# Emission and Air Quality Trends Review 1999-2011

## Kentucky

July 2013

# Project Objective

- To develop and present publicly available information on trends in emissions and ambient air quality in the U.S. since 1999 in easy to understand visual and tabular formats

# Emission Trends

- Study Team collected and processed U.S. EPA emission inventories for years within the study period of interest (1999-2011)

- By pollutant and source category
  - electric utility coal fuel combustion
  - mobile sources
  - industrial fuel combustion & industrial processes
  - all other

# Emissions Data Summary

- Data Obtained from EPA National Emission Inventory (NEI) and Trends Websites
  - EPA's Trends reports and emission comparisons include interpolations of all categories between key years (1999, 2002, 2005, 2008, 2011) at county-pollutant level
  - Represented Pollutants: VOC, NOx, $SO_2$, and $PM_{2.5}$
- Project Improvement
  - The Study Team augmented above data with year specific CEM emissions (2002 through 2011)

# Emission Changes

- The following slides also include the tonnage-based emissions change from 1999 to 2011 for each pollutant

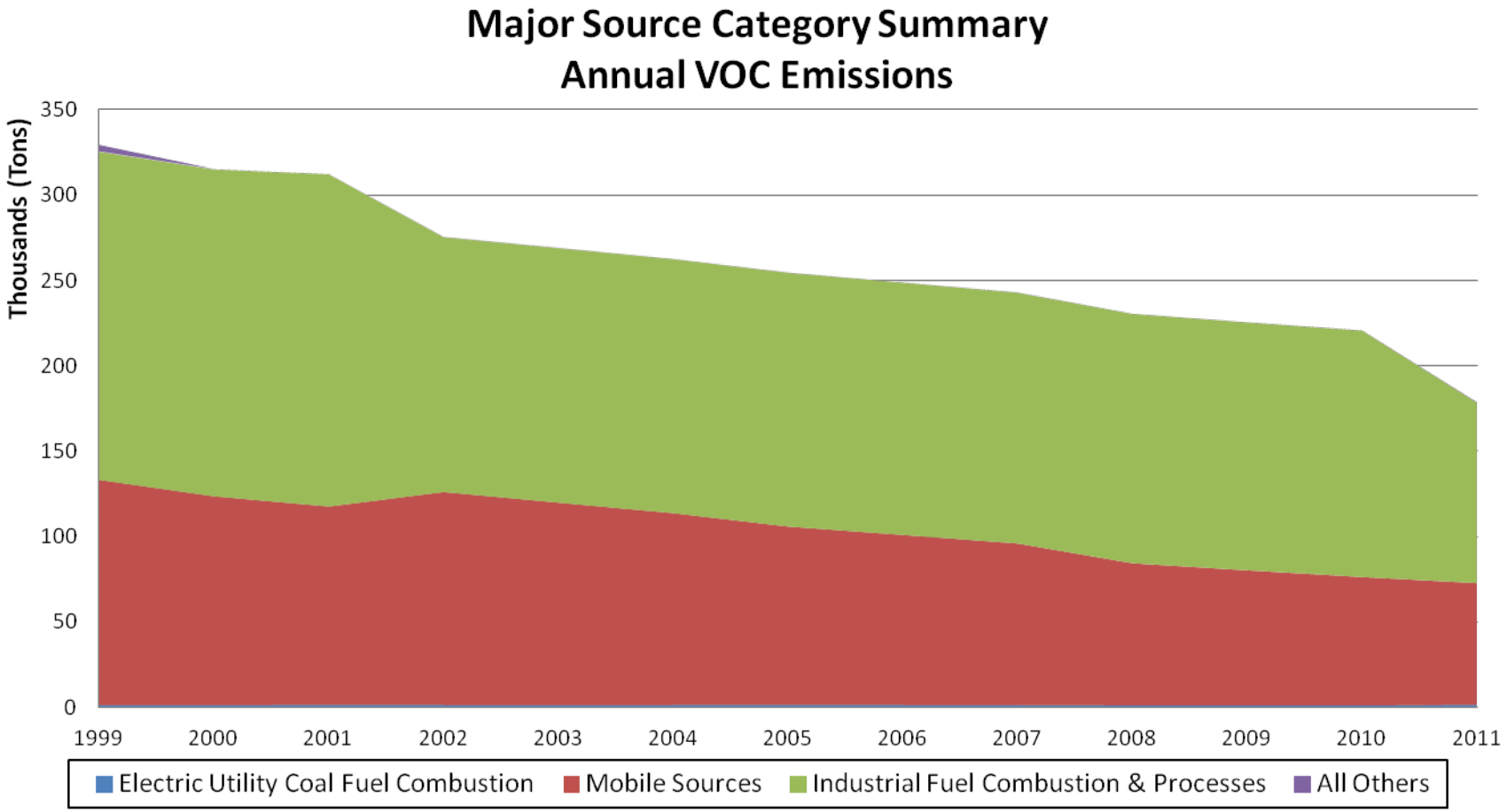
- Negative values indicate decrease in emissions, positive values indicate an increase

# Kentucky Emission Trends (VOC)

| | Annual Emissions (Tons) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Source Category** | **1999** | **2001** | **2003** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** |
| Electric Utility Coal Fuel Combustion | 1,365 | 1,441 | 1,385 | 1,435 | 1,439 | 1,375 | 1,213 | 1,067 | 1,114 | 1,522 |
| Mobile Sources | 131,718 | 116,092 | 118,408 | 104,364 | 99,430 | 94,495 | 83,077 | 79,101 | 75,125 | 71,152 |
| Industrial Fuel Combustion & Processes | 192,506 | 194,832 | 149,275 | 148,831 | 147,963 | 147,095 | 146,227 | 145,359 | 144,491 | 105,946 |
| All Others | 3,735 | 39 | 49 | 58 | 42 | 60 | 38 | 33 | 55 | 228 |
| **Total** | **329,323** | **312,404** | **269,117** | **254,688** | **248,874** | **243,024** | **230,555** | **225,560** | **220,785** | **178,848** |

| | Annual Emissions Change (Percent since 1999) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Source Category** | **1999** | **2001** | **2003** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** |
| Electric Utility Coal Fuel Combustion | 0% | 6% | 2% | 5% | 5% | 1% | -11% | -22% | -18% | 12% |
| Mobile Sources | 0% | -12% | -10% | -21% | -25% | -28% | -37% | -40% | -43% | -46% |
| Industrial Fuel Combustion & Processes | 0% | 1% | -22% | -23% | -23% | -24% | -24% | -24% | -25% | -45% |
| All Others | 0% | -99% | -99% | -98% | -99% | -98% | -99% | -99% | -99% | -94% |
| **Total** | **0%** | **-5%** | **-18%** | **-23%** | **-24%** | **-26%** | **-30%** | **-32%** | **-33%** | **-46%** |

