

# **Technical Justification to Support a Designation of Attainment of the 1-hour Sulfur Dioxide (SO<sub>2</sub>) NAAQS for Connecticut**

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## 1.0 Background

Sulfur dioxide (SO<sub>2</sub>)<sup>1</sup> is a criteria air pollutant for which the Environmental Protection Agency (EPA) has established a national ambient air quality standard (NAAQS) under sections 108 and 109 of the Clean Air Act (CAA). EPA is required to periodically assess the SO<sub>2</sub> NAAQS every five years and, if warranted by current science, revise the standard so as to protect public health with an adequate margin of safety. EPA first set standards for SO<sub>2</sub> in 1971. EPA set a 24-hour primary standard at 140 parts per billion (ppb) and an annual average standard at 30 ppb (to protect health). EPA also set a 3-hour average secondary standard at 500 ppb (to protect the public welfare). In 1996, EPA reviewed the SO<sub>2</sub> NAAQS and chose not to revise the standards. In 2010, EPA revised the primary SO<sub>2</sub> NAAQS by establishing a new 1-hour standard at a level of 75 ppb. EPA revoked the two existing primary standards because they would not provide additional public health protection given a 1-hour standard at 75 ppb. The 1-hour SO<sub>2</sub> NAAQS is designed to protect against exposure to the entire group of sulfur oxides (SO<sub>x</sub>). SO<sub>2</sub> is the component of greatest concern and is used as the indicator for the larger group of SO<sub>x</sub>. Other gaseous sulfur oxides (e.g., SO<sub>3</sub>) are found in the atmosphere at concentrations much lower than SO<sub>2</sub>. SO<sub>2</sub> emissions are a concern as both a criteria pollutant and because SO<sub>2</sub> is a precursor pollutant to the secondary formation of fine particulate matter, defined under the CAA as particles smaller than 2.5 microns (PM<sub>2.5</sub>).

Short-term exposure to SO<sub>2</sub> is a public health concern. Current scientific evidence, according to EPA, links short-term exposures to SO<sub>2</sub>, ranging from 5 minutes to 24 hours, with an array of adverse respiratory effects including bronchoconstriction and increased asthma symptoms.

These effects are of particular concern for persons with asthma at times of elevated activity (e.g., while exercising or playing.) Studies also show a connection between short-term exposure and increased visits to emergency departments and hospital admissions for respiratory illnesses, particularly in at-risk populations including children, the elderly, and asthmatics.

Emissions that lead to high concentrations of SO<sub>2</sub> generally also lead to the formation of other SO<sub>x</sub>. Control measures that reduce SO<sub>2</sub> will also reduce people's exposures to all gaseous SO<sub>x</sub>. This has the important co-benefit of reducing the formation of fine sulfate particles, which pose significant public health threats.

SO<sub>x</sub> can react with other compounds in the atmosphere to form PM<sub>2.5</sub>. These particles penetrate deeply into sensitive parts of the lungs and can cause or worsen respiratory disease, such as emphysema and bronchitis, and can aggravate existing heart disease, leading to increased hospital admissions and premature death. EPA's NAAQS for PM<sub>2.5</sub> are designed to provide protection against these health effects. The PM<sub>2.5</sub> NAAQS also recognizes that there is a transport component associated with SO<sub>2</sub> when in humid conditions it reacts in the atmosphere to form sulfates, which later lead to the formation of PM<sub>2.5</sub>. Monitored levels of sulfates are decreasing, but still contribute to downwind formation of PM<sub>2.5</sub>. See Section 2.1.

According to EPA, the highest ambient concentrations of gaseous SO<sub>2</sub> emissions generally occur relatively close to one or a few key SO<sub>2</sub> sources in an area, often within 10-20 kilometers of the

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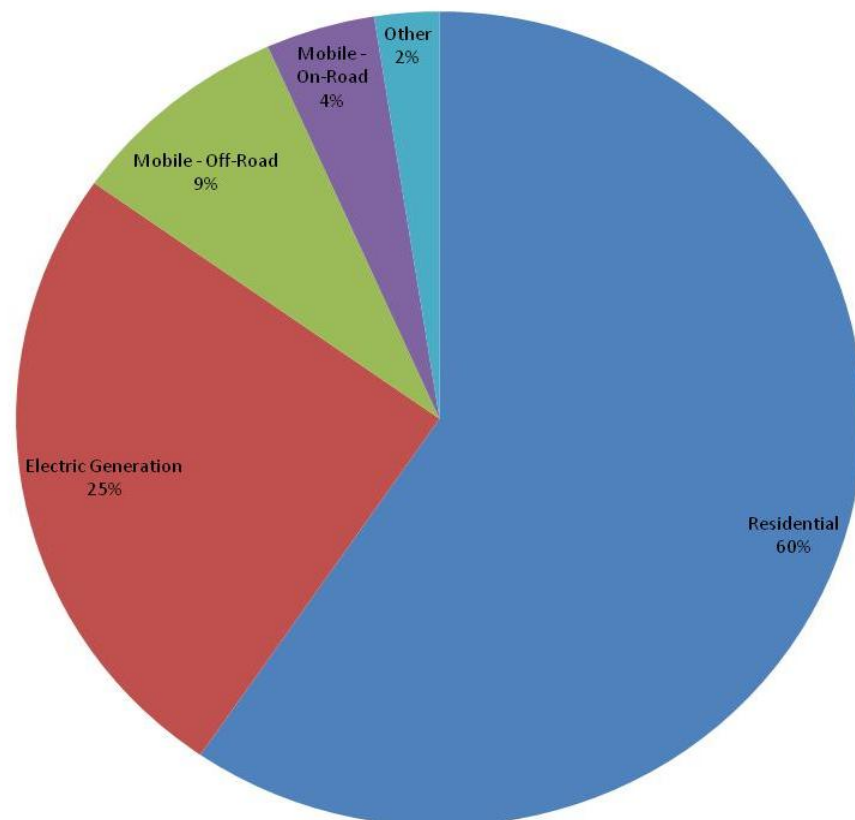
<sup>1</sup> According to EPA, SO<sub>2</sub> is one of a group of highly reactive gasses known as "oxides of sulfur" or "SO<sub>x</sub>"

**Figure 1**

**Connecticut 2008 Sulfur Dioxide Emissions Inventory**

parent source.<sup>2</sup> Additionally, the SO<sub>2</sub> health standard is a one hour standard and therefore, particular attention needs to be paid to peaking units that run infrequently but are capable of emitting high rates of SO<sub>2</sub>. SO<sub>2</sub> is unlike ozone for which, in a state like Connecticut, the majority can often be attributable to long range transport. As such, Connecticut's SO<sub>2</sub> control efforts have focused primarily on lowering the sulfur content of fuel used by in-state sources.

Connecticut sources emitted nearly 20,000 tons of SO<sub>2</sub> in 2008: 2,600 tons from mobile sources and 17,000 tons from stationary/area sources. The combustion of residential and commercial heating oil and electricity generation produces 96% of stationary/area source SO<sub>2</sub> emissions (85% of total SO<sub>2</sub> emissions; see Figure 1).



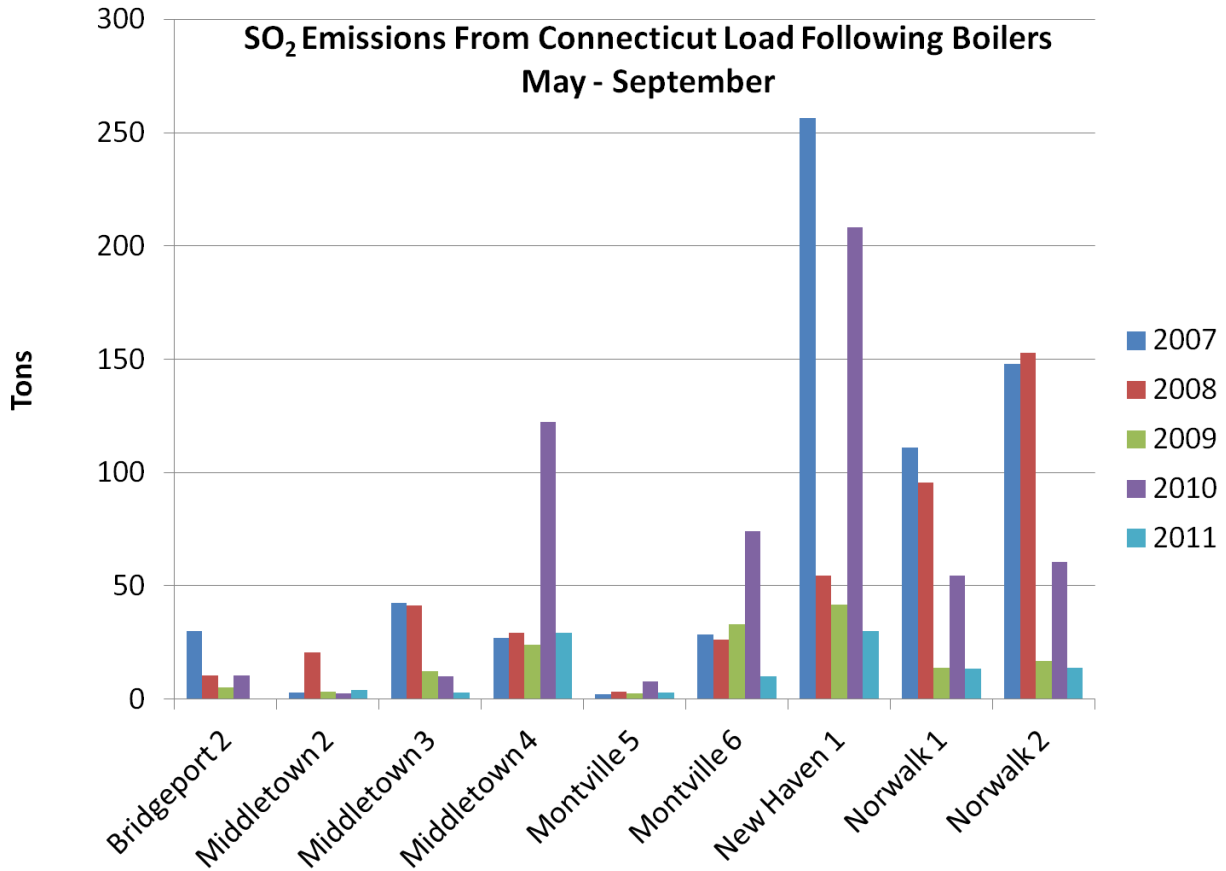
Data Source: 2008 National Emissions Inventory <http://www.epa.gov/ttn/chief/net/2008inventory.html>

