonal trends analyzed. This analysis showed diurnal trends when higher SO<sub>2</sub> concentrations occurred.

Once data for all SO<sub>2</sub> monitors in the state were processed, data was re-formatted in order to calculate the hourly-seasonal 99<sup>th</sup> percentile averages over a 3-year period, as detailed in EPA's draft "Guidance for 1-Hour SO<sub>2</sub> Nonattainment Area SIP Submissions: Appendix A. Section 8 – Background Concentrations". The 99<sup>th</sup> percentile concentrations based on each hour of the day and each of the four seasons of the year were calculated for each SO<sub>2</sub> monitor.

In order to calculate the seasonal hourly 99<sup>th</sup> percentile average, the data was grouped by the seasonal months. Spring was represented by concentrations recorded in March, April and May; summer represented by June, July and August; fall represented by September, October and November and winter represented by December, January and February. Once this data was grouped by seasons, the 99<sup>th</sup> percentile was calculated for each hour of the day, making twenty-four separate 99<sup>th</sup> percentiles for each SO<sub>2</sub> monitoring site per season. The average of the twenty-four 99<sup>th</sup> percentiles over the three-year period represents the hourly-seasonal 1-hour SO<sub>2</sub> background.

The initial analysis created pollution roses to determine the wind directions from which the highest SO<sub>2</sub> concentrations were impacting each SO<sub>2</sub> monitor. This analysis helped to identify the nearest upwind SO<sub>2</sub> emission sources impacting the SO<sub>2</sub> monitor. With those wind directions identified, the SO<sub>2</sub> concentrations (10 ppb and above) resulting from the upwind SO<sub>2</sub> emission sources were removed from the analysis, in order to calculate a representative ambient SO<sub>2</sub> background concentration for each SO<sub>2</sub> monitor in the state. This analysis helps to prevent double-counting SO<sub>2</sub> emission source impacts in an air quality modeling analysis.

The results of the seasonal analysis can be found below in Table 3 and are divided into geographical regions of the states. Most monitors show higher SO<sub>2</sub> concentrations in the winter. By calculating the ambient SO<sub>2</sub> background values, as taken from the draft EPA guidance methodology, the resulting 99<sup>th</sup> percentile concentrations fall within a range of 7.3 ppb to 9.9 ppb with the average concentration over the season from the SO<sub>2</sub> monitoring site with the highest design value from each county being 8.2 ppb.

**Table 3**  
**99<sup>th</sup> percentiles for 1-Hour SO<sub>2</sub> Background Values (ppb) for 2011-2013**  
**(without upwind major source impacts)**

	<b>Vigo Co.</b>	<b>Marion Co.</b>	<b>Morgan Co.</b>	<b>Daviess Co.</b>	<b>Pike Co.</b>
	<b>18-167-1014</b>	<b>18-097-0057</b>	<b>18-109-1001</b>	<b>18-027-0002</b>	<b>18-125-0005</b>
1-Hour DV ('11-'13)	123	78	81	109	143
Hourly Ave	3.5	1.9	1.8	2.4	3.5
Hourly 99 <sup>th</sup> %	8.8	8.6	9.4	8.6	9.9
Winter 99 <sup>th</sup> %	9.3	8.1	8.8	8.8	10.5
Spring 99 <sup>th</sup> %	7.9	8.3	7.9	7.8	10.1
Summer 99 <sup>th</sup> %	8.4	7.9	7.9	7.6	9.0
Fall 99 <sup>th</sup> %	8.1	8.2	7.2	6.6	8.4

### Summary

Calculations to determine 1-hour SO<sub>2</sub> background concentrations calculations were made according to U.S. EPA “Guidance for 1-Hour SO<sub>2</sub> Nonattainment Area SIP Submissions: Appendix A. Section 8 – Background Concentrations”. This approach calls for the removal of SO<sub>2</sub> concentrations emitted from SO<sub>2</sub> emission sources directly upwind of a SO<sub>2</sub> monitor. This allows for more representative ambient background values to be determined, not overly conservative values that could possibly double-count direct source impact and background concentrations in air quality modeling.

As of the end of the 2013 monitoring season, there were twenty-one SO<sub>2</sub> monitors throughout the state with six of the SO<sub>2</sub> monitors recording 1-hour design values above the 1-hour SO<sub>2</sub> NAAQS of 75 ppb. These six monitors reside in the following five counties: Daviess, Marion, Morgan, Pike and Vigo (two monitors). The U.S. EPA guidance approach for calculating SO<sub>2</sub> background values showed the maximum hourly-seasonal 99<sup>th</sup> percentiles for all SO<sub>2</sub> monitors over the latest 3 years of available SO<sub>2</sub> monitoring ranged between 7.3 ppb to 9.9 ppb

Tables, Charts and Graphs  
of 1-hour SO<sub>2</sub> Concentrations

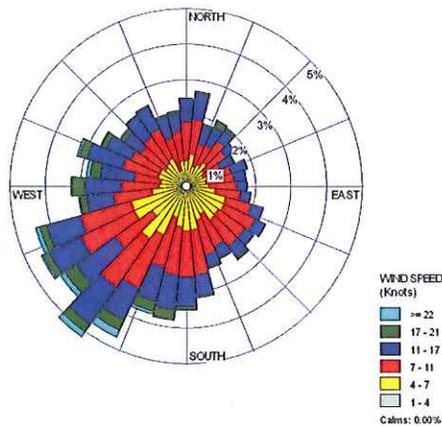
**HARDING STREET**  
**Marion County SO<sub>2</sub> Monitor**  
**2011 – 2013**

## Harding Street SO<sub>2</sub> Concentration Summary (2011-2013)

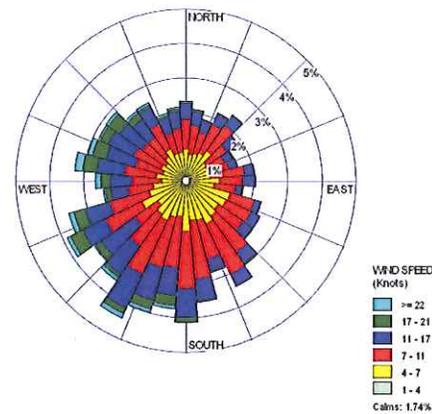
Site ID 18-097-0057	2011	2012	2013
Design Value (3 yr-ending)	80 ppb	86 ppb	78 ppb
Maximum Concentration	129 ppb	209 ppb	113ppb
Average Concentration	2.1 ppb	2.7 ppb	2.9 ppb

## Indianapolis Airport National Weather Service Wind Roses

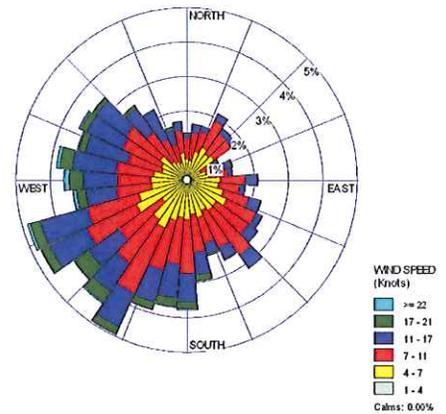
Indianapolis Wind Rose 2011



Indianapolis Wind Rose 2012



Indianapolis Wind Rose 2013



## EPA's Seasonal and Temporal SO<sub>2</sub> Background Determination

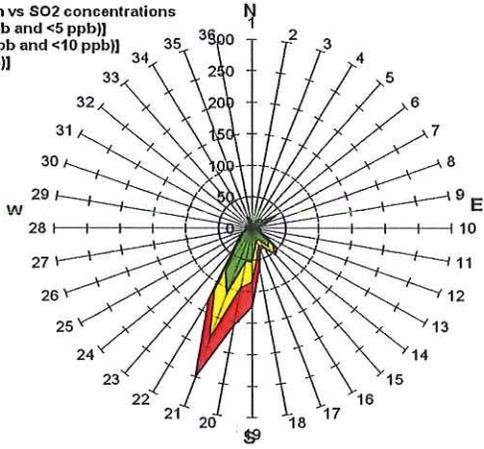
Marion County	Concentrations with all values (ppb)	Concentrations without upwind sources (ppb)
1-Hour DV (11-13)	78	78
Hourly Ave	2.8	1.9
Hourly Ave 99th	25.7	8.6
Winter 99th	19.7	8.1
Spring 99th	27.2	8.3
Summer 99th	19.1	7.9
Fall 99th	29.2	8.2