# Kentucky Emission Trends (VOC)

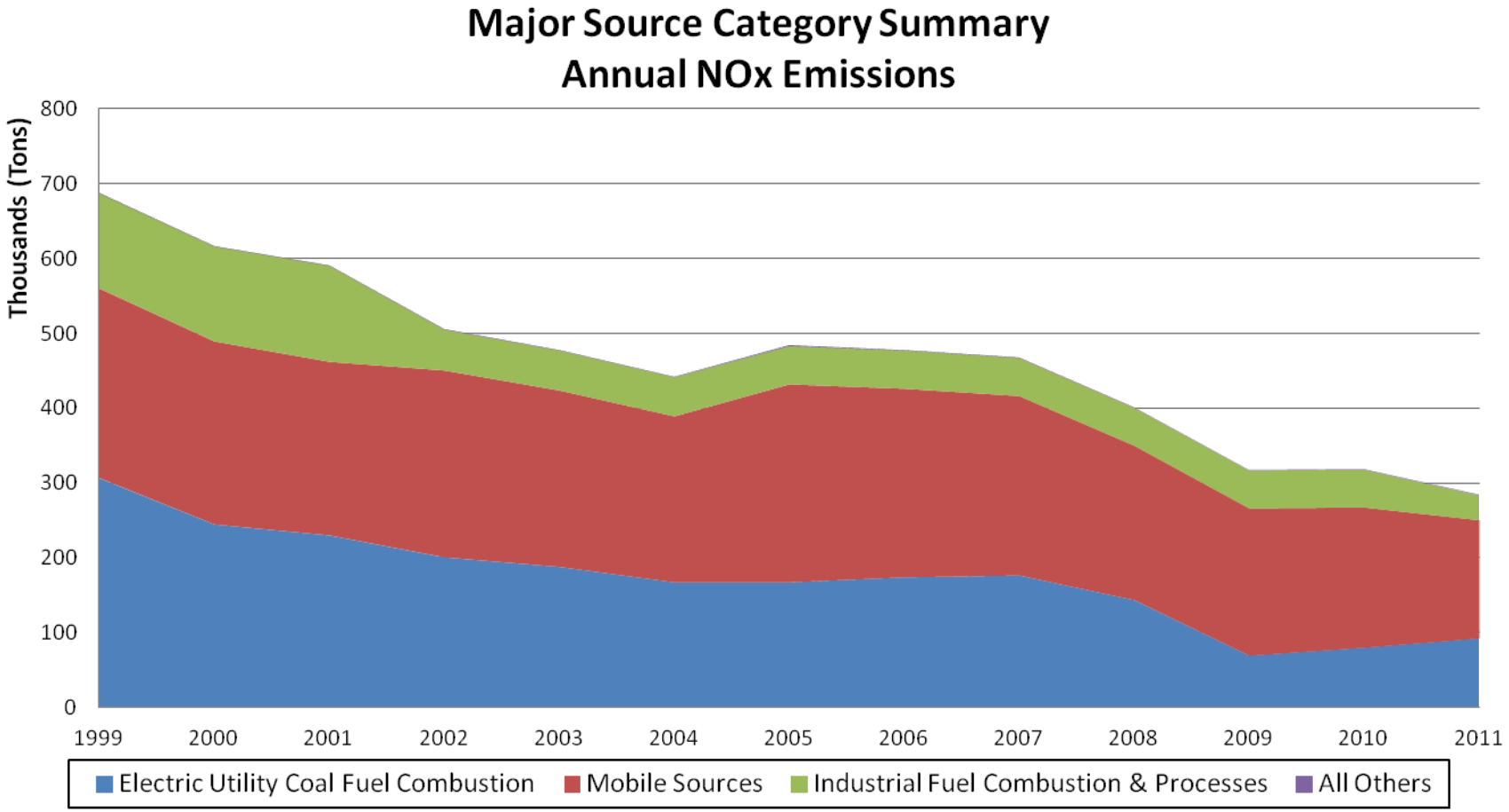


# Kentucky Emission Trends (NOx)

| | Annual Emissions (Tons) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Source Category** | **1999** | **2001** | **2003** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** |
| Electric Utility Coal Fuel Combustion | 306,404 | 229,722 | 187,519 | 166,983 | 173,568 | 176,110 | 143,140 | 68,765 | 79,245 | 91,871 |
| Mobile Sources | 253,389 | 232,081 | 235,963 | 264,672 | 252,294 | 239,917 | 206,532 | 197,149 | 187,767 | 158,059 |
| Industrial Fuel Combustion & Processes | 127,433 | 128,562 | 53,589 | 51,300 | 51,191 | 51,041 | 50,800 | 50,667 | 50,542 | 33,318 |
| All Others | 673 | 693 | 641 | 1,421 | 648 | 789 | 649 | 595 | 707 | 893 |
| **Total** | **687,899** | **591,058** | **477,713** | **484,376** | **477,702** | **467,856** | **401,120** | **317,176** | **318,261** | **284,140** |

| | Annual Emissions Change (Percent since 1999) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Source Category** | **1999** | **2001** | **2003** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** |
| Electric Utility Coal Fuel Combustion | 0% | -25% | -39% | -46% | -43% | -43% | -53% | -78% | -74% | -70% |
| Mobile Sources | 0% | -8% | -7% | 4% | 0% | -5% | -18% | -22% | -26% | -38% |
| Industrial Fuel Combustion & Processes | 0% | 1% | -58% | -60% | -60% | -60% | -60% | -60% | -60% | -74% |
| All Others | 0% | 3% | -5% | 111% | -4% | 17% | -4% | -12% | 5% | 33% |
| **Total** | **0%** | **-14%** | **-31%** | **-30%** | **-31%** | **-32%** | **-42%** | **-54%** | **-54%** | **-59%** |