The Department of Energy and Environmental Protection (DEEP) analyzed the source of Connecticut SO<sub>2</sub> emissions and found that SO<sub>2</sub> is generated during fossil fuel combustion from the oxidation of sulfur contained in fuel. The amount of uncontrolled SO<sub>2</sub> emitted is almost entirely dependent on the sulfur content of the fuel and is essentially independent of burner design.

With respect to the electric generating sector, older load following boilers burning coal and oil pose the greatest risk of exceeding the NAAQS, especially on hot days when there is greater power demand. On these high demand days, emissions from load following boilers can be as much as 4 to 5 times higher than on an average demand days. New environmental requirements and the implementation of end-user energy efficiency programs along with changing energy market dynamics that include the installation of new, clean and efficient generating capacity; the completion of transmission upgrades and significant price shifts in natural gas have combined to marginalize the capacity utilization of load following boilers over the past several years. Figure 2, however, demonstrates that without permanently enforceable emission limits, SO<sub>2</sub> emissions will fluctuate with power demand during the summer months.

<sup>2</sup> See page 5-6 of [Next Steps for Area Designations and Implementation of the Sulfur Dioxide National Ambient Air Quality Standard](#)

Figure 2



The analysis set forth in this Technical Justification supports an assessment of the appropriate designation/classification for Connecticut pursuant to section 107 of the CAA and informs DEEP as to what further actions Connecticut should take to implement the SO<sub>2</sub> NAAQS.

## 1.1 Introduction

On June 22, 2010 the EPA published a revised primary ambient air quality standard for SO<sub>2</sub><sup>3</sup> by establishing a 1-hour standard at a level of 75 parts per billion (ppb) or 196 micrograms per cubic meter (ug/m<sup>3</sup>), which became effective on August 23, 2010. The form of the 1-hour standard is a 3-year average of the 99<sup>th</sup> percentile of the annual distribution of daily maximum 1-hour average concentrations. For ambient monitoring purposes, the 3-year average of the 99<sup>th</sup> percentile of the annual distribution of daily maximum 1-hour average concentrations defines the design value. The design value is valid if it encompasses three consecutive calendar years of complete data. A year meets data completeness requirements when all 4 quarters are complete. A quarter is complete when at least 75 percent of the sampling days for each quarter have complete data. A sampling day has complete data if 75 percent of the hourly concentration values are

<sup>3</sup> See 75 Fed. Reg. 35520 at <http://www.gpo.gov/fdsys/pkg/FR-2010-06-22/pdf/2010-13947.pdf>

reported. For modeling purposes, the 4<sup>th</sup> highest annual daily 1-hour value averaged over all modeled years is used to represent the 99<sup>th</sup> percentile design value.

In EPA's notice of proposed rulemaking for the 1-hour SO<sub>2</sub> NAAQS, published in the Federal Register on December 8, 2009<sup>4</sup>, a monitoring focused approach to demonstrating attainment with the new NAAQS was recommended. EPA proposed a network of approximately 345 additional SO<sub>2</sub> monitors nationwide to be sited at locations of expected maximum impacts. EPA eventually abandoned this as not being extensive enough and, if made more extensive would become too burdensome and expensive to develop. In the final NAAQS rule published in the Federal Register on June 22, 2010, and in keeping with EPA's historical approach to SO<sub>2</sub> NAAQS implementation, EPA recommended a hybrid approach that combines monitoring and modeling as the most technically appropriate and cost effective method to assess 1-hour ambient SO<sub>2</sub> concentrations. For initial designations, EPA determined that areas would be designated "nonattainment" if either available monitoring data or appropriate refined modeling results show a violation, or "attainment" if both available monitoring data and appropriate modeling indicate the area is attaining. All other areas would be designated "unclassifiable".

Connecticut previously submitted a designation recommendation to EPA on June 8, 2011 as required by Section 107(d)(1)(A) of the Clean Air Act. In accordance with the final NAAQS rule, Connecticut proposed that the entire state be designated as unclassifiable because available monitoring data showed compliance with the SO<sub>2</sub> NAAQS but no modeling was yet available to provide a spatially robust assessment of compliance around large SO<sub>2</sub> emitting sources. Subsequent to Connecticut's recommendation, on August 3, 2012, EPA extended the date by which it would issue initial designations from June 2, 2012 to June 2, 2013. In accordance with EPA's draft guidance<sup>5</sup>, Connecticut now demonstrates attainment with the 2012 1-hour SO<sub>2</sub> NAAQS through a combination of the necessary large source modeling and current quality assured ambient monitoring.

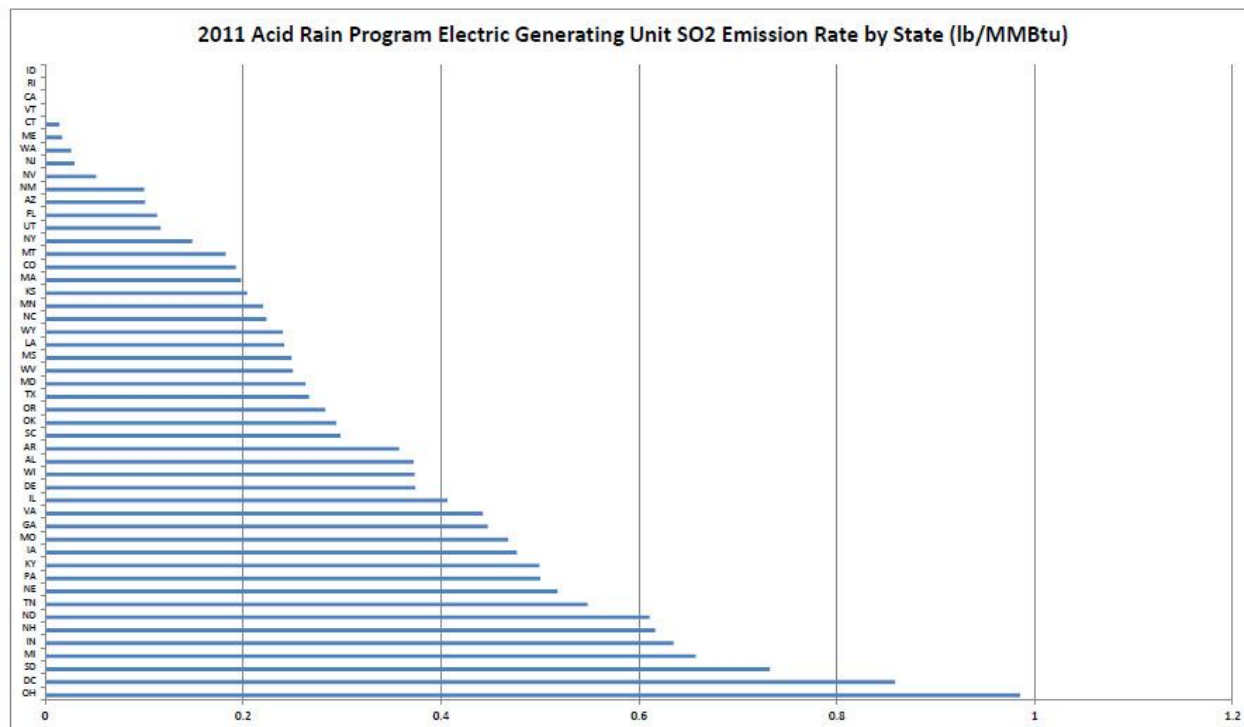
In order to maintain both near term and long term compliance with the SO<sub>2</sub> NAAQS, Connecticut has done much to reduce SO<sub>2</sub> emissions. For example, in 2000 Connecticut adopted the most stringent SO<sub>2</sub> emissions standards in the nation which resulted in a greater than 60% reduction from 1999 SO<sub>2</sub> levels – a reduction of over 27,000 tons/year. Connecticut remains committed to protecting public health through additional common-sense approaches to reduce these harmful emissions while also supporting Connecticut's transition to a cheaper, cleaner and more reliable energy future. This effort has achieved significant results; Figure 3 demonstrates that SO<sub>2</sub> emission rates in Connecticut are the fifth lowest in the nation.