# Harding Street Pollution Roses

## Harding Street Meteorology

Harding St Marion County - Harding St. Met 2011

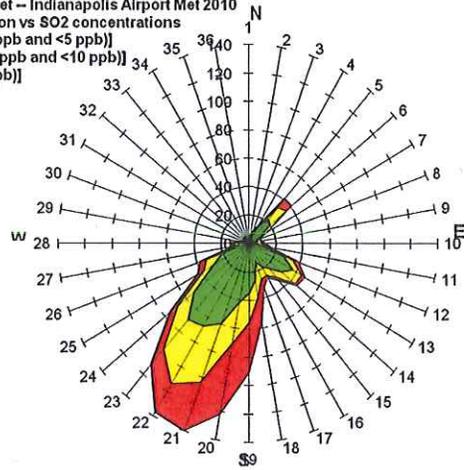
Wind Direction vs SO2 concentrations  
 [green (>=2 ppb and <5 ppb)]  
 [yellow (>=5 ppb and <10 ppb)]  
 [red (>=10 ppb)]



## Indianapolis Airport NWS Meteorology

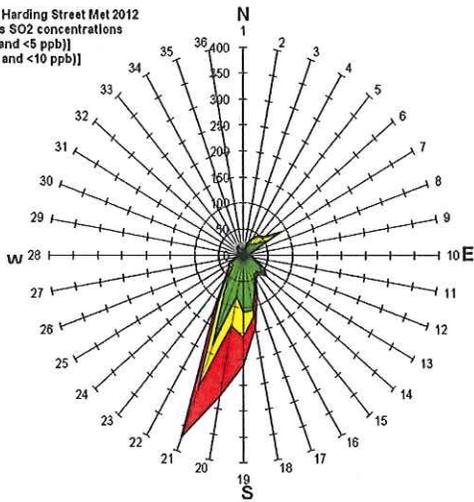
Harding Street -- Indianapolis Airport Met 2010

Wind Direction vs SO2 concentrations  
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 [yellow (>=5 ppb and <10 ppb)]  
 [red (>=10 ppb)]



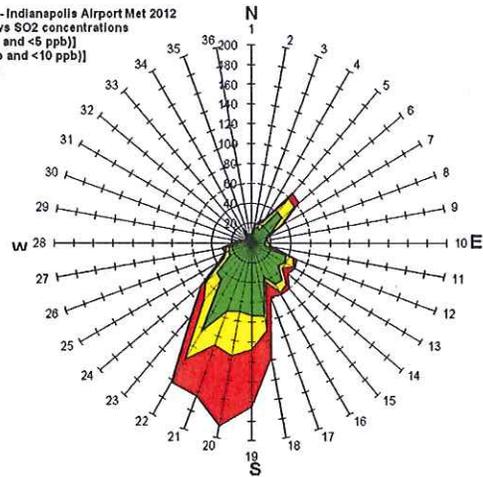
Harding Street -- Harding Street Met 2012

Wind Direction vs SO2 concentrations  
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 [yellow (>=5 ppb and <10 ppb)]  
 [red (>=10 ppb)]



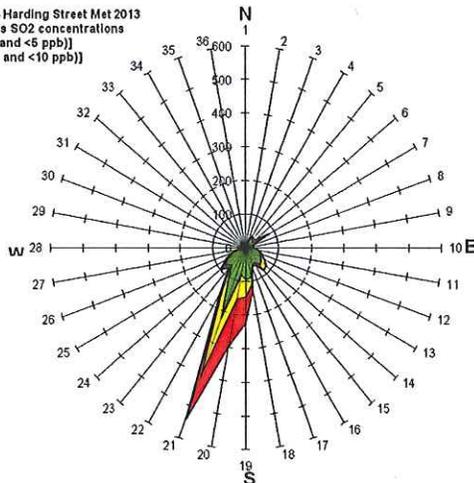
Harding Street -- Indianapolis Airport Met 2012

Wind Direction vs SO2 concentrations  
 [green (>=2 ppb and <5 ppb)]  
 [yellow (>=5 ppb and <10 ppb)]  
 [red (>=10 ppb)]



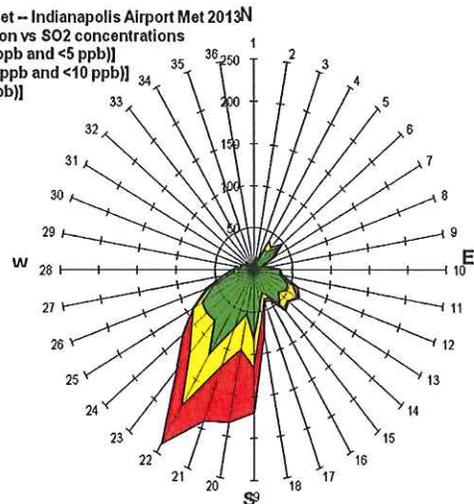
Harding Street -- Harding Street Met 2013

Wind Direction vs SO2 concentrations  
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 [yellow (>=5 ppb and <10 ppb)]  
 [red (>=10 ppb)]