# Kentucky Emission Trends (NOx)

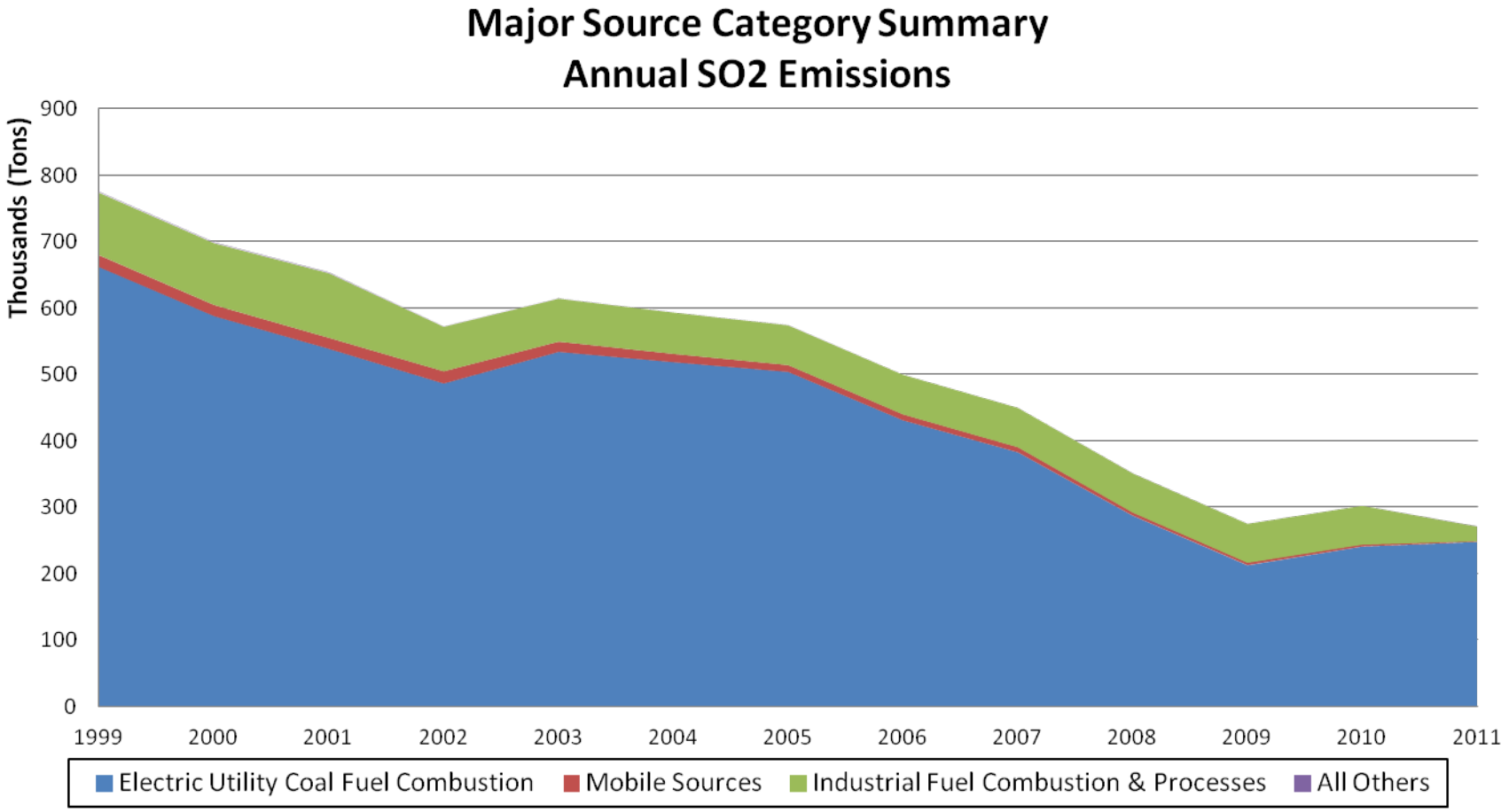


# Kentucky Emission Trends ($SO_2$)

| | Annual Emissions (Tons) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Source Category** | **1999** | **2001** | **2003** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** |
| Electric Utility Coal Fuel Combustion | 662,247 | 538,860 | 534,169 | 504,008 | 430,825 | 382,538 | 286,877 | 211,940 | 240,213 | 247,341 |
| Mobile Sources | 17,921 | 16,677 | 15,706 | 10,470 | 9,251 | 8,031 | 5,260 | 4,441 | 3,621 | 1,640 |
| Industrial Fuel Combustion & Processes | 93,877 | 97,388 | 64,813 | 60,039 | 59,748 | 59,457 | 59,166 | 58,874 | 58,583 | 22,275 |
| All Others | 565 | 593 | 67 | 60 | 48 | 46 | 56 | 39 | 27 | 216 |
| **Total** | **774,610** | **653,518** | **614,755** | **574,578** | **499,871** | **450,073** | **351,360** | **275,293** | **302,445** | **271,472** |

| | Annual Emissions Change (Percent since 1999) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Source Category** | **1999** | **2001** | **2003** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** |
| Electric Utility Coal Fuel Combustion | 0% | -19% | -19% | -24% | -35% | -42% | -57% | -68% | -64% | -63% |
| Mobile Sources | 0% | -7% | -12% | -42% | -48% | -55% | -71% | -75% | -80% | -91% |
| Industrial Fuel Combustion & Processes | 0% | 4% | -31% | -36% | -36% | -37% | -37% | -37% | -38% | -76% |
| All Others | 0% | 5% | -88% | -89% | -92% | -92% | -90% | -93% | -95% | -62% |
| **Total** | **0%** | **-16%** | **-21%** | **-26%** | **-35%** | **-42%** | **-55%** | **-64%** | **-61%** | **-65%** |