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<sup>4</sup> See 74 Fed. Reg. 64810 at <http://www.gpo.gov/fdsys/pkg/FR-2009-12-08/pdf/E9-28058.pdf>

<sup>5</sup> Guidance for 1-Hour SO<sub>2</sub> NAAQS SIP Submissions (Public Review Draft 9/22/2011)  
[http://www.epa.gov/air/sulfurdioxide/pdfs/DraftSO2Guidance\\_9-22-11.pdf](http://www.epa.gov/air/sulfurdioxide/pdfs/DraftSO2Guidance_9-22-11.pdf)

Figure 3



Given the importance of protecting public health, Connecticut continues to pursue actions that will result in common sense reductions in SO<sub>2</sub> emissions to assist Connecticut in meeting its regional haze commitments, reducing acid deposition, and maintaining compliance with the new SO<sub>2</sub> NAAQS. DEEP is actively engaged in reducing the allowable sulfur emission rates from permitted and registered sources. Our research indicates the fuels available in Connecticut have much lower sulfur contents than allowed by law. This fact has lead many facilities to voluntarily modify their issued permits and registrations to reduce the allowable sulfur content of their fuel. Additionally, [Conn. Gen. Stat. §16a-21a](#) restricts the sulfur content of home heating oil to 15 parts per million when the states of New York, Massachusetts and Rhode Island institute similar restrictions. New York and Massachusetts already have such requirements in place. Rhode Island is expected to take final action in 2013.

A number of efforts are underway that are anticipated to reduce the allowable sulfur content of fuels in Connecticut. DEEP has drafted regulatory revisions to reduce the allowable sulfur content of residual oil, distillate oil, kerosene and jet fuel used in stationary sources and is taking stakeholder comments before formally proposing the regulation. The Governor has also proposed legislation that would require the use of ultra-low sulfur heating oil throughout the state as early as July 1, 2013<sup>6</sup>. This legislative proposal is intended to implement a portion of Connecticut's final Comprehensive Energy Strategy.<sup>7</sup>

The remainder of this document will discuss the 2009 – 2011 ambient monitoring data and large source-specific modeling results, both of which support an initial designation of attainment with the 1-hour SO<sub>2</sub> NAAQS for the state of Connecticut.

<sup>6</sup> See Section 18 of [House Bill 6360](#) (2013 Session of the Connecticut General Assembly)

<sup>7</sup> See [2013 Comprehensive Energy Strategy for Connecticut](#), Finalized February 19, 2013

## 2.0 Connecticut's SO<sub>2</sub> Ambient Monitoring Data

DEEP has monitored ambient SO<sub>2</sub> levels at various locations throughout Connecticut since the early 1970's. Figure 4 provides a historical perspective, depicting annual-average design value trends at the longest running monitoring sites. Annual design values have decreased significantly over the past 30 years with current measured values averaging around 10% of the previous 30 ppb annual NAAQS. The highest monitored 2011 annual design values measured 2 ppb, at both the New Haven (Criscuolo Park) and Westport (Sherwood Island) sites.

Figure 4

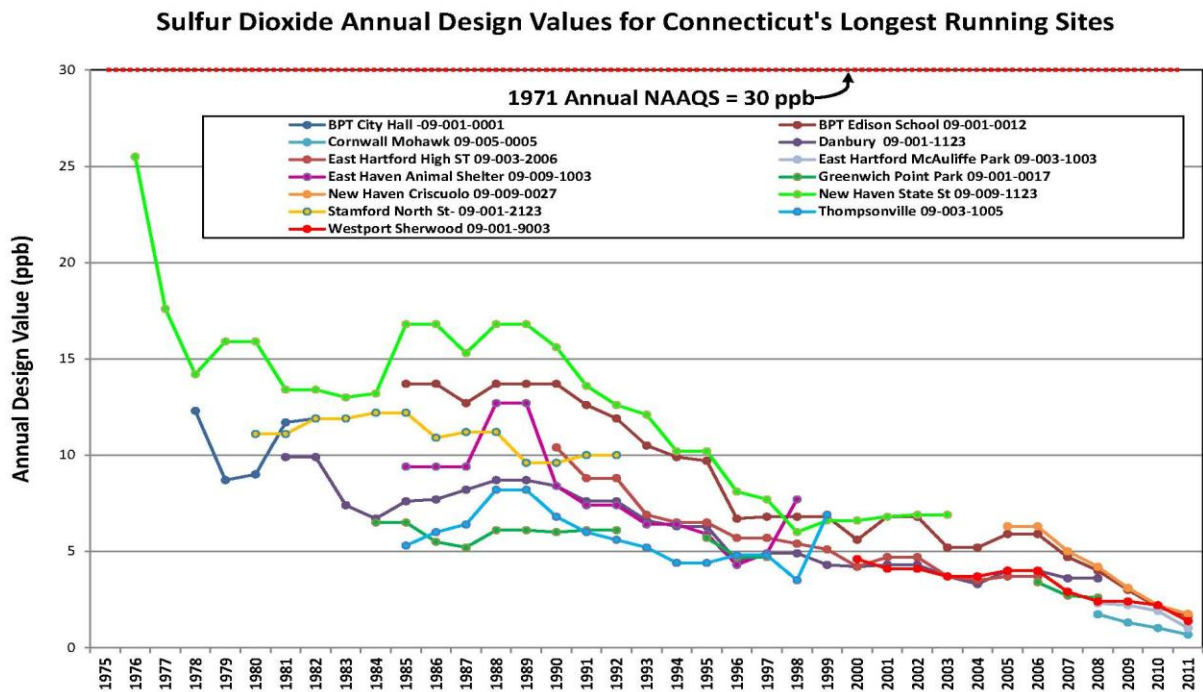
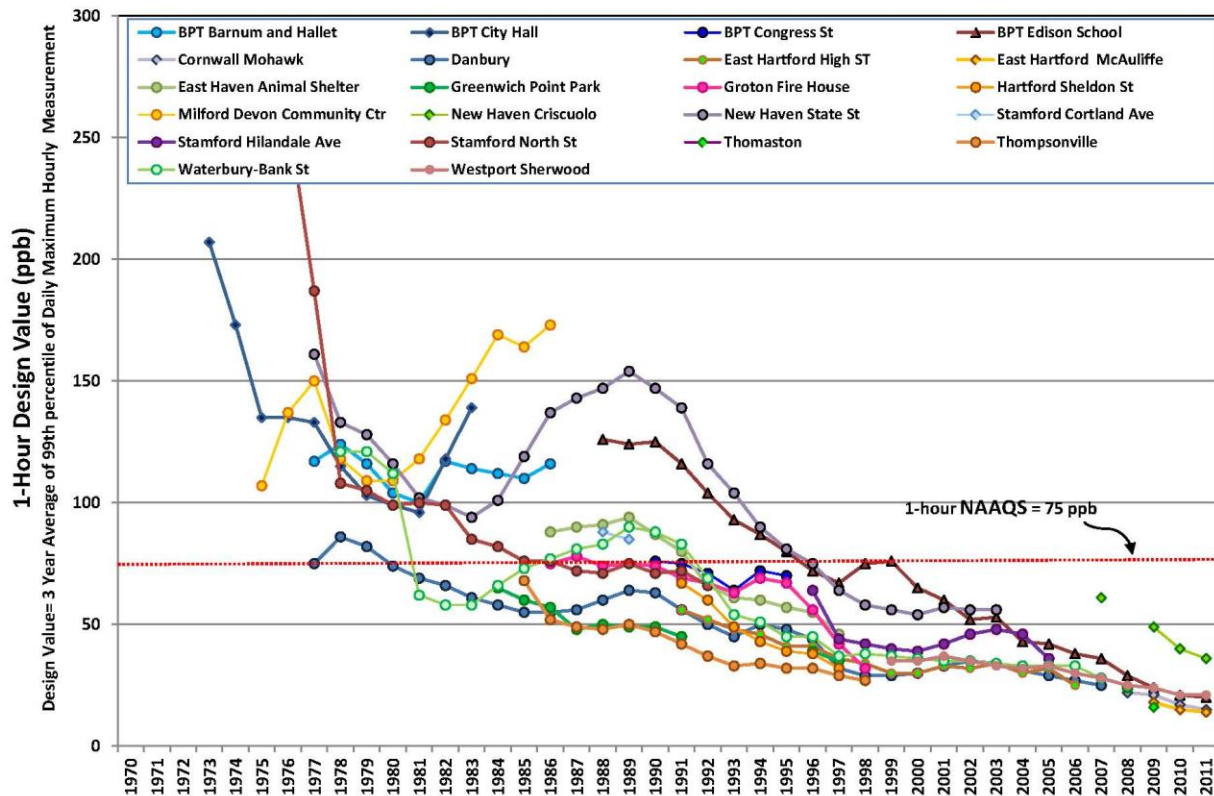


Figure 5 depicts historical 1-hour SO<sub>2</sub> monitored design value trends since 1980 at Connecticut air quality sites, again showing a significant decline in measured values over the period of record. Design values at all air quality monitors have not exceeded the new 1-hour NAAQS of 75 ppb since 2000 or earlier. Monitoring data indicates design values for the new 1-hour SO<sub>2</sub> NAAQS continue to trend downward over the period of record.