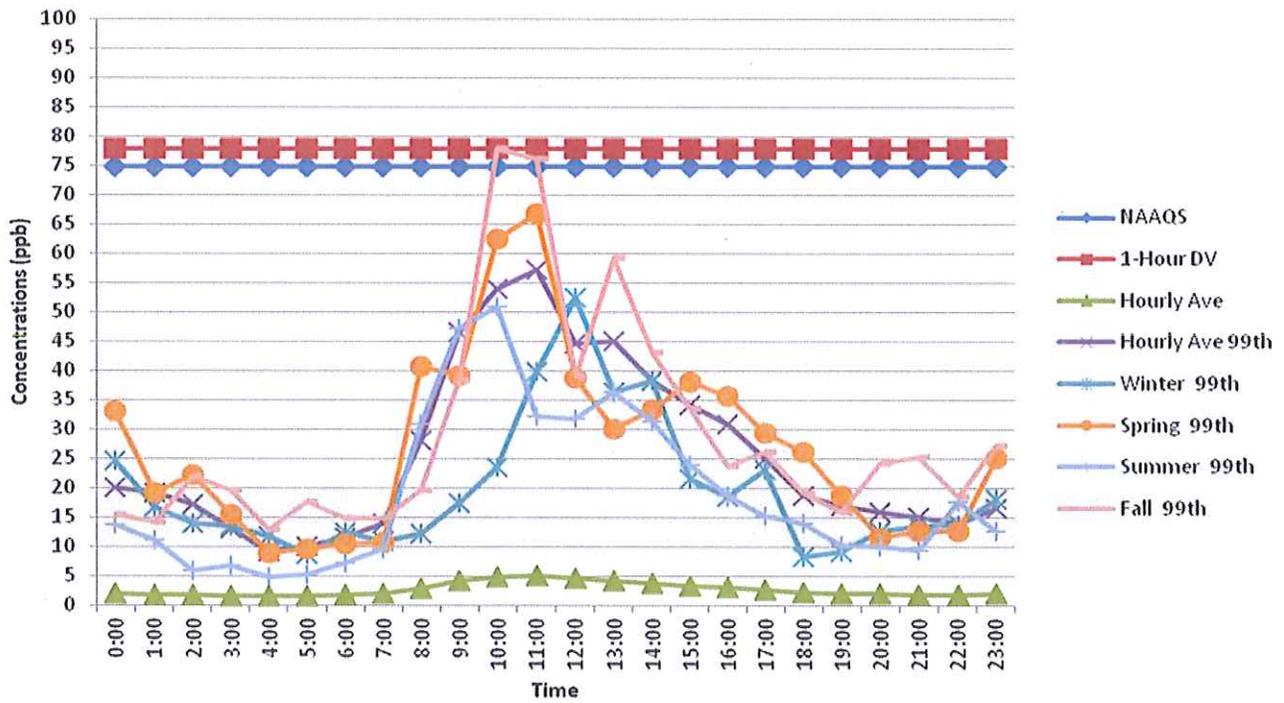


Harding Street -- Indianapolis Airport Met 2013

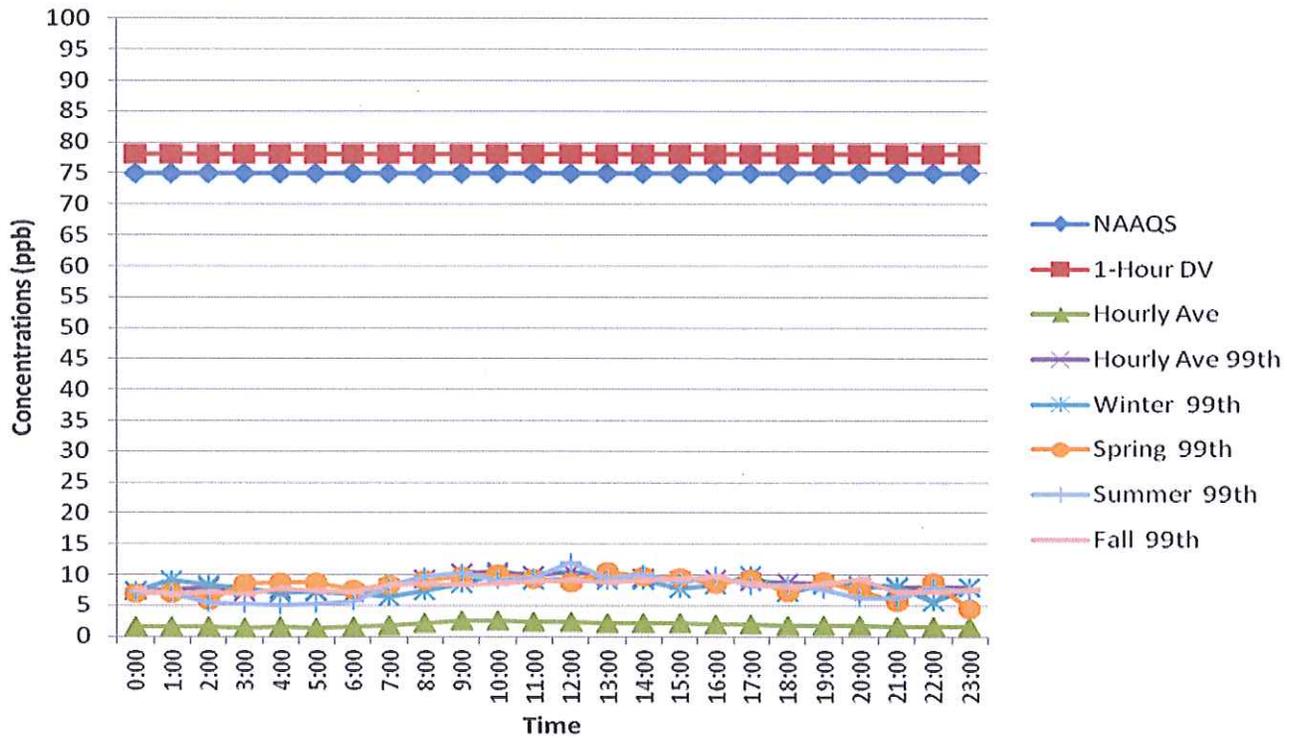
Wind Direction vs SO2 concentrations  
 [green (>=2 ppb and <5 ppb)]  
 [yellow (>=5 ppb and <10 ppb)]  
 [red (>=10 ppb)]



Harding St. - Marion County (18-097-0057)  
SO2 Monitoring 2011-2013



Harding St. - Marion County (18-097-0057)  
SO2 Monitoring with No Source Impact 2011-2013



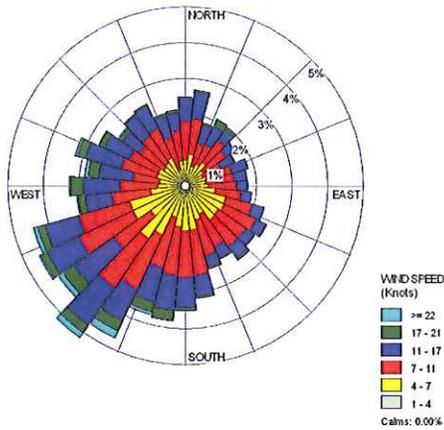
IPL Centerton Grade School  
Morgan County SO<sub>2</sub> Monitor  
2011 – 2013

# IPL Centerton Grade School SO<sub>2</sub> Concentration Summary (2011-2013)

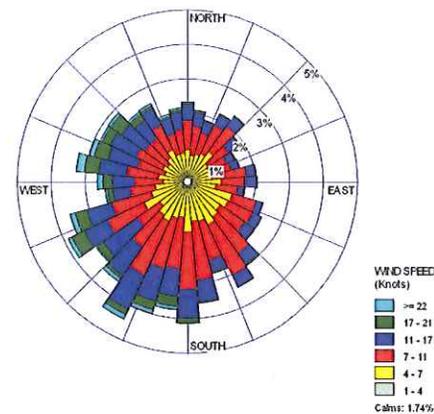
Site ID 18-109-1001	2011	2012	2013
Design Value (3 yr-ending)	100 ppb	94 ppb	81 ppb
Maximum Concentration	143 ppb	147 ppb	71 ppb
Average Concentration	3.4 ppb	2.4 ppb	1.8 ppb

## Indianapolis Airport National Weather Service Wind Roses

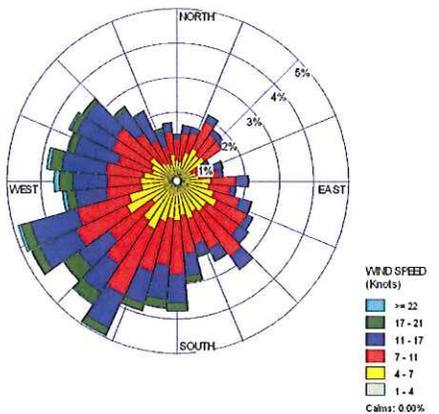
Indianapolis Wind Rose 2011



Indianapolis Wind Rose 2012



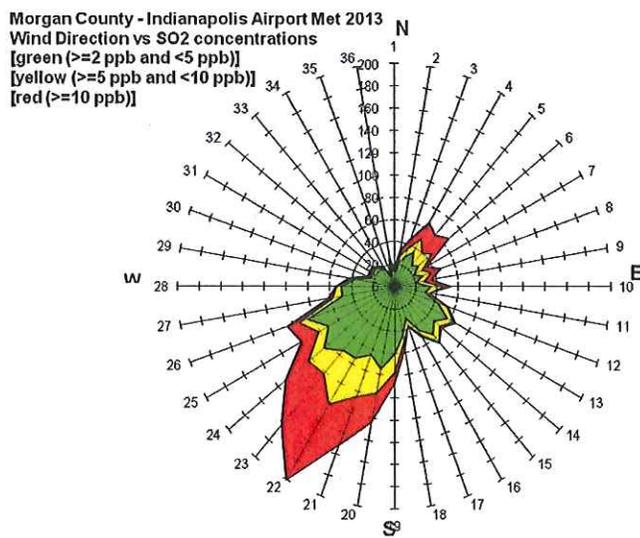
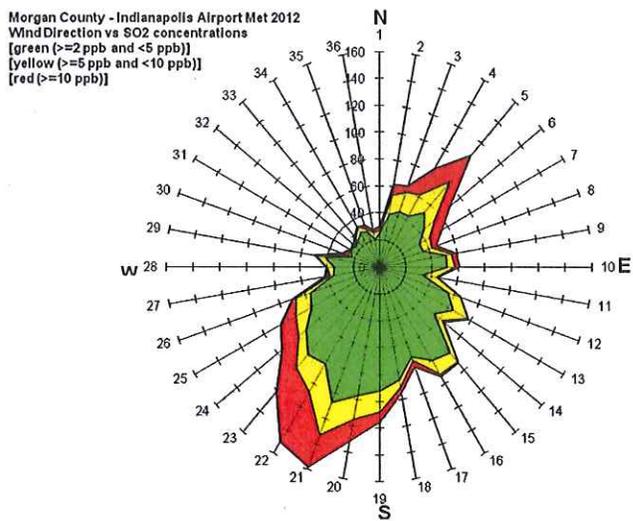
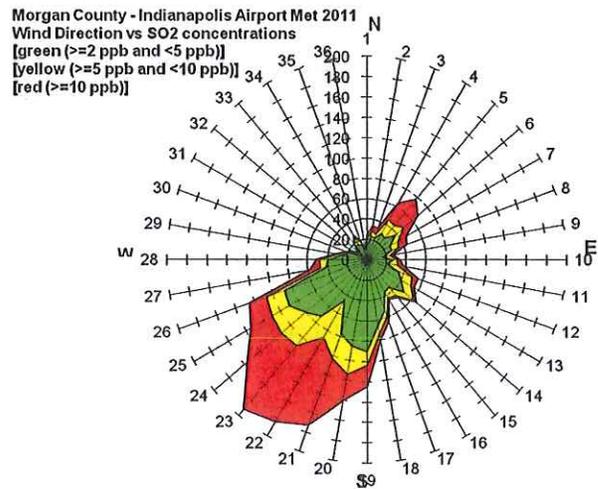
Indianapolis Wind Rose 2013