# Kentucky Emission Trends ($SO_2$)

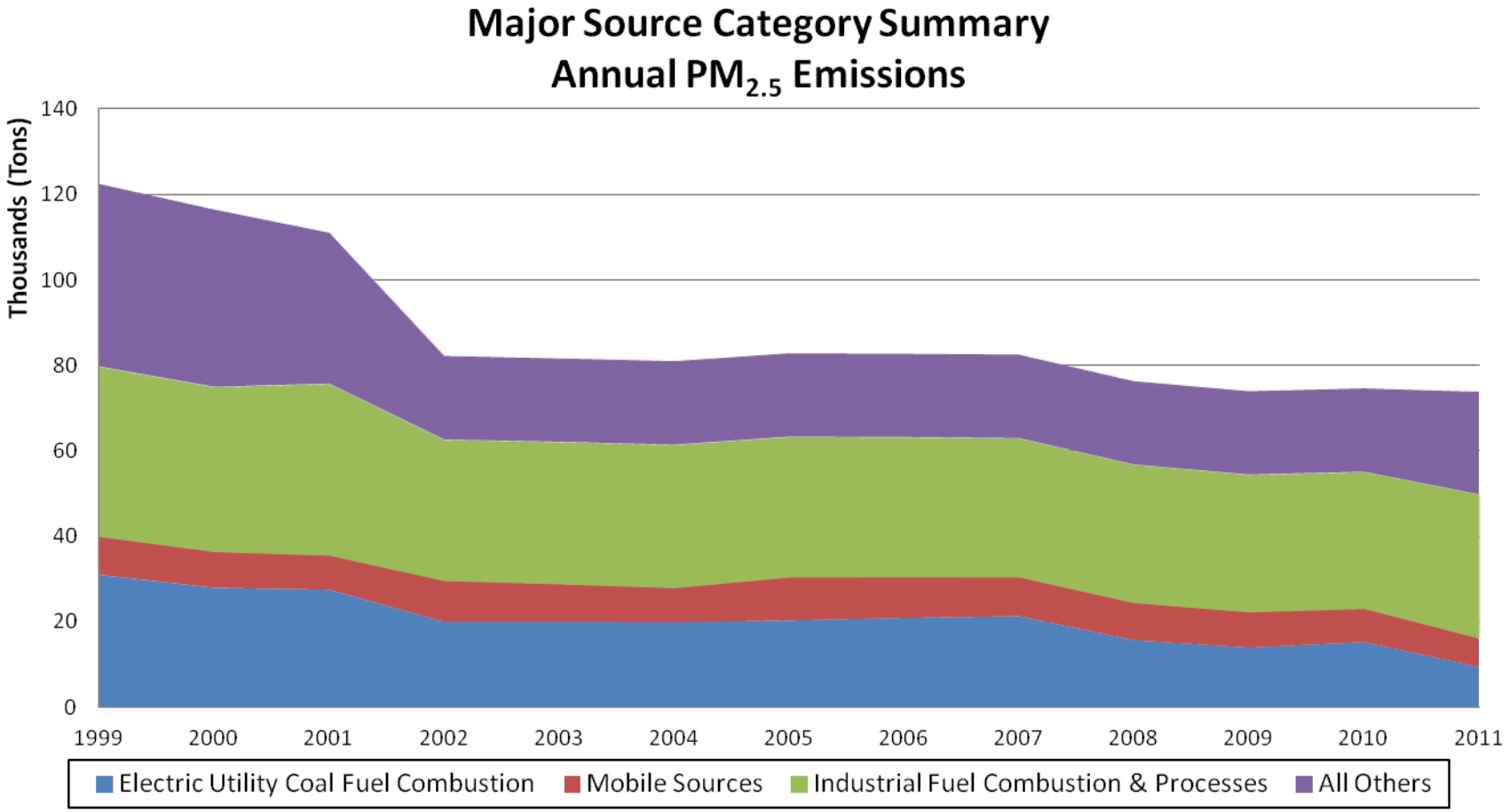


# Kentucky Emission Trends ($PM_{2.5}$)

| | Annual Emissions (Tons) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Source Category** | **1999** | **2001** | **2003** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** |
| Electric Utility Coal Fuel Combustion | 30,904 | 27,428 | 19,916 | 20,215 | 20,800 | 21,224 | 15,613 | 13,898 | 15,165 | 9,367 |
| Mobile Sources | 9,014 | 8,100 | 8,906 | 10,187 | 9,695 | 9,204 | 8,809 | 8,355 | 7,901 | 6,759 |
| Industrial Fuel Combustion & Processes | 39,792 | 40,161 | 33,276 | 32,883 | 32,711 | 32,539 | 32,366 | 32,194 | 32,022 | 33,720 |
| All Others | 42,610 | 35,241 | 19,470 | 19,467 | 19,457 | 19,471 | 19,454 | 19,449 | 19,466 | 23,895 |
| **Total** | **122,320** | **110,930** | **81,567** | **82,752** | **82,663** | **82,437** | **76,242** | **73,896** | **74,554** | **73,740** |

| | Annual Emissions Change (Percent since 1999) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Source Category** | **1999** | **2001** | **2003** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** |
| Electric Utility Coal Fuel Combustion | 0% | -11% | -36% | -35% | -33% | -31% | -49% | -55% | -51% | -70% |
| Mobile Sources | 0% | -10% | -1% | 13% | 8% | 2% | -2% | -7% | -12% | -25% |
| Industrial Fuel Combustion & Processes | 0% | 1% | -16% | -17% | -18% | -18% | -19% | -19% | -20% | -15% |
| All Others | 0% | -17% | -54% | -54% | -54% | -54% | -54% | -54% | -54% | -44% |
| **Total** | **0%** | **-9%** | **-33%** | **-32%** | **-32%** | **-33%** | **-38%** | **-40%** | **-39%** | **-40%** |

# Kentucky Emission Trends ($PM_{2.5}$)



# Emission Trends Summary

- All pollutants have decreased since 1999 in aggregate across Kentucky
- NOx and SO2 from Electric Utility Fuel Combustion sources show significant decrease over time as a result of Acid Rain Program, NOx Budget Trading Program and CAIR control implementation
- Onroad emission step increase seen between 2004 and 2005 is the result of EPA's method change and MOVES model integration for estimating onroad mobile source emissions