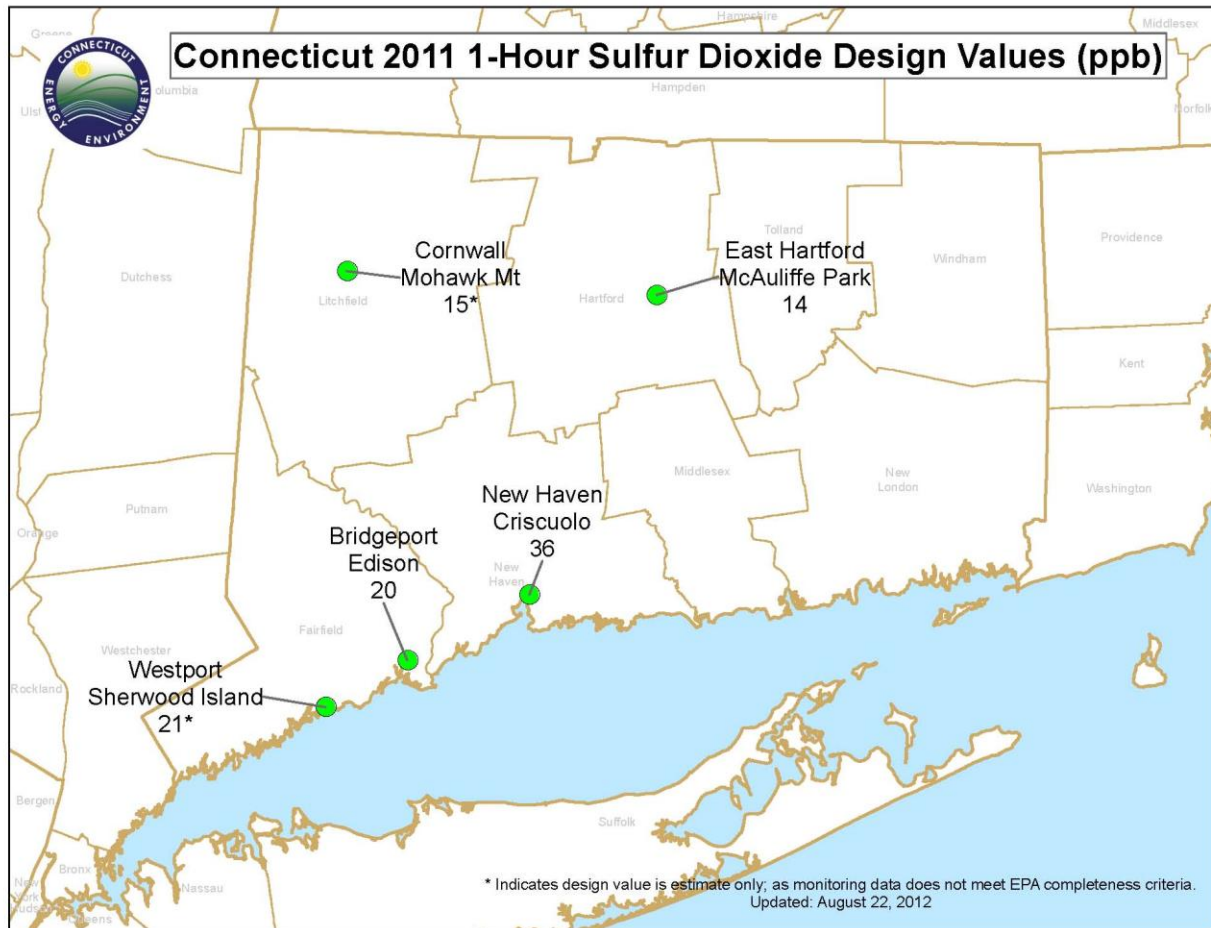


**Figure 5**  
**Sulfur Dioxide 1-Hour Design Values for Connecticut Sites**



DEEP’s current SO<sub>2</sub> monitoring network consists of Thermo Environmental Instruments, Inc. Model 43i-TLE continuous trace monitors operated at five sites: Bridgeport (Edison School), Cornwall (Mohawk Mountain), East Hartford (McAuliffe Park), New Haven (Crisculo Park), and Westport (Sherwood Island). These instruments comply with federal equivalent method EQSA-0486-060. Figure 6 shows the most recent 1-hour SO<sub>2</sub> design values (for 2011) for these sites. Design values range from a low of 14 ppb at the East Hartford site to a high of 36 ppb at the New Haven site. These values are well below the new 1-hour SO<sub>2</sub> NAAQS of 75 ppb. Compliance with the new 1-hour SO<sub>2</sub> NAAQS is achieved at a monitor when the 3-year average of the 99<sup>th</sup> percentile of the annual distribution of daily maximum 1-hour average concentrations (i.e., the design value) does not exceed 75 ppb. The 2010 data for the Cornwall (Mohawk Mountain) and Westport sites are incomplete, due to site enhancements conducted during the summer and early fall months. Thus, the Cornwall and Westport 2011 design value should be considered an estimated value. Preliminary data for 2012 indicates a maximum monitored 1-hour SO<sub>2</sub> design value in Connecticut of 32 ppb measured at the New Haven (Crisculo Park) site.

Figure 6



## 2.1 Speciated Particulate Matter Monitoring

The atmospheric reaction of  $\text{SO}_2$  in humid conditions produces sulfate ions ( $\text{SO}_4^{2-}$ ), which form particulate ammonium sulfate when neutralized by ammonium ion ( $\text{NH}_4^+$ ). Particulate speciation monitoring is conducted at the 2 NCore sites in Connecticut: the urban New Haven Criscoolo Park CSN<sup>8</sup> site and the rural Cornwall Mohawk Mountain IMPROVE<sup>9</sup> site. Based on IMPROVE program speciation mass reconstruction methods,  $\text{PM}_{2.5}$  mass fractions were derived from species analysis at the 2 sites. The results, shown in Figure 7, indicate that fine particulate ammonium sulfate is a significant fraction of  $\text{PM}_{2.5}$  mass, and that there has been a sharp decline in  $\text{PM}_{2.5}$  sulfate from 2004 to 2011 at both sites. Accordingly,  $\text{SO}_2$  emission reductions in Connecticut result in reductions of downwind particulate matter.

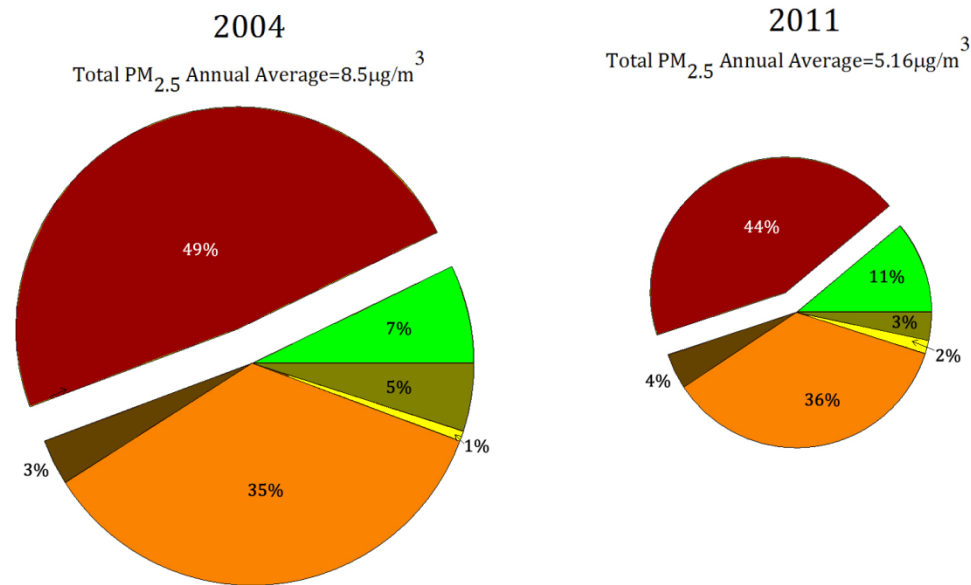
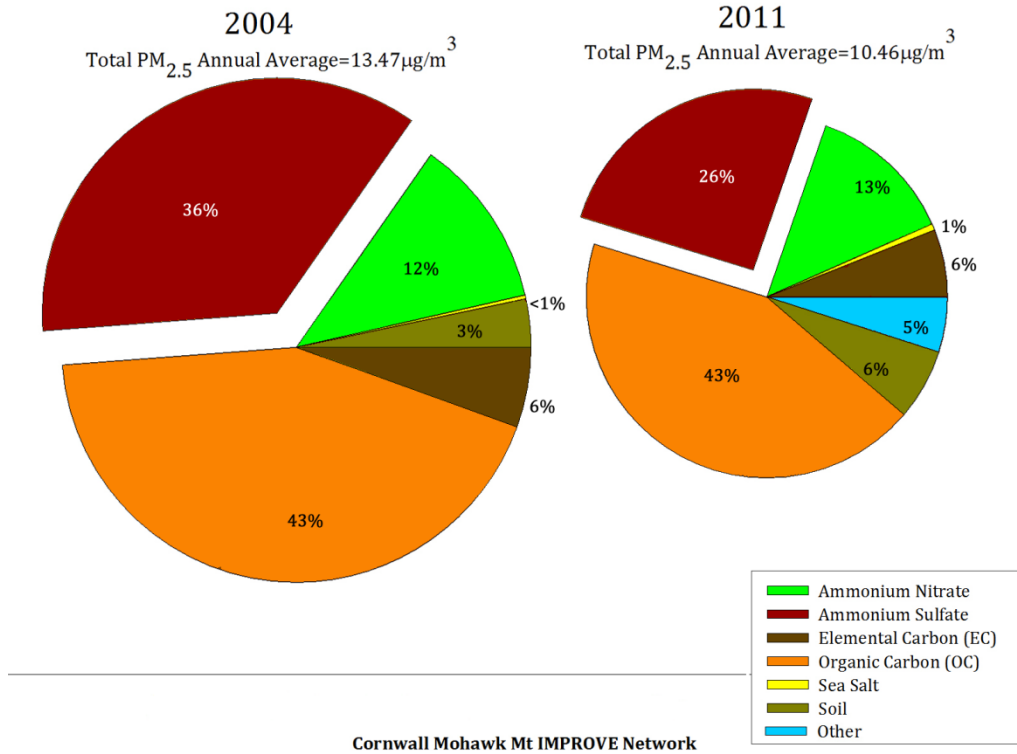
<sup>8</sup> Chemical Speciation Network

<sup>9</sup> Interagency Monitoring of Protected Visual Environments

**Figure 7**

**Particulate Matter Constituents: Annual Average**

New Haven Criscoolo Speciated Trend Network



Mass Reconstruction Methodology, Consistent with current IMPROVE methodology  
 Other=(Measured PM<sub>2.5</sub>-Mass Reconstruction Total)  
 updated: 2/19/13

## 2.2 Overview of Measured SO<sub>2</sub> Design Concentrations

As discussed in Section 2.0 above, all DEEP air quality monitoring sites currently measure compliance with the new 1-hour SO<sub>2</sub> NAAQS. These air quality monitoring sites also show a declining trend in design values over the longer term. A review of Figures 4 and 5 demonstrate that SO<sub>2</sub> ambient levels are declining over time. Figure 6 indicates that current 2011 design values are all less than half the NAAQS. At four of the five monitor locations design values are less than a third of the NAAQS.