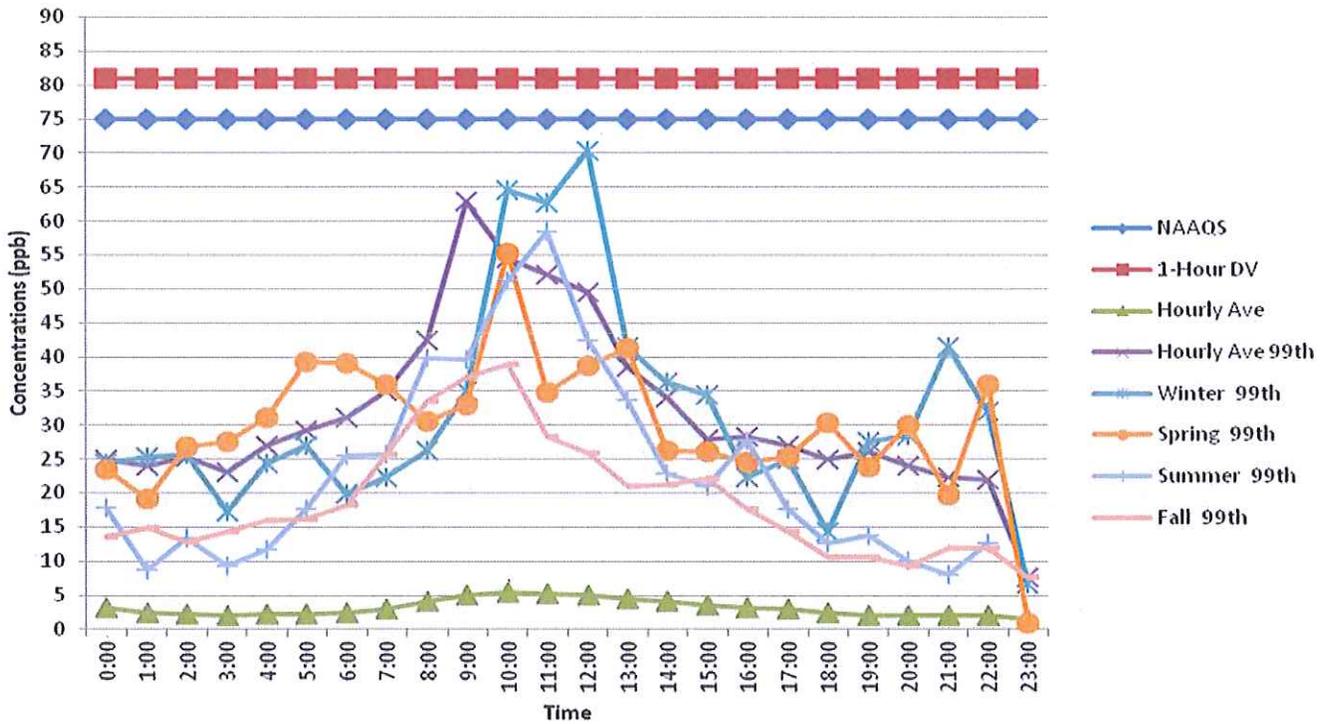
## EPA's Seasonal and Temporal 1-Hour SO<sub>2</sub> Background Determination

Morgan County	Concentrations with all values (ppb)	Concentrations without upwind sources (ppb)
1-Hour DV (11-13)	81	81
Hourly Ave	3.1	1.8
Hourly Ave 99th	31.8	9.4
Winter 99th	31.5	8.8
Spring 99th	29.9	7.9
Summer 99th	23.5	7.9
Fall 99th	18.9	7.2

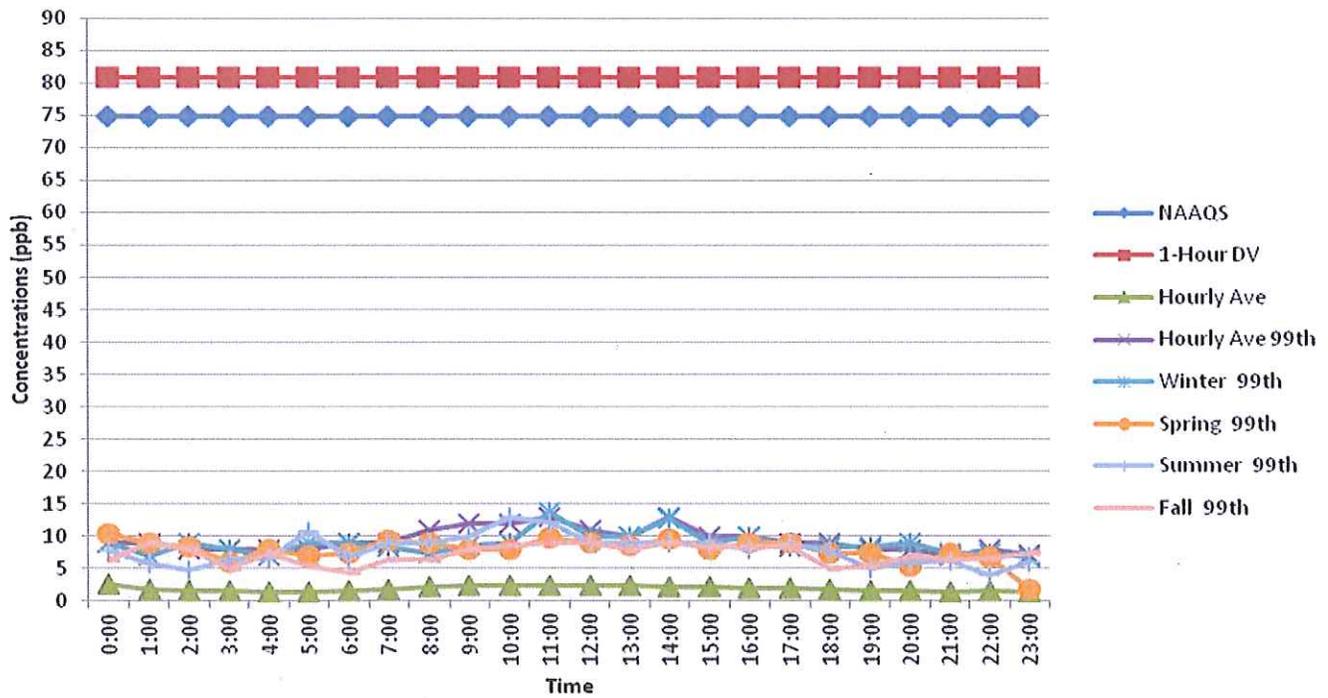
# Morgan County/Indianapolis Airport Pollution Roses



Centernton School -Morgan County (18-109-1001)  
SO2 Monitoring 2011-2013



Centernton School- Morgan County (18-109-1001)  
SO2 Monitoring with No Source Impacts - 2011-2013



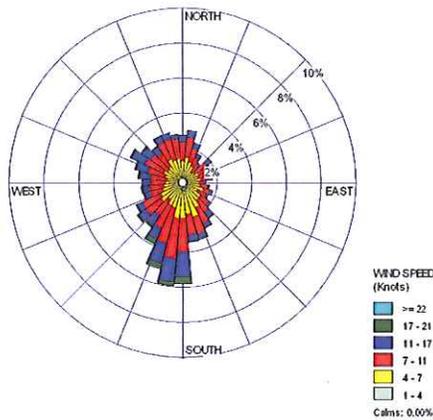
Fort Harrison Road - Terre Haute  
Vigo County SO<sub>2</sub> Monitor  
2011 – 2013

## Fort Harrison Road SO<sub>2</sub> Concentration Summary (2011-2013)

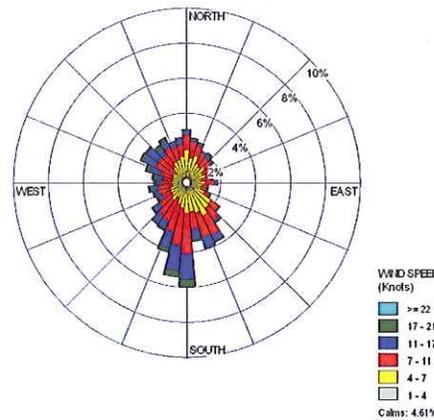
<b>Site ID 18-167-1014</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>
<b>Design Value 3 yr -ending</b>	150 ppb	145 ppb	123 ppb
<b>Maximum Concentration</b>	208 ppb	150 ppb	151 ppb
<b>Average Concentration</b>	5.2 ppb	4.7 ppb	4.0 ppb