# Air Quality Design Values

- Ozone
  - Annual 4th highest daily maximum 8-hour average averaged over three consecutive years
  - Current standard = 0.075 ppm
- $PM_{2.5}$ Annual
  - Annual arithmetic mean of quarterly means averaged over three consecutive years
  - Current standard = 12 ug/$m^3$
- $PM_{2.5}$ 24-Hour
  - Annual 98th percentile of daily averages averaged over three consecutive years
  - Current standard = 35 ug/$m^3$

# State-Wide Design Value (DV) Trends

- Trends in state-wide maximum DV and average DV
  - Max DV: Maximum DVs over all valid trend monitoring sites in the state in each overlapping three year period
  - Average DV: Average of DVs over all valid trend monitoring sites in the state in each overlapping three year period
- Compute linear trend via least-squares regression

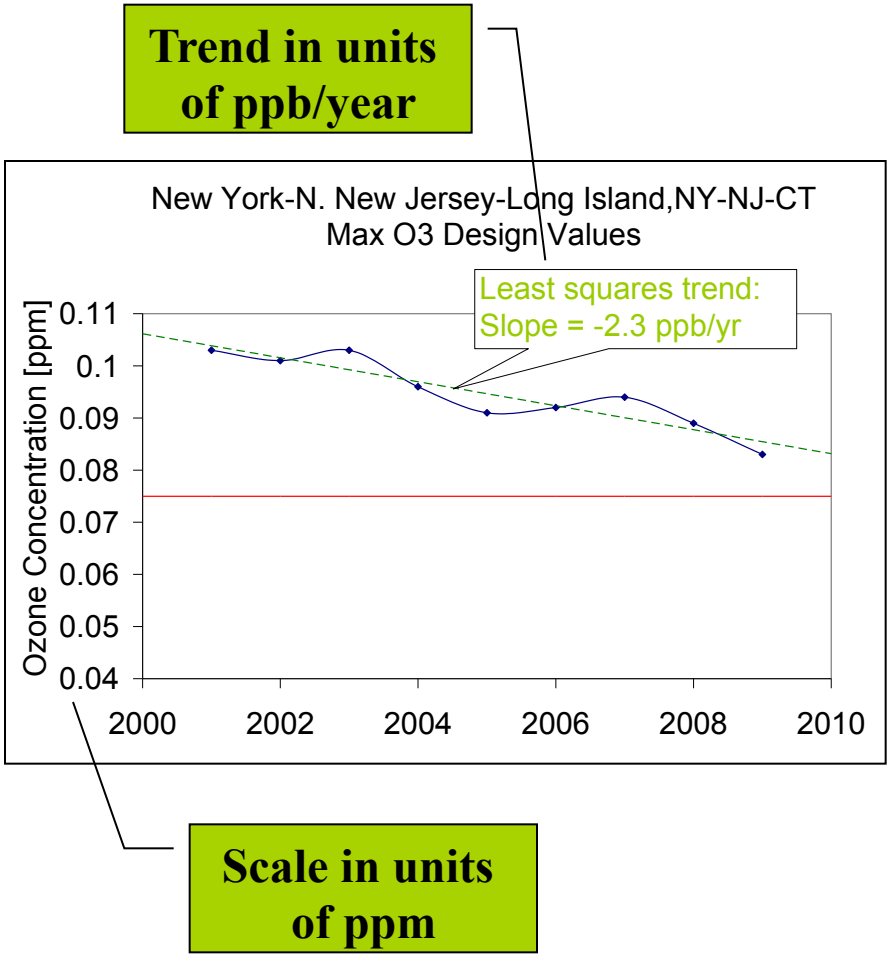
# Data Handling Procedures

- $O_3$ design value (DV) for each overlapping three-year period starting with 1999-2001 and ending with 2009-2011
  - DV calculated using annual 4$^{th}$ highest daily max 8-hr averages and percent of valid observations, based on EPA data handling conventions
  - Data associated with exceptional events that have received EPA concurrence are omitted
  - Selection of trend sites require valid DV in 9 out of 11 three-year periods between 1999 and 2011
  - Identification of nonattainment areas is with respect to the 2008 8-hour standard only

# Data Handling Procedures

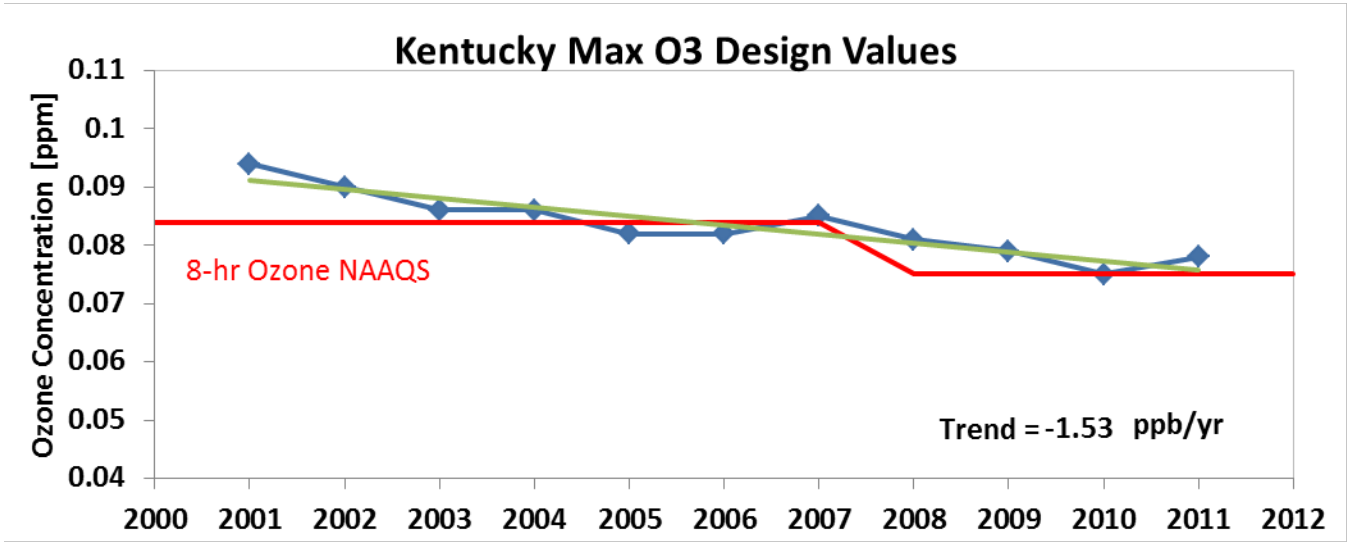
- Annual $PM_{2.5}$ DV and 24-hr $PM_{2.5}$ DV for each overlapping three-year period starting with 1999-2001 and ending with 2009-2011
  - DV calculations based on EPA data handling conventions
  - Data extracted from monitors that have a non-regulatory monitoring type are omitted
  - Selection of trend sites require valid DV in 9 out of 11 three-year periods between 1999 and 2011