Connecticut believes that its monitoring network alone adequately demonstrates compliance with the 1-hour NAAQS when one considers current design values in relation to the NAAQS, and the trends in these values over the past decade. However, in keeping with current EPA draft guidance Connecticut has performed modeling of its large  $\geq 100$  ton/year actual SO<sub>2</sub> emitting sources to enhance the robustness of measured design concentrations in areas surrounding these large sources.

## 3.0 Large SO<sub>2</sub> Source Specific Modeling

In accordance with the September 22, 2011 EPA guidance<sup>10</sup>, DEEP modeled the actual emissions from 19 emission units located at 4 facilities with actual emissions greater than 100 tons per year of SO<sub>2</sub> in order to calculate maximum design impacts on 1-hour ambient SO<sub>2</sub> levels in Connecticut. DEEP performed this modeling in consultation with the applicable EPA and DEEP modeling guidance documents listed below. The results of this modeling, discussed in section 3.8 indicates that based on actual emissions, the modeled sources do not cause a violation of the 1-hour SO<sub>2</sub> NAAQS.

- Guideline on Air Quality Models, 40 CFR Part 51, Appendix W ([http://www.epa.gov/ttn/scram/guidance/guide/appw\\_05.pdf](http://www.epa.gov/ttn/scram/guidance/guide/appw_05.pdf) )
- Guidance Concerning the Implementation of the 1-hour SO<sub>2</sub> NAAQS for the Prevention of Significant Deterioration Program, August 23, 2010 (<http://www.epa.gov/region07/air/nsr/nsrmemos/appwso2.pdf> )
- Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO<sub>2</sub> National Ambient Air Quality Standard, March 1, 2011 ([http://www.epa.gov/ttn/scram/guidance/clarification/Additional\\_Clarifications\\_Appendix\\_W\\_Hourly-NO2-NAAQS\\_FINAL\\_03-01-2011.pdf](http://www.epa.gov/ttn/scram/guidance/clarification/Additional_Clarifications_Appendix_W_Hourly-NO2-NAAQS_FINAL_03-01-2011.pdf))
- Applicability of Appendix W Modeling Guidance for the 1-hour SO<sub>2</sub> National Ambient Air Quality Standard, August 23, 2010 ([http://www.epa.gov/ttn/scram/guidance/clarification/ClarificationMemo\\_AppendixW\\_Hourly-SO2-NAAQS\\_FINAL\\_08-23-2010.pdf](http://www.epa.gov/ttn/scram/guidance/clarification/ClarificationMemo_AppendixW_Hourly-SO2-NAAQS_FINAL_08-23-2010.pdf))

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<sup>10</sup> See Guidance for 1-Hour SO<sub>2</sub> NAAQS SIP Submissions (Public Review Draft 9/22/2011) ([http://www.epa.gov/air/sulfurdioxide/pdfs/DraftSO2Guidance\\_9-22-11.pdf](http://www.epa.gov/air/sulfurdioxide/pdfs/DraftSO2Guidance_9-22-11.pdf))

- Area Designations for the 2010 Revised Primary Sulfur Dioxide National Ambient Air Quality Standards, March 24, 2011  
<http://www.epa.gov/air/sulfurdioxide/pdfs/20110411so2designationsguidance.pdf>
- Connecticut DEEP New Source Review Air Quality Modeling Guidance Website  
[http://www.ct.gov/dep/cwp/view.asp?a=2684&q=461156&depNav\\_gid=1997](http://www.ct.gov/dep/cwp/view.asp?a=2684&q=461156&depNav_gid=1997)
- Guidance for 1-Hour SO<sub>2</sub> NAAQS SIP Submissions (Public Review Draft 9/22/2011)  
[http://www.epa.gov/air/sulfurdioxide/pdfs/DraftSO2Guidance\\_9-22-11.pdf](http://www.epa.gov/air/sulfurdioxide/pdfs/DraftSO2Guidance_9-22-11.pdf)

EPA has indicated that it will be issuing additional technical guidance on 1-hour SO<sub>2</sub> NAAQS implementation later this year. DEEP will review any new EPA guidance and, if necessary, make adjustments to its technical approach in a timely manner.

### **3.1 Selection of Sources to be Modeled**

EPA's September 22, 2011 draft guidance states that it is reasonable to focus on sources (i.e., facilities) of SO<sub>2</sub> with  $\geq 100$  tons per year (tpy) or more of actual emissions and also to consider including smaller sources with short stacks or sources located in complex terrain. Connecticut's inventory of point sources contains approximately 9006 separate facilities. In lieu of selecting sources based on a matrix of variables (i.e., emission rate, stack height, terrain, distance to terrain, and stack to building height ratios), Connecticut has chosen a more cost effective yet conservative approach to source selection in keeping with EPA guidance.

Staff utilized the current DEEP point source inventory of all permitted and registered SO<sub>2</sub> emission units in Connecticut to develop the inventory of  $\geq 100$  tpy actual SO<sub>2</sub> emitting sources. The inventory of large SO<sub>2</sub> emitters included sources with total annual actual emissions  $\geq 100$  tpy in any year from 2009 – 2011. Staff excluded from modeling individual units at the  $\geq 100$  tpy sources that are operated on an intermittent basis and have a state or federally enforceable restriction on hours of operation of  $< 300$  hours/year. Such sources are instead considered part of measured background. Likewise, sources with less than 100 tpy actual emissions in each of the three years 2009 - 2011 are also considered part of monitored background and were not explicitly modeled.

Table 1 lists inventoried point sources in Connecticut with annual actual emissions of SO<sub>2</sub>  $\geq 100$  tpy in any of the three years 2009 – 2011. There are 4 such facilities identified in the inventory representing a total of 19 individual SO<sub>2</sub> emission units.

**Table 1.** Compilation of the SAS / EMIT 2009 – 2011 Connecticut point source inventory of town premise combinations (sources) with  $\geq$  100 tpy actual emissions in any of the three years. Individual emission units with an enforceable restriction on annual hours of operation of  $<$  300 were excluded from this list. Stack heights are in feet above grade, emission values are in pounds/hour or tons/year as noted in column heading. The maximum allowable lb/hour emission rates (“LB/HR\_ALLOW”) of a unit were calculated from the maximum firing rate of the unit unless the firing rate is otherwise restricted by a state or federally enforceable condition. “TPY Total Premise Actual” represents the maximum TPY actual emissions from the three years of data.