## Terre Haute Airport-National Weather Service Wind Roses

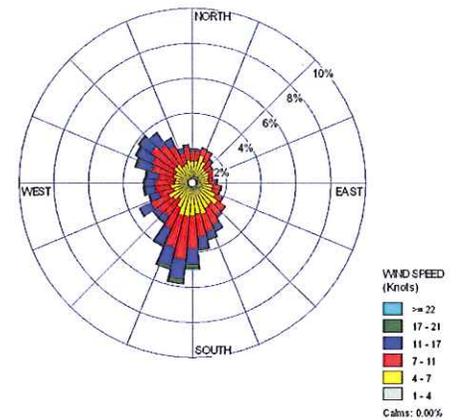
Terre Haute Wind Rose 2011



Terre Haute Wind Rose 2012



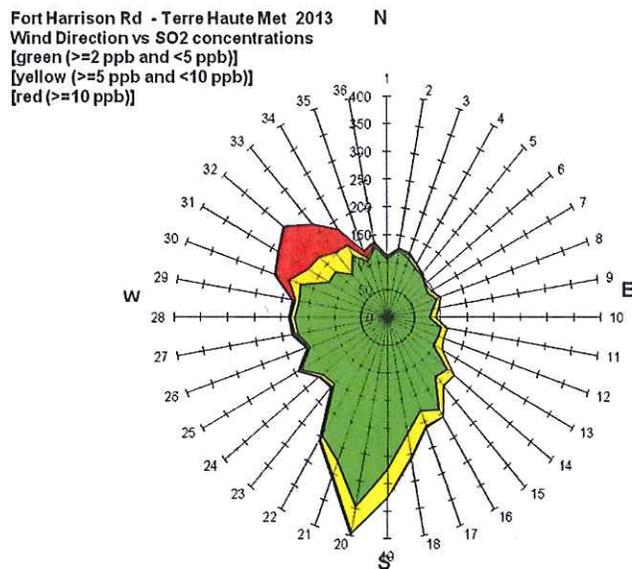
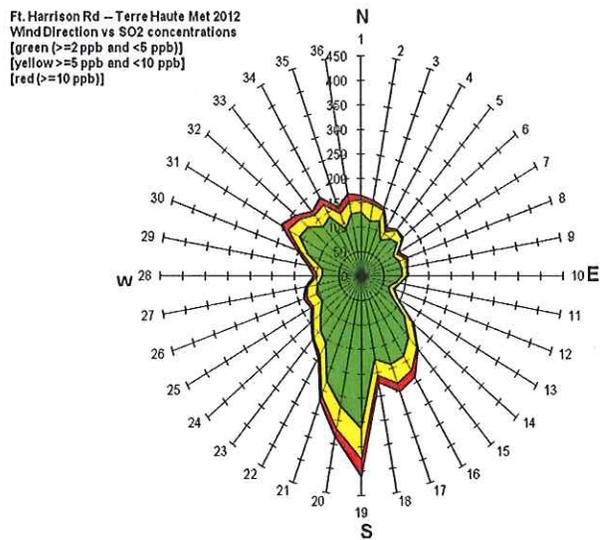
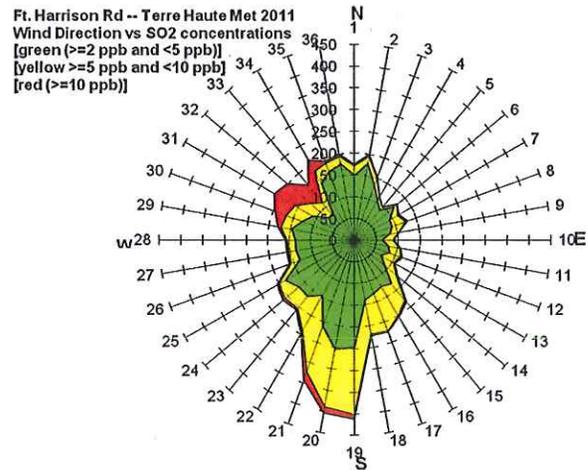
Terre Haute Wind Rose 2013



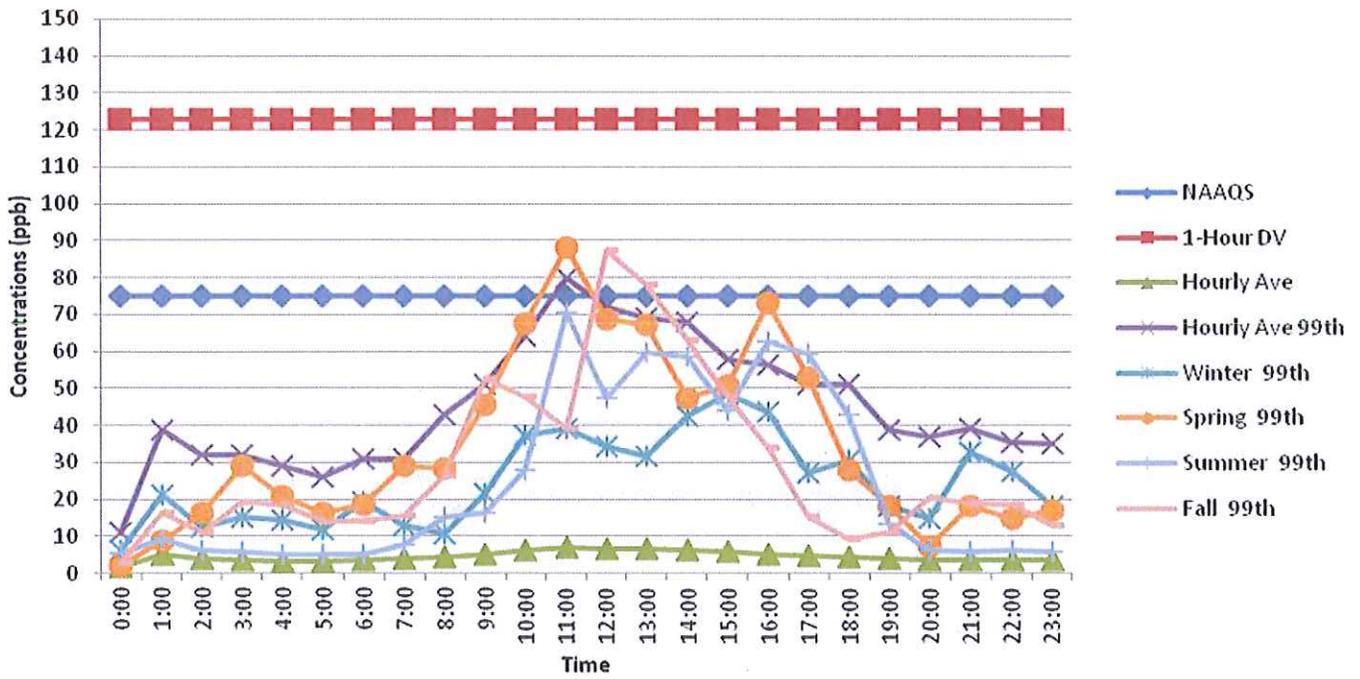
## EPA's Seasonal and Temporal 1-Hour SO<sub>2</sub> Background Determination

<b>Vigo County</b>	<b>Concentrations with all values (ppb)</b>	<b>Concentrations without upwind sources (ppb)</b>
1-Hour DV (10-12)	123	123
Hourly Ave	4.6	3.5
Hourly Ave 99th	45.0	8.8
Winter 99th	24.7	9.3
Spring 99th	34.8	7.9
Summer 99th	24.7	8.4
Fall 99th	29.0	8.1

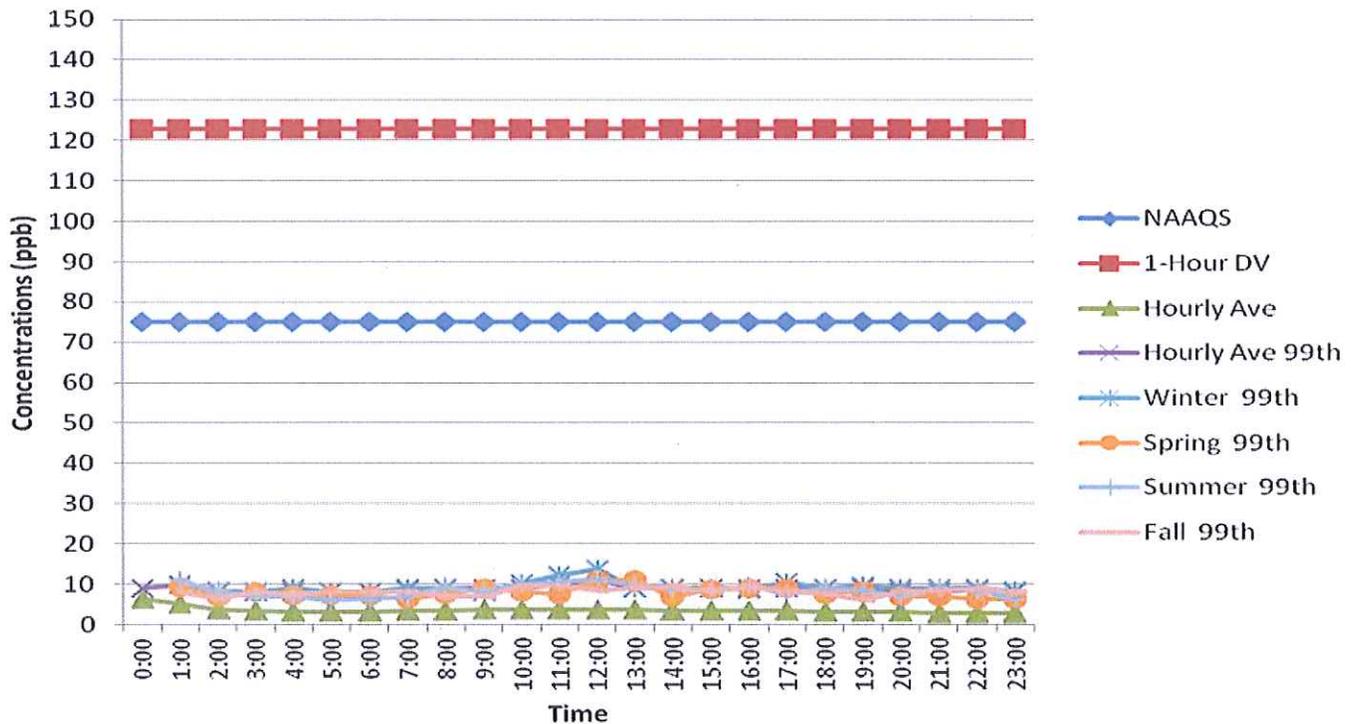
# Fort Harrison Road/Terre Haute NWS Meteorology Pollution Roses