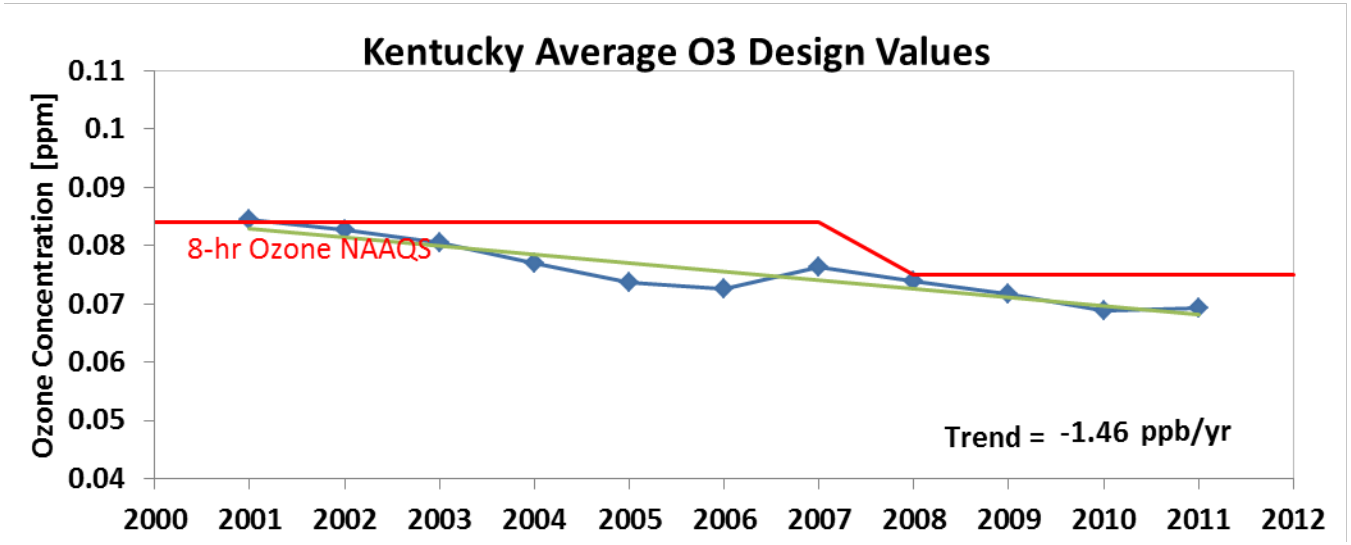
# Trend Calculation




- Trends based on linear least squares fit to rolling three year design values (DVs)
- Negative trend indicates improving air quality
- DVs based on each 3-year period: 1999-2001, 2000-2002, … 2009-2011
- Notes
  - On plots, DVs are for three year period ending in year shown (i.e., 2009-2011 DV plotted as 2011 value)
  - Ozone trend values expressed as ppb/year (1,000 ppb = 1 ppm); DVs are plotted as ppm

# Max/Ave $O_3$ DVs and Trend



# Ozone Trends by Site in Kentucky

| Monitoring Sites | County | 2009-2011 DV [ppm] | Trend [ppm/ yr] |
|---|---|---|---|
| 2101300024420101 | Bell, KY | 0.063 | -2.21 |
| 2101500034420101 | Boone, KY | 0.067 | -2.20 |
| 2101900174420101 | Boyd, KY | 0.069 | -2.27 |
| 2102900064420101 | Bullitt, KY | 0.07 | -1.63 |
| 2104305004420101 | Carter, KY | 0.066 | -1.53 |
| 2105900054420101 | Daviess, KY | 0.073 | -0.40 |
| 2106105014420101 | Edmonson, KY | 0.07 | -1.57 |
| 2106700124420101 | Fayette, KY | 0.069 | -1.04 |
| 2108900074420101 | Greenup, KY | 0.068 | -1.65 |

Note: Only monitoring sites meeting data completeness criteria listed

# Ozone Trends by Site in Kentucky

| Monitoring Sites | County | 2009-2011 DV [ppm] | Trend [ppm/yr] |
|---|---|---|---|
| 2109100124420101 | Hancock, KY | 0.072 | -1.20 |
| 2109300064420101 | Hardin, KY | 0.068 | -1.13 |
| 2110100144420101 | Henderson, KY | 0.074 | -0.76 |
| 2111100274420101 | Jefferson, KY | 0.074 | -1.21 |
| 2111100514420101 | Jefferson, KY | 0.078 | -0.75 |
| 2111110214420101 | Jefferson, KY | N/A | -1.72 |
| 2111300014420101 | Jessamine, KY | 0.068 | -1.00 |
| 2111700074420101 | Kenton, KY | N/A | -1.37 |