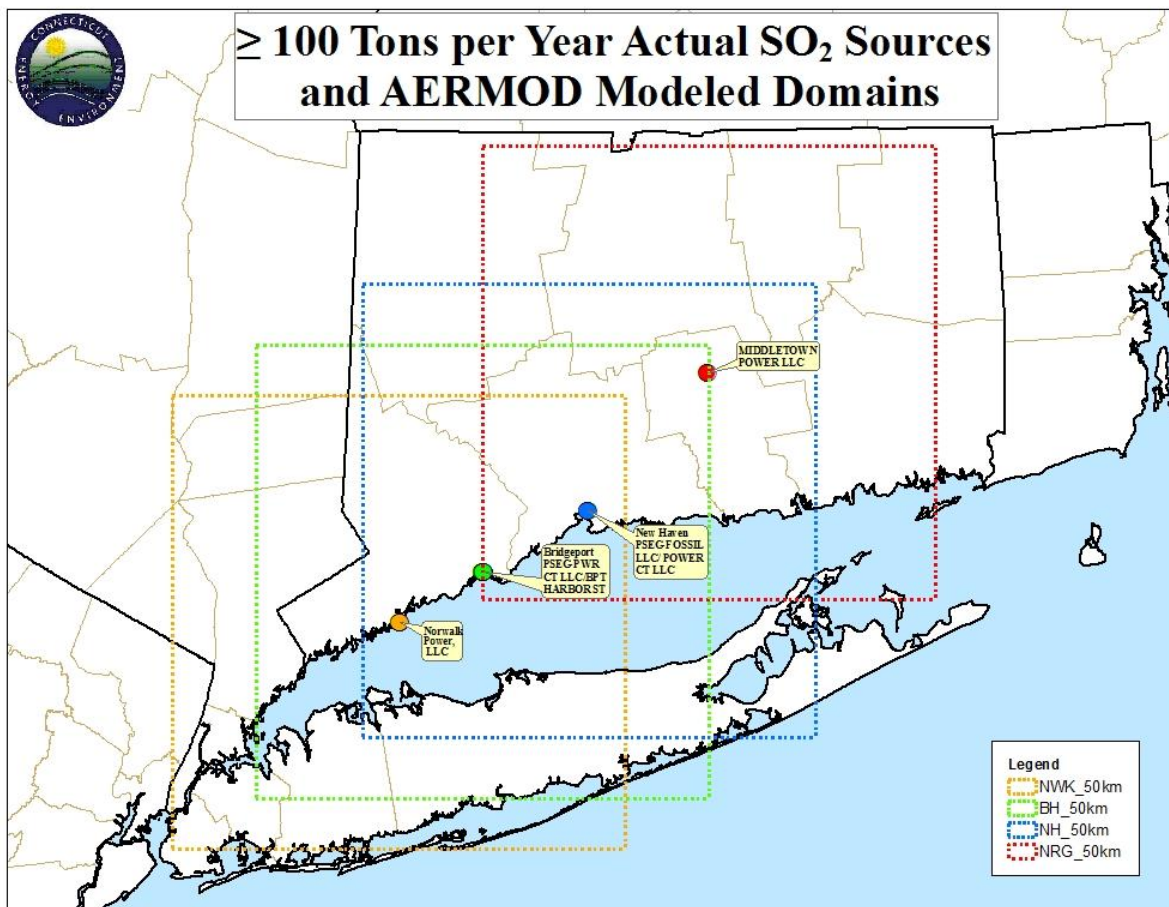
NAME	DESCRIPT	STK_HGT	LB/HR_ALLOW	LB/HR_ACTUAL	TPY Total Premise Actual	TPY Total Premise Allow
MIDDLETOWN POWER LLC	BLR B&W AUXIL HEAT	498	7.6	NA		
MIDDLETOWN POWER LLC	BLR C.E. #4	498	1413.0	CEM		
MIDDLETOWN POWER LLC	BLR RILEY #2	266	376.8	CEM		
MIDDLETOWN POWER LLC	BLR B&W (CY) #3	266	663.4	CEM		
MIDDLETOWN POWER LLC	P&W FT4A-8 TURBINE	25	12.9	NA		
MIDDLETOWN POWER LLC	GE LM6000 TURBINE 50 MW	213	0.96	NA		
MIDDLETOWN POWER LLC	GE LM6000 TURBINE 50 MW	213	0.96	NA		
MIDDLETOWN POWER LLC	GE LM6000 TURBINE 50 MW	213	0.96	NA		
MIDDLETOWN POWER LLC	GE LM6000 TURBINE 50 MW	213	0.96	NA	235.2	19580
NORWALK POWER, LLC	BLR C.E. #1	350	8936.9	CEM		
NORWALK POWER, LLC	BLR C.E. #2	350	8936.9	CEM		
NORWALK POWER, LLC	WESTINGHOUSE TURBINE191G	35	63.9	NA		
NORWALK POWER, LLC	BLR SUPERIOR C300 HT6	167	4.3	NA	489.0	18216.7
PSEG FOSSIL LLC/ NEW HAVEN CT	B&W STEAM GENERATOR 2	226	82.2	NA		
PSEG FOSSIL LLC/ NEW HAVEN CT	C.E. STEAM GENERATOR 1	389	14257.4	CEM		
PSEG FOSSIL LLC/ NEW HAVEN CT	GE LM6000 TURBINE	130	2.9	NA	216.9	14454.9
PSEG PWR CT LLC/BPT HARBOR	C.E. STEAM GENERATOR #3	498	18212	CEM		
PSEG PWR CT LLC/BPT HARBOR	B&W GENERATOR (CY) #2	251	8600.1	CEM		
PSEG PWR CT LLC/BPT HARBOR	P&WA FT4A-8 TURBINE	25	83.3	NA	2974.6	32448.5



### 3.2 Modeling Domains

Figure 8 depicts the location of the facilities listed in Table 1 above and shows the modeling domains used for these sources. Each of these domains are 100 km per side. Note that all emission units listed in Table 1 of this document for Norwalk Power, PSEG Bridgeport, and PSEG New Haven were included in the Norwalk Bridgeport and New Haven modeling domains. Middletown Power emission units were modeled separately in the Middletown domain. For a more detailed discussion of receptor spacing in the domains see Section 3.6 below.

Figure 8



### **3.3 Dispersion Models Used**

For this analysis, DEEP utilized the most recent version of the AERMOD modeling system which includes the dispersion model AERMOD (version 12345) and its pre-processor modules AERMINUTE, AERMET (version 12345), AERSURFACE, and AERMAP.

### **3.4 Modeled Emissions**

As discussed in Section 3.1 above, DEEP included sources with total annual actual emissions  $\geq 100$  tpy in any of the years 2009 – 2011 in the inventory of large SO<sub>2</sub> emitters to be explicitly modeled. EPA has stated they are considering amendments to their modeling guidelines so that only sources with actual emissions of 1,000-3,000 tons per year (or higher in rural areas) will need to be modeled. Had DEEP selected this threshold, no sources in Connecticut would have been assessed.

Individual unit emission rates modeled at the  $\geq 100$  tpy sources reflect current allowable hourly rates except for those units equipped with SO<sub>2</sub> Continuous Emissions Monitoring (CEM). DEEP calculated the maximum allowable lb/hour emission rates of a unit from the maximum firing rate of the unit, unless the firing rate is otherwise restricted in a state or federally enforceable manner. For units with CEM, DEEP ran hour by hour CEM data concurrently with hourly meteorological data for the purpose of calculating maximum and 99<sup>th</sup> percentile design impacts (CEM data files will be submitted under separate cover upon request). See Table 1 above for a listing of these sources and individual emission rates modeled.



### 3.5 Meteorological Data

Table 2 identifies the meteorological data bases used in the modeling. The AERMOD-ready five year meteorological data sets can be accessed through the web link set forth in Table 2. DEEP generated these data sets from National Weather Service (NWS) Automated Surface Observing System (ASOS) stations in Connecticut and upper air sounding data at either Albany, NY or Brookhaven, NY. DEEP used integrated Surface Hourly Data (ISHD), pre-processed through the EPA developed program AERMINUTE. This program uses the archived one minute wind data to develop hourly average wind speed and wind direction. This approach reduced the number of calm hours produced from the technique outlined in Section 6 of the Meteorological Monitoring Guideline (EPA 2000) to calculate average wind speed and direction. DEEP used Forecast Systems Laboratory (FSL) formatted upper air data and processed with the AERMINUTE produced surface data by the meteorological preprocessor AERMET (version 12345) to generate the AERMOD ready data sets referenced in Table 2.

**Table 2: Meteorological data bases**

MODELING DOMAIN	METEOROLOGICAL DATA BASE <sup>1</sup>
Middletown Power, LLC	Surface: Bradley Airport 2007 - 2011; Upper air: Albany, NY 2007 - 2011
PSEG Bridgeport; PSEG New Haven; Norwalk Power, LLC	Surface: Sikorsky Airport 2007 - 2011; Upper air: Brookhaven 2007 - 2011

<sup>1</sup> [http://www.ct.gov/deep/cwp/view.asp?a=2684&q=450396&deepNav\\_GID=1619](http://www.ct.gov/deep/cwp/view.asp?a=2684&q=450396&deepNav_GID=1619)

### 3.6 Receptor Spacing

DEEP employed the EPA sponsored terrain pre-processor AERMAP in the development of receptor networks for the modeling domains. AERMAP processes Digital Elevation Model (DEM) data and creates an elevation and height scale (the terrain height and location that has the greatest influence on dispersion) for each receptor in the domain. AERMAP automatically selects the closest node elevation in each quadrant with respect to the receptor or source and then weights that elevation with respect to the distance from the receptor or source. The closer the node elevation, the more weight it is given. Conversely, further distances are weighted less. AERMAP is also capable of processing National Elevation Dataset (NED) data in GEO-TIFF format, which is accessible through the U.S. Geological Survey (USGS) Seamless Data Server <http://seamless.usgs.gov/index.php>. The program also has the ability to process Digital Elevation Model (DEM) data in the USGS DEM format. AERMAP does not have the capability of processing both formats within a single application. The USGS NED (1-arc second) GEO-TIFF formatted data was used to develop receptors for the four modeling domains that make up this modeling exercise.

DEEP developed a Cartesian grid centered on the dominant SO<sub>2</sub> source in each domain with 250 meter spacing out to a distance in all directions of 5 kilometers (km) aligned with the Universal Transverse Mercator (UTM) grid marks. From 2 km to 10 km, the grid shifts to 500 meter spacing. From 10 km to 20 km, 1 km spacing was used. Finally, 2 km spacing was developed

from 20 to 50 km from the center of the grid. See Figures 10, 11, 12 and 13 for a graphic depiction of the receptor network for each of the four modeling domains.

### **3.7 Background Air Quality**

EPA's March 1, 2011 memorandum, "Additional Clarification Regarding Application of Appendix W...", notes that ambient air quality data should generally be used to account for background concentrations. The memorandum identifies the following hierarchy for developing background concentrations:

Tier Ia – highest measured 1-hour concentration

Tier Ib – 1-hour design value for the latest 3-year period

Tier II – multi-year average of 2<sup>nd</sup> high measured 1-hour concentrations for each season and hour-of-day combination, or the 4<sup>th</sup> high measured 1-hour concentration for hour-of-day only.

Tier III – no background concentration needs to be included, if a comprehensive emission inventory is used in the modeling.