**Fort Harrison Rd - Terre Haute, Vigo County (18-167-1014)  
SO2 Monitoring 2011-2013**



**Fort Harrison Rd Terre Haute - Vigo County (18-167-1014)  
SO2 Monitoring with No Source Impact 2011-2013**



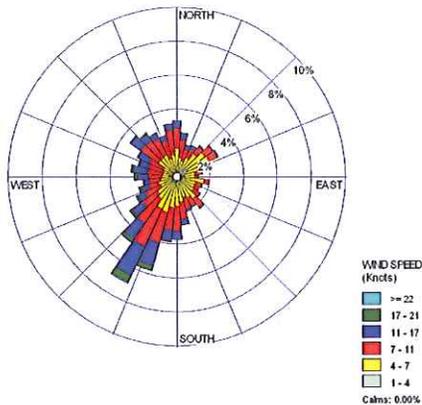
West of SR 57  
Daviness County SO<sub>2</sub> Monitor  
2011 – 2013

## Davieess County SO<sub>2</sub> Concentration Summary (2011-2013)

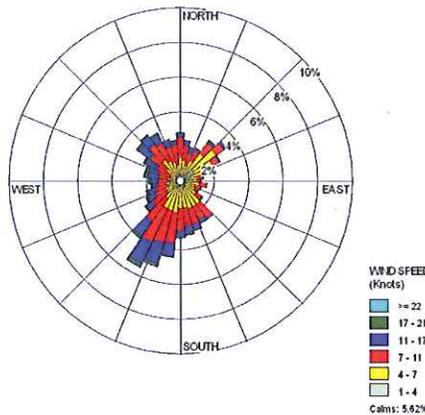
<b>Site ID 18-027-0002</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>
<b>Design Value (3 yr – ending)</b>	118 ppb	98 ppb	109 ppb
<b>Maximum Concentration</b>	130 ppb	147 ppb	202 ppb
<b>Average Concentration</b>	4.4 ppb	2.5 ppb	2.9 ppb

## Evansville Airport-National Weather Service Wind Roses

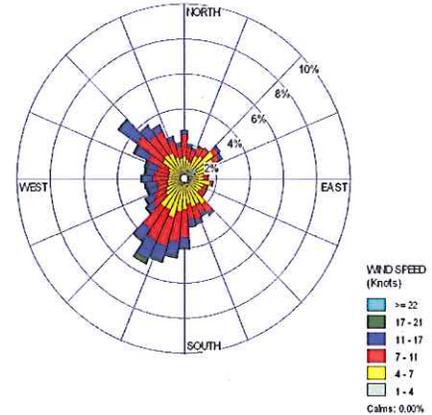
Evansville Wind Rose 2011



Evansville Wind Rose 2012



Evansville Wind Rose 2013

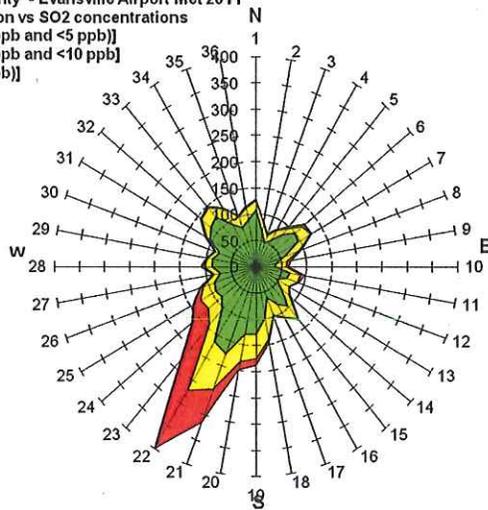


## EPA's Seasonal and Temporal 1-Hour SO<sub>2</sub> Background Determination

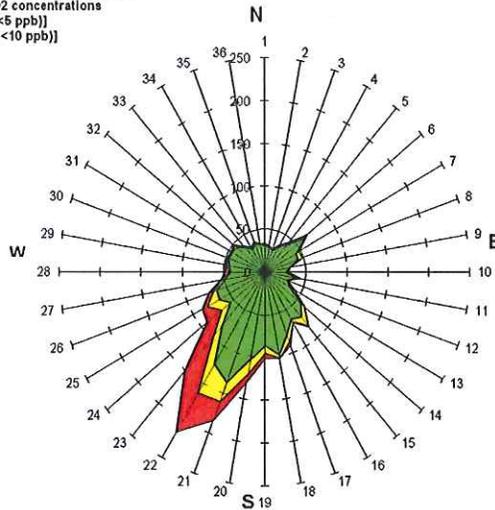
Davieess County	Concentrations with all values (ppb)	Concentrations without upwind sources (ppb)
1-Hour DV (11-13)	109	109
Hourly Ave	3.7	2.4
Hourly Ave 99th	35.5	8.6
Winter 99th	41.5	8.8
Spring 99th	26.7	7.8
Summer 99th	21.2	7.6
Fall 99th	24.6	6.6

# Daviess County/Evansville NWS Meteorology Pollution Roses

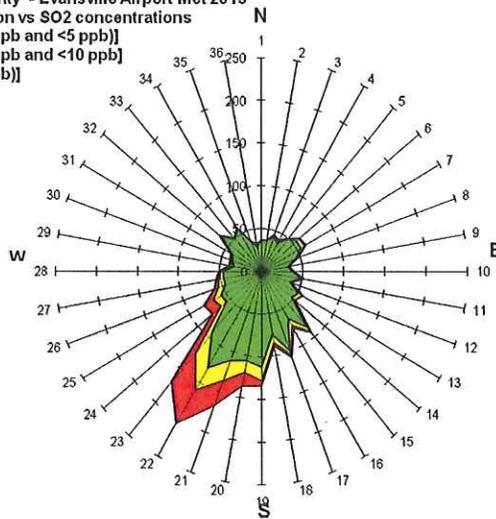
Daviess County - Evansville Airport Met 2011  
Wind Direction vs SO2 concentrations  
[green (>=2 ppb and <5 ppb)]  
[yellow >=5 ppb and <10 ppb]  
[red (>=10 ppb)]



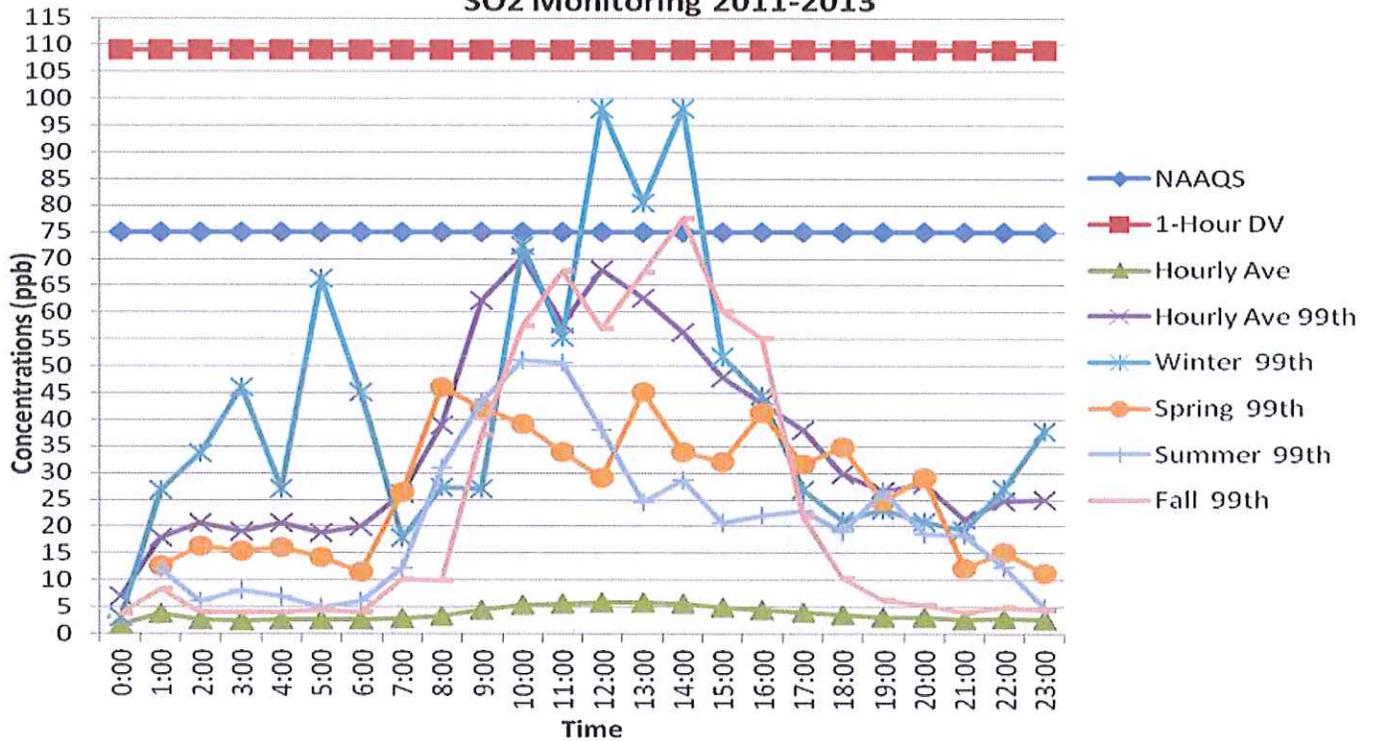
Daviess County- Evansville Airport Met 2012  
Wind Direction vs SO2 concentrations  
[green (>=2 ppb and <5 ppb)]  
[yellow >=5 ppb and <10 ppb]  
[red (>=10 ppb)]