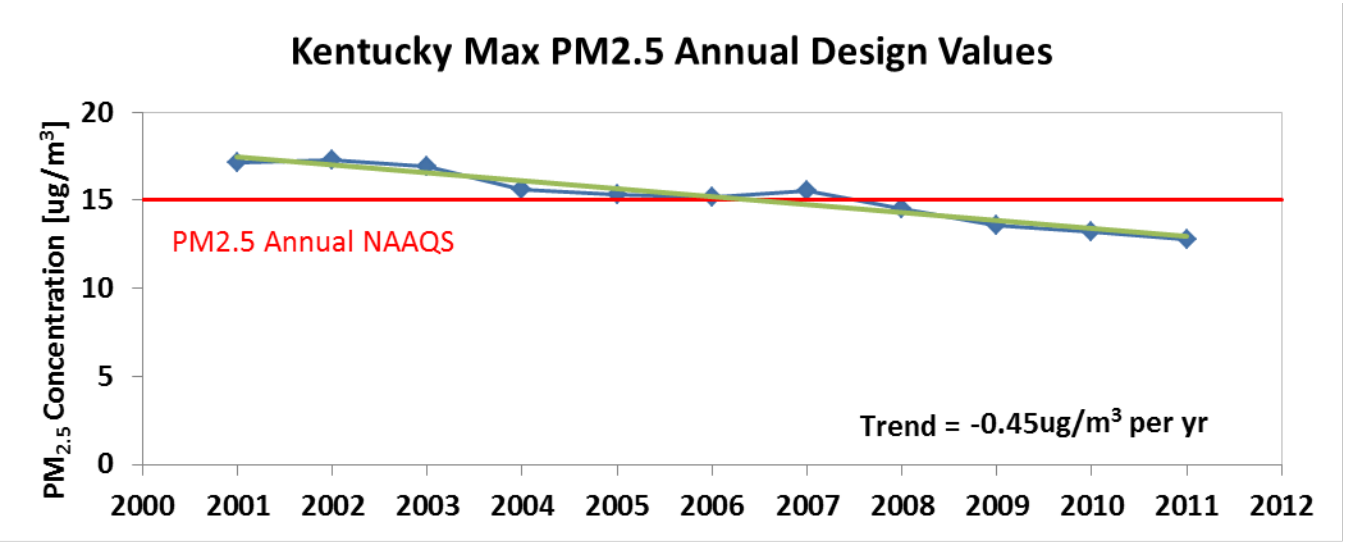
Note: Only monitoring sites meeting data completeness criteria listed

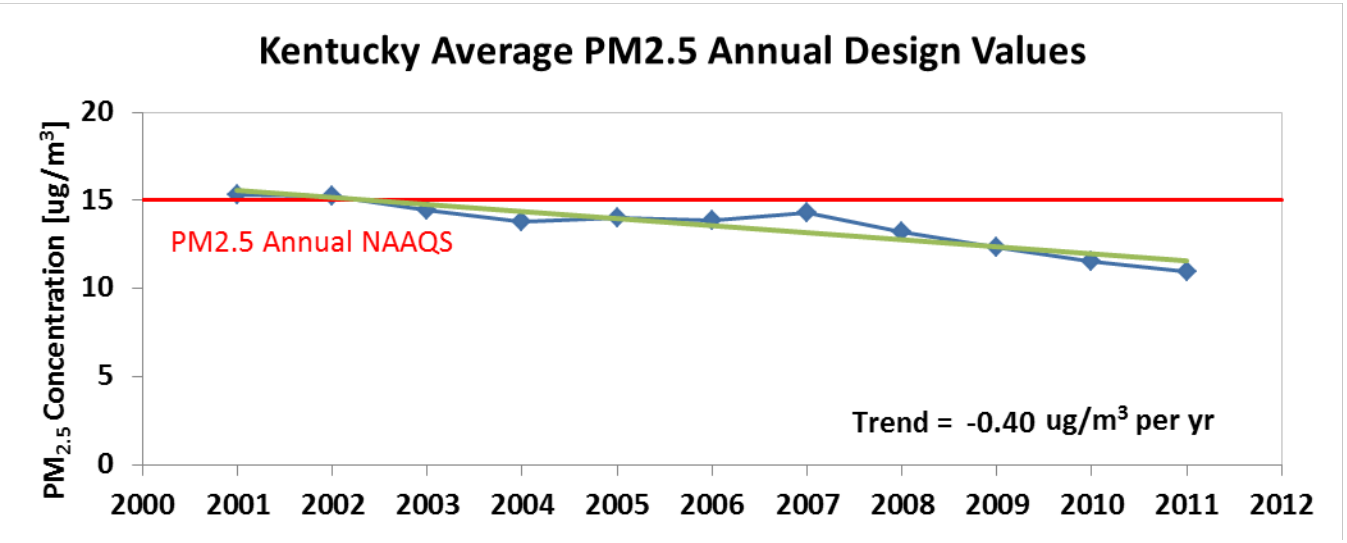
# Ozone Trends by Site in Kentucky

| Monitoring Sites | County | 2009-2011 DV [ppm] | Trend [ppm/yr] |
|---|---|---|---|
| 2113900034420101 | Livingston, KY | 0.068 | -2.10 |
| 2114510244420101 | McCracken, KY | 0.07 | -1.33 |
| 2118500044420101 | Oldham, KY | 0.078 | -1.59 |
| 2119300034420101 | Perry, KY | 0.065 | -1.00 |
| 2119500024420101 | Pike, KY | 0.066 | -0.95 |
| 2119900034420101 | Pulaski, KY | 0.064 | -2.01 |
| 2121300044420101 | Simpson, KY | 0.07 | -1.49 |
| 2122700084420101 | Warren, KY | 0.064 | -2.32 |