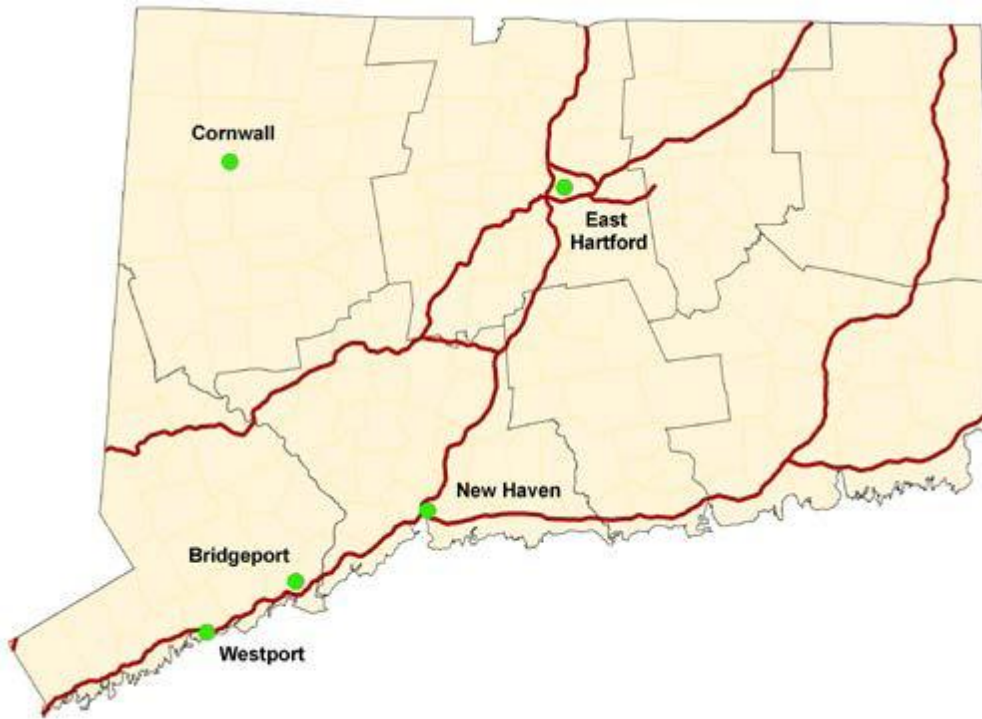
DEEP developed background values from hourly SO<sub>2</sub> levels measured by Federal Reference Method (FRM) equivalent monitors located in Connecticut. DEEP used hourly values from January 1, 2009 through December 31, 2011. Table 3 lists the sites used to develop background for each of the proposed modeling domains.

**Table 3. Background monitoring sites**

MODELING DOMAIN	MONITORING SITE
CENTRAL (Middletown Domain)	E. Hartford, McAuliffe Park EPA site# 09-003-1003; Lat. 41.78471 N; Lon. -72.63158
SOUTHWEST (Norwalk and Bridgeport Domains)	Bridgeport, Edison Sch. EPA site# 09-001-0012 Lat. 41.19500N; Lon. -73.16350 W
SOUTH (New Haven Domain)	Criscuolo Park EPA site# 09-009-0027 Lat. 41.30117; Lon. -72.90288

Figure 9 below depicts Connecticut DEEP’s FRM equivalent SO<sub>2</sub> monitoring sites in a geographic context.

**Figure 9**



DEEP used a Tier II approach to develop background concentrations. A multi-year average of 2<sup>nd</sup> high measured 1-hour concentrations for each season and hour-of-day combination from the years 2009 – 2011 accounted for background SO<sub>2</sub> concentrations from out of state transport, and local in state point, area and mobile source emissions. The 96 season by hour of day values can be found in the AERMOD input files. These files will be provided in electronic form under separate cover upon request.

### 3.8 Model Results

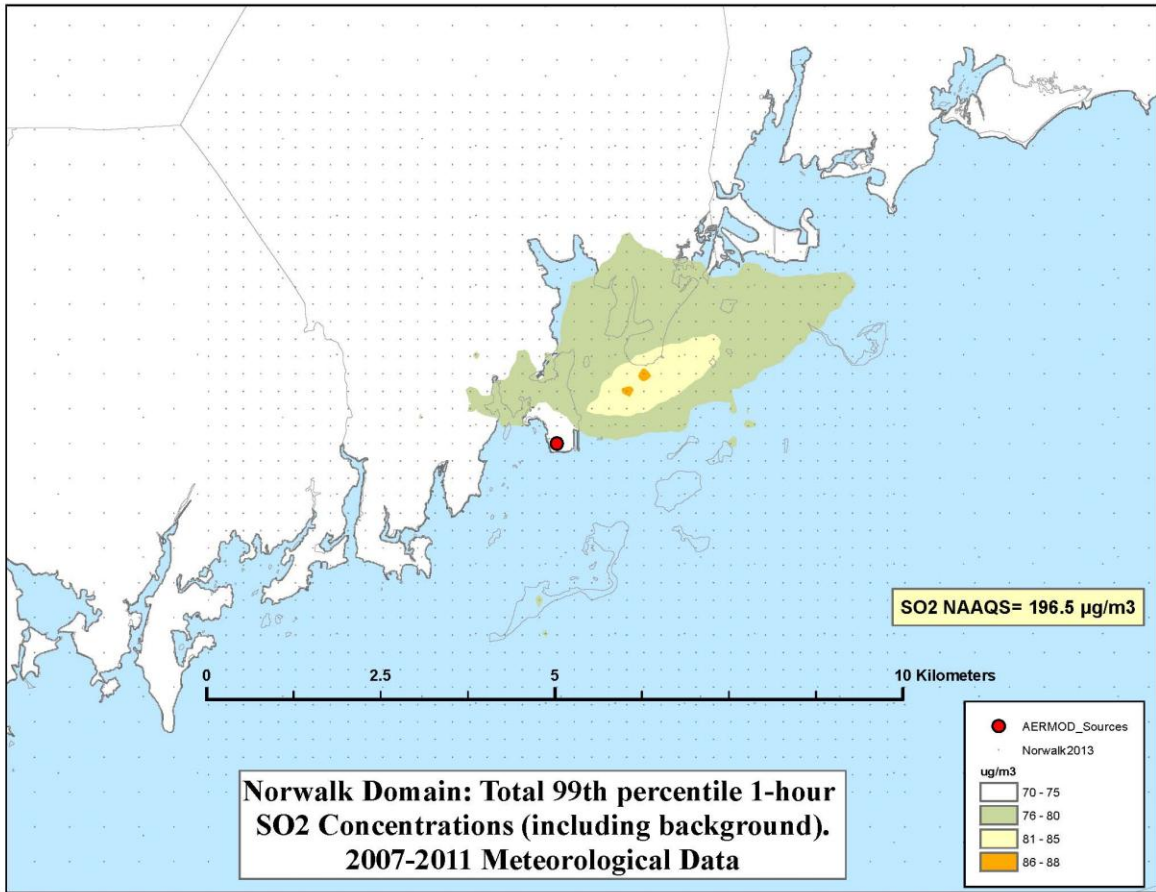
Model results for each of the domains are reported below in two forms. Table 4 contains the single maximum 99<sup>th</sup> percentile design concentration for each of the modeling domains. Figures 10, 11, 12 and 13 present total concentration (including background) isopleths for the four receptor domains modeled. Note that all emission units listed in Table 1 of this document for Norwalk Power, PSEG Bridgeport, and PSEG New Haven were included in the Norwalk Bridgeport and New Haven modeling domains. Middletown Power emission units were modeled separately in the Middletown domain. No other emission units were included in the Middletown domain. All dispersion model input and output files will be provided under separate cover upon request.

Results of the large source-specific modeling support an initial designation of attainment of the 1-hour SO<sub>2</sub> NAAQS of 75 ppb (196 µg/m<sup>3</sup>) for the state of Connecticut.

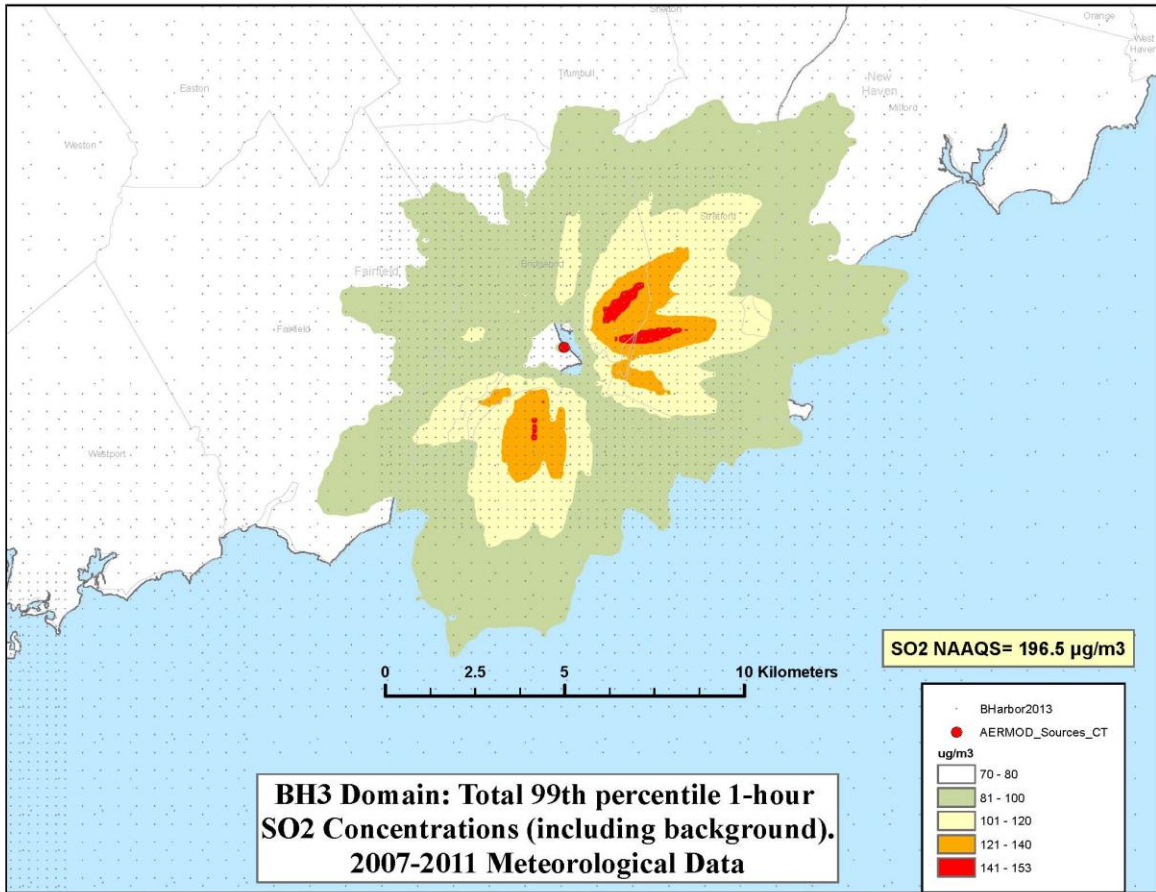
**Table 4**  
**AERMOD Modeling Results for**  
**Connecticut's ≥100 TPY Actual SO<sub>2</sub> Sources**