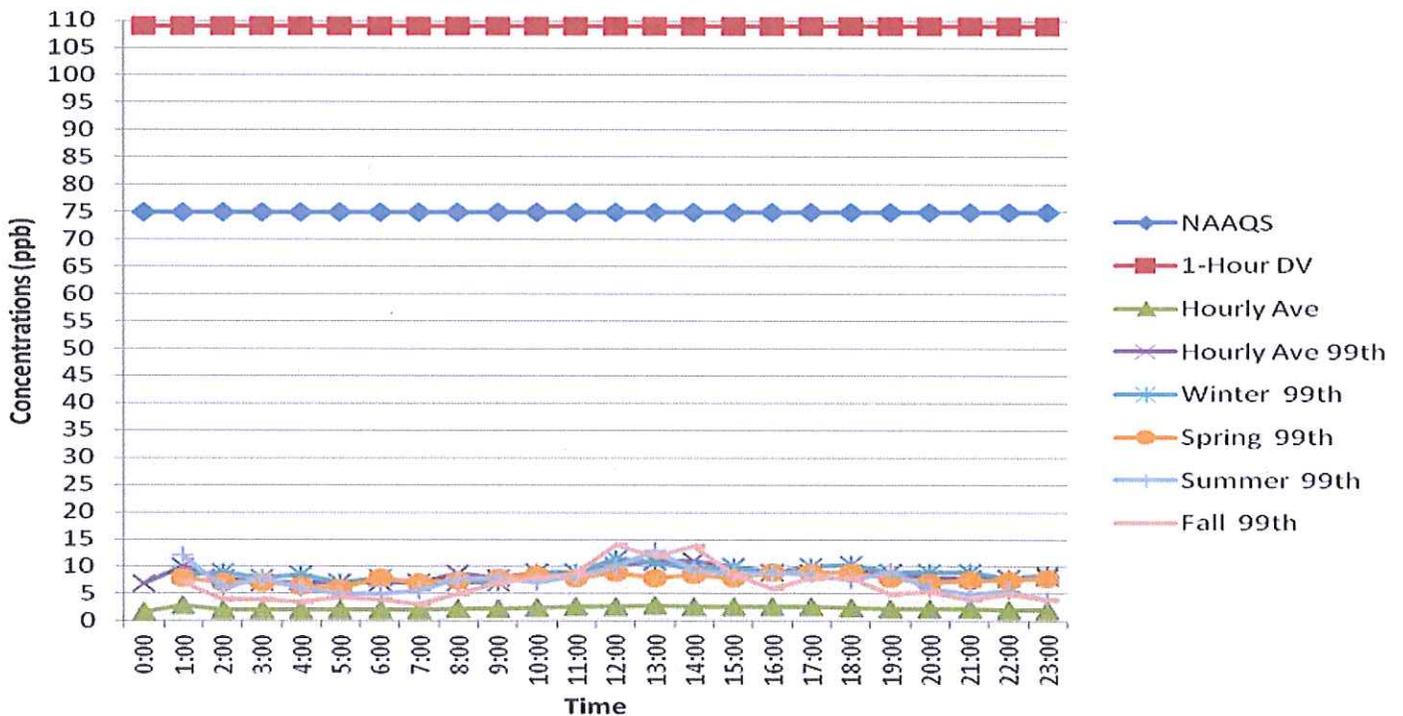
Daviess County - Evansville Airport Met 2013  
Wind Direction vs SO2 concentrations  
[green (>=2 ppb and <5 ppb)]  
[yellow >=5 ppb and <10 ppb]  
[red (>=10 ppb)]



**Daviess County (18-027-0002)  
SO2 Monitoring 2011-2013**



**Daviess County (18-027-0002)  
SO2 Monitoring with No Source Impact 2011-2013**



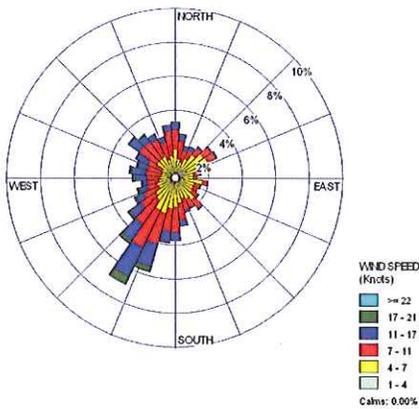
Arda Lane  
Pike County SO<sub>2</sub> Monitor  
2011 – 2013

## Arda Lane SO<sub>2</sub> Concentration Summary (2011-2013)

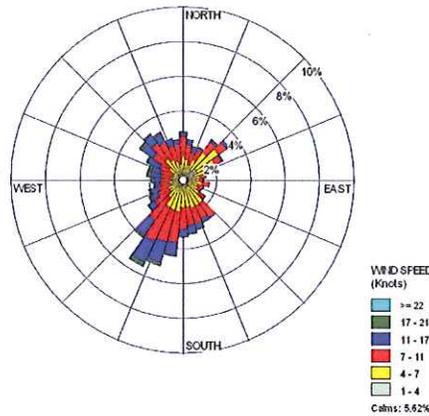
Site ID 18-125-0005	2011	2012	2013
Design Value (3 yr – ending)	175 ppb	157 ppb	143 ppb
Maximum Concentration	198 ppb	212 ppb	293 ppb
Average Concentration	5.9 ppb	5.0 ppb	3.4 ppb

## Evansville Airport-National Weather Service Wind Roses

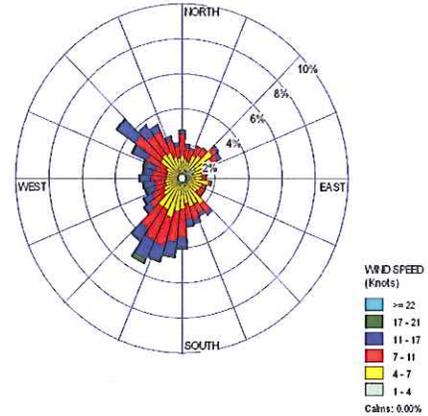
Evansville Wind Rose 2011



Evansville Wind Rose 2012



Evansville Wind Rose 2013

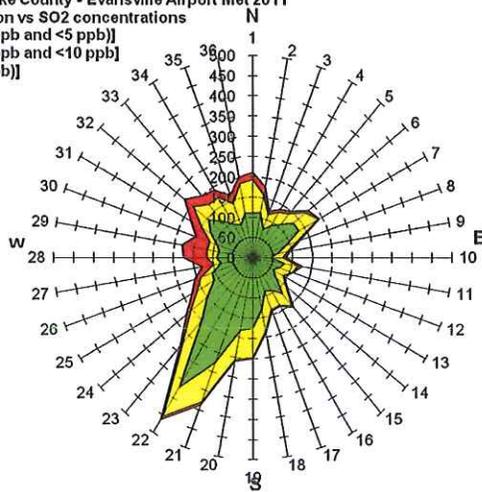


## EPA's Seasonal and Temporal 1-Hour SO<sub>2</sub> Background Determination

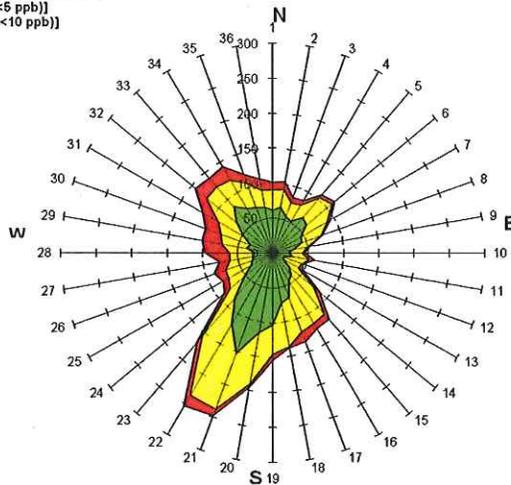
Pike County	Concentrations with all values (ppb)	Concentrations without upwind sources (ppb)
1-Hour DV (11-13)	143	143
Hourly Ave	5.7	3.5
Hourly Ave 99th	48.2	9.9
Winter 99th	55.8	10.5
Spring 99th	38.5	10.1
Summer 99th	28.8	9.0
Fall 99th	29.6	8.4