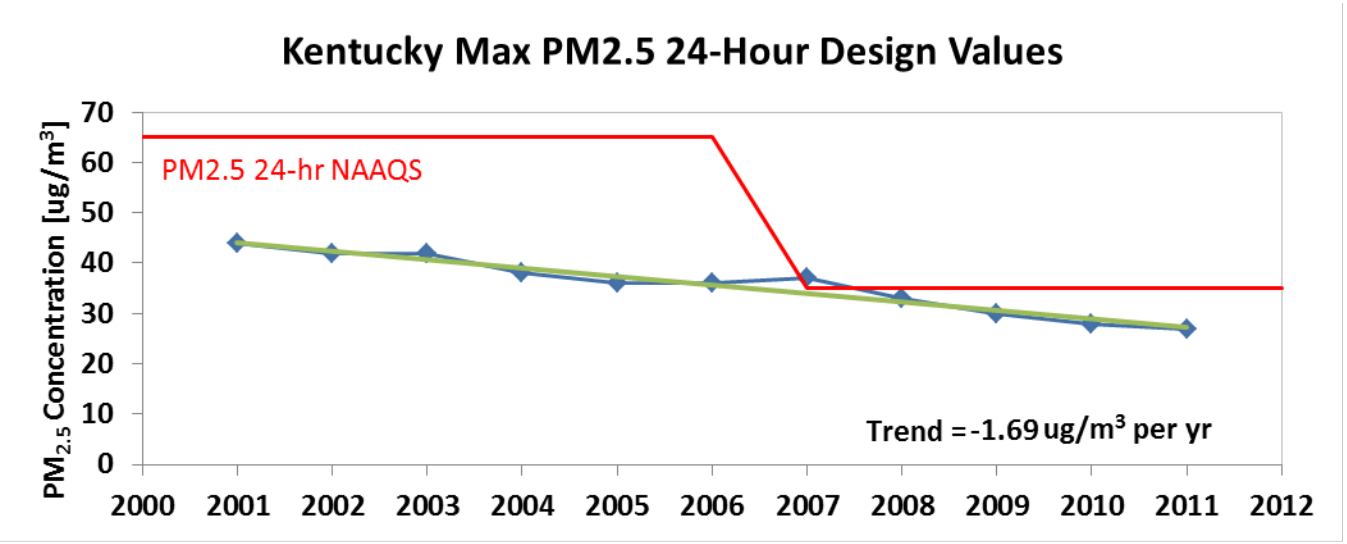
Note: Only monitoring sites meeting data completeness criteria listed

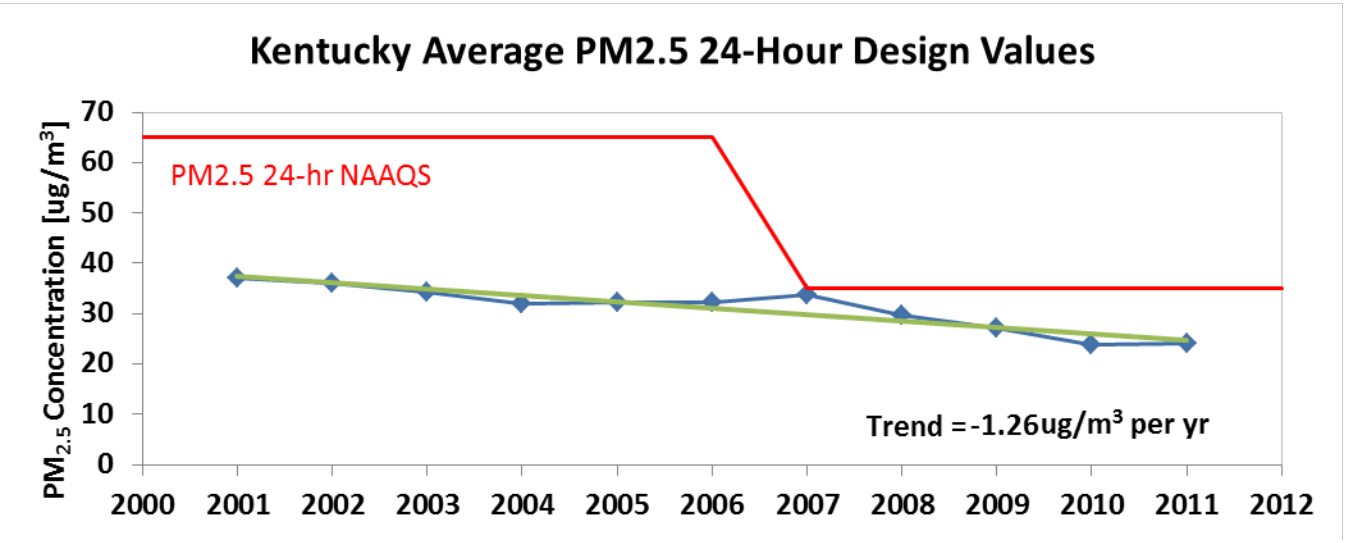
# Max/Ave $PM_{2.5}$ Annual DVs and Trend



# Max/Ave $PM_{2.5}$ 24-Hour DVs and Trend



# $PM_{2.5}$ Trends by Site in Kentucky

| | | 2009-2011 DV [ug/m³] | | Trend [ug/m³ per year] | |
|---|---|---|---|---|---|
| **Monitoring Site** | **County** | **Annual** | **24-Hr** | **Annual DV** | **24-Hr DV** |
| 210130002 | Bell | 11.3 | 26 | -0.40 | -1.08 |
| 210190017 | Boyd | 10.8 | 24 | -0.43 | -1.24 |
| 210290006 | Bullitt | N/A | N/A | -0.28 | -1.15 |
| 210430500 | Carter | 9.1 | 19 | -0.31 | -1.05 |
| 210670012 | Fayette | 11.2 | 23 | -0.42 | -1.47 |
| 210670014 | Fayette | N/A | N/A | -0.49 | -1.62 |
| 210730006 | Franklin | N/A | N/A | -0.32 | -1.18 |
| 210930006 | Hardin | 11.1 | 23 | -0.32 | -1.02 |

Note: Only monitoring sites meeting data completeness criteria listed

# $PM_{2.5}$ Trends by Site in Kentucky

| | | 2009-2011 DV [ug/m³] | | Trend [ug/m³ per year] | |
|---|---|---|---|---|---|
| **Monitoring Site** | **County** | **Annual** | **24-Hr** | **Annual DV** | **24-Hr DV** |
| 211110043 | Jefferson | N/A | 27 | N/A | -1.42 |
| 211110044 | Jefferson | 12.8 | 27 | -0.45 | -1.51 |
| 211110051 | Jefferson | 12.7 | 27 | -0.34 | -0.82 |
| 211170007 | Kenton | N/A | N/A | -0.37 | -1.07 |
| 211451004 | McCracken | 11.1 | 24 | -0.29 | -0.73 |
| 211510003 | Madison | 9.9 | 20 | -0.45 | -1.26 |
| 211950002 | Pike | 9.7 | 24 | -0.46 | -1.35 |

Note: Only monitoring sites meeting data completeness criteria listed

# Air Quality Trends Summary

- Average $O_3$ and $PM_{2.5}$ design values have decreased since 1999 in Kentucky

- $O_3$ and $PM_{2.5}$ design values have decreased since 1999 in all currently designated $O_3$ and $PM_{2.5}$ non-attainment areas in Kentucky