Domain Name	All + Background 4th High Avg 1-Hr Conc. (µg/m <sup>3</sup> )	Maximum Impact Location (NAD 83 UTM SYSTEM)		
	2007-11	X (m)	Y (m)	Z (m)
<b>Norwalk</b>	<b>88.1</b>	634744	4549016	0.00
<b>Bridgeport</b>	<b>159</b>	654583	4559540	5.50
<b>New Haven</b>	<b>87.5</b>	675805	4573389	6.90
<b>Middletown</b>	<b>89.7</b>	701504	4600627	173

Figure 10



**Figure 11**



**Figure 12**

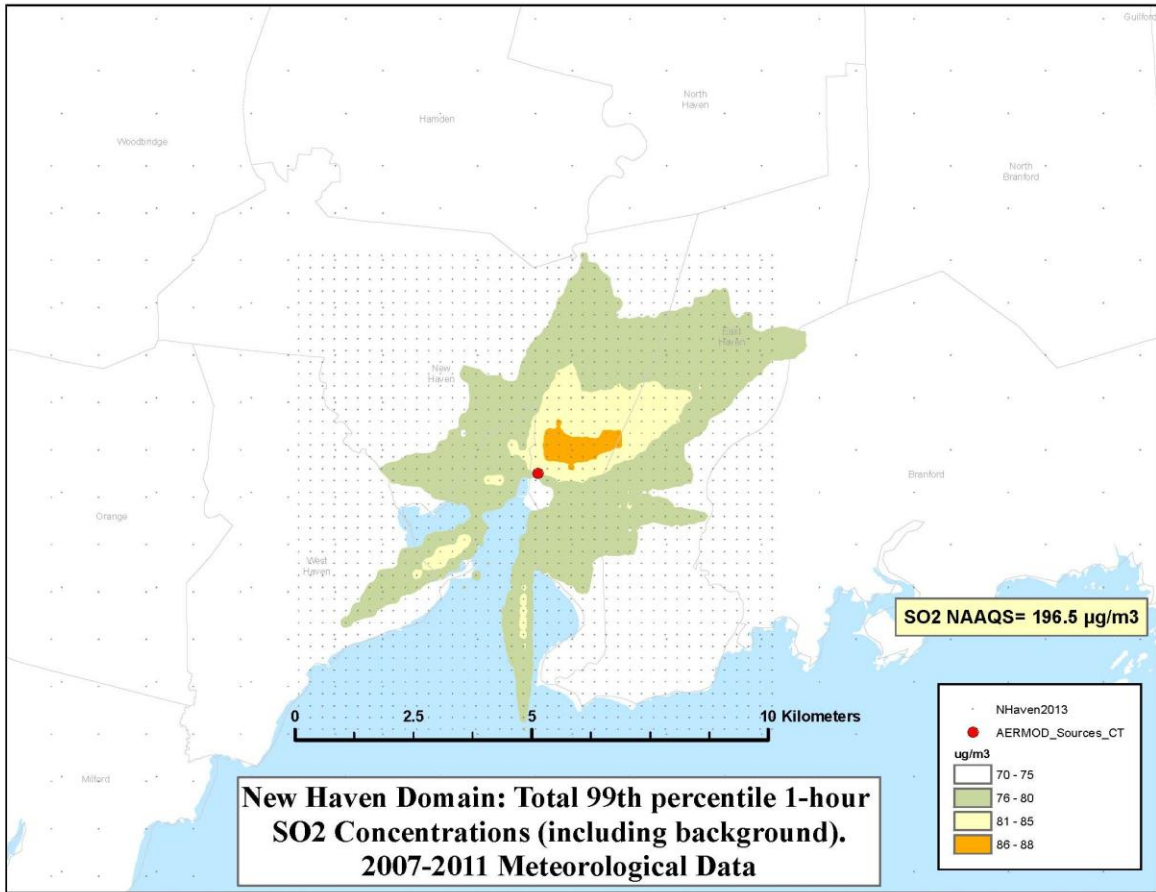
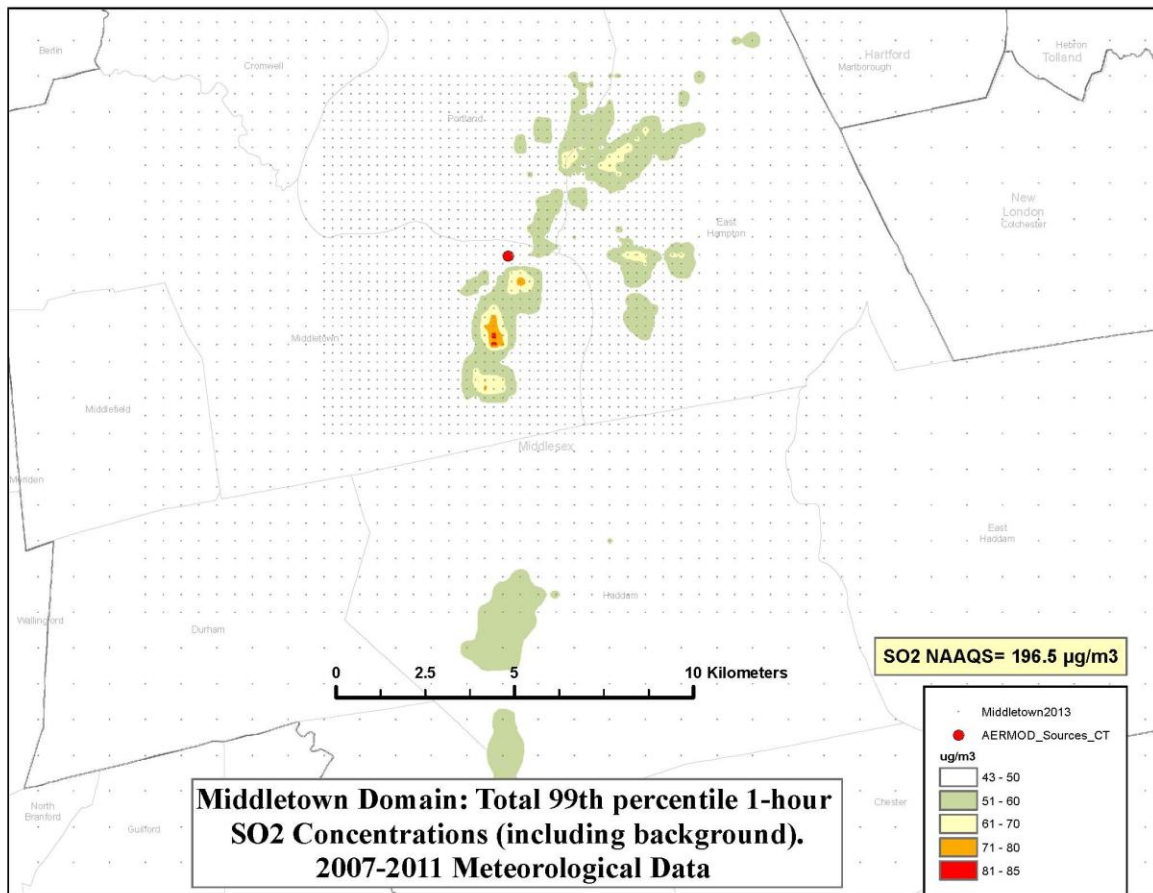




Figure 13



### 3.9 Conclusion

EPA should designate Connecticut as attainment for the SO<sub>2</sub> NAAQS. In addition to monitoring SO<sub>2</sub> levels well below the NAAQS<sup>11</sup>, DEEP has completed modeling of all sources in Connecticut with greater than 100 tpy actual emissions. This modeling, when based on actual emissions for those emission units with CEM data and allowable emissions for those units without CEM, shows compliance with the NAAQS<sup>12</sup>.

DEEP is implementing enforceable limits that will enable all impacted sources to demonstrate compliance with the 1-hour SO<sub>2</sub> NAAQS on an ongoing basis. Connecticut remains committed to protecting public health through additional common-sense approaches to reduce these harmful emissions while also supporting Connecticut's transition to a cheaper, cleaner and more reliable energy future.

<sup>11</sup> See Figure 6

<sup>12</sup> See Table 4