# Pike County/Evansville NWS Meteorology Pollution Roses

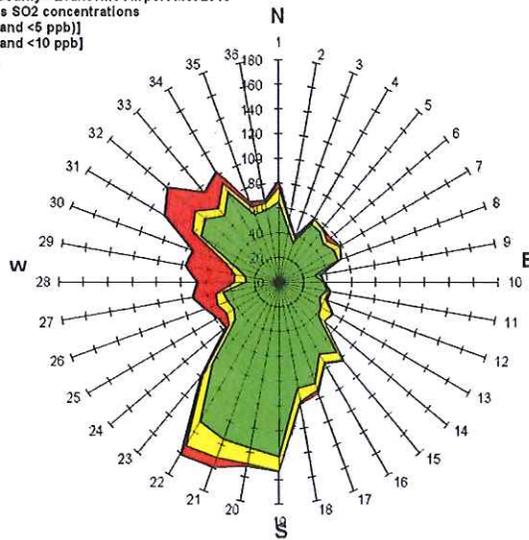
Arda Lane Pike County - Evansville Airport Met 2011  
 Wind Direction vs SO2 concentrations  
 [green (>=2 ppb and <5 ppb)]  
 [yellow (>=5 ppb and <10 ppb)]  
 [red (>=10 ppb)]



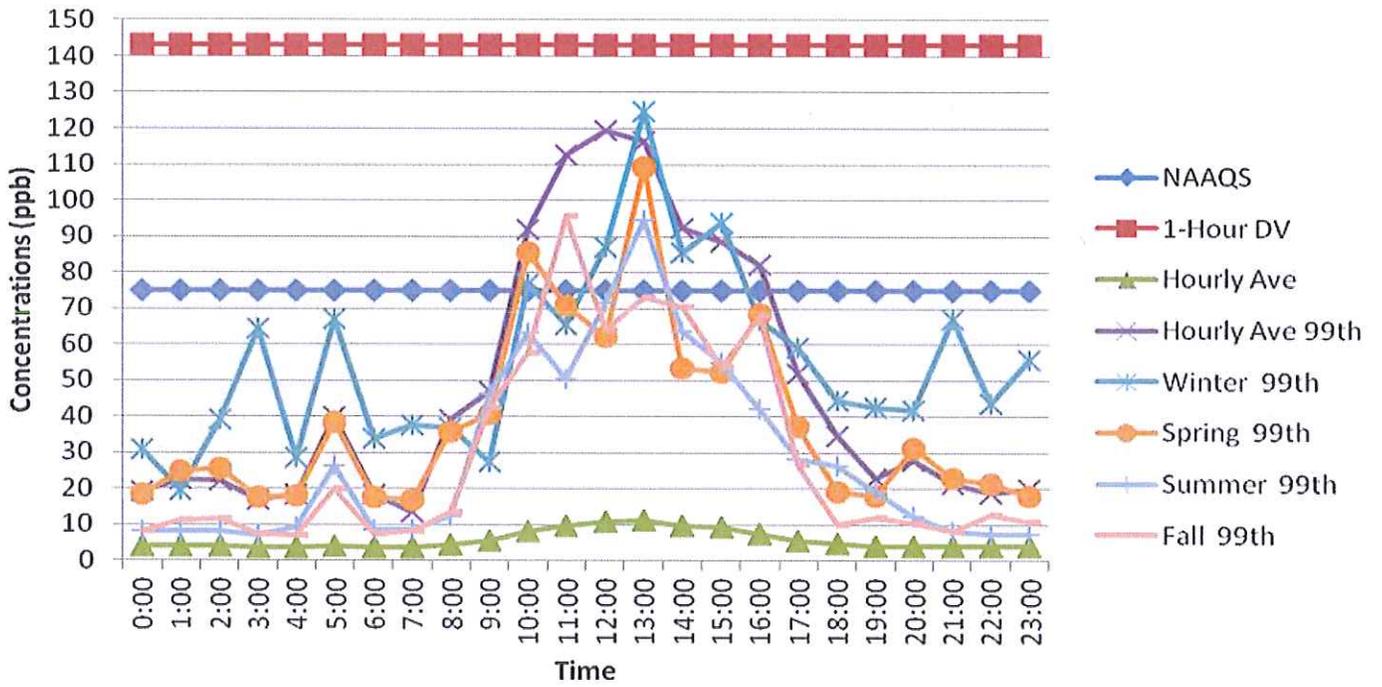
Arda Lane Pike County - Evansville Airport Met 2012  
 Wind Direction vs SO2 concentrations  
 [green (>=2 ppb and <5 ppb)]  
 [yellow (>=5 ppb and <10 ppb)]  
 [red (>=10 ppb)]



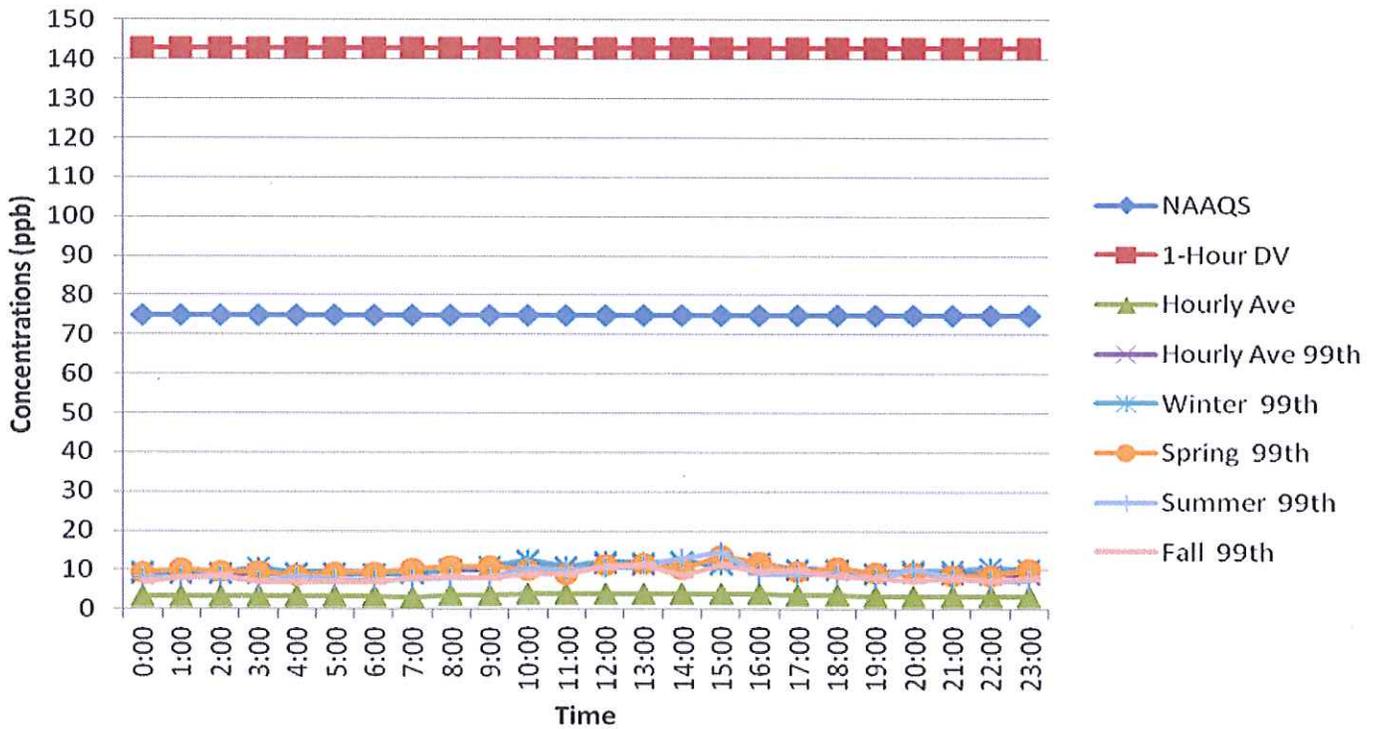
Arda Lane Pike County - Evansville Airport Met 2013  
 Wind Direction vs SO2 concentrations  
 [green (>=2 ppb and <5 ppb)]  
 [yellow (>=5 ppb and <10 ppb)]  
 [red (>=10 ppb)]



**East Arda Lane - Pike County (18-125-0005)  
SO2 Monitoring 2011-2013**



**East Arda Lane - Pike County (18-125-0005)  
SO2 Monitoring with No Source Impact 2011-2013**



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