C.P. Crane Generating Station

Chase, Maryland

Brandon Shores & H.A. Wagner Generating Stations

Fort Smallwood Complex, Maryland

Evaluation of Compliance with the 1-hour NAAQS for SO_2

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1. Introduction

Wingra Engineering, S.C. was hired by the Sierra Club to conduct an air modeling impact analysis to characterize the impacts of certain facilities that may be causing exceedences of the 1-hour sulfur dioxide (SO_2) national ambient air quality standard (NAAQS). This document describes the results and procedures for an evaluation conducted for three Maryland generating stations located near Baltimore, Maryland. These three stations are C.P. Crane Generating Station in Chase, Maryland and Brandon Shores & H.A. Wagner Generating Stations at the Fort Smallwood Complex in Maryland. This analysis incorporates emissions from the most recent four years (2012-2015) and uses the most current version of EPA's AERMOD and related software.

The dispersion modeling analysis predicted ambient air concentrations for comparison with the 1-hour SO_2 NAAQS. The modeling was performed using the most recent version of AERMOD, AERMET, and AERMINUTE, with data provided to the Sierra Club by regulatory air agencies and through other publicly-available sources as documented below. The analysis was conducted in adherence to all available USEPA guidance for evaluating source impacts on attainment of the 1-hour SO_2 NAAQS via dispersion modeling, including the AERMOD Implementation Guide; USEPA's Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 National Ambient Air Quality Standard, August 23, 2010; modeling guidance promulgated by USEPA in Appendix W to 40 CFR Part 51; USEPA's March 2011 Modeling Guidance for SO_2 NAAQS Designations; [1] and, USEPA's December 2013 SO2 NAAQS Designations Technical Assistance Document.[2]

2. Compliance with the 1-hour SO_2 NAAQS

2.1 1-hour SO_2 NAAQS

The 1-hour SO_2 NAAQS takes the form of a three-year average of the 99th-percentile of the annual distribution of daily maximum 1-hour concentrations, which cannot exceed 75 ppb.[3] Compliance with this standard was verified using USEPA's AERMOD air dispersion model, which produces air concentrations in units of $\mu g/m^3$. The 1-hour SO_2 NAAQS of 75 ppb equals 196.2 $\mu g/m^3$, and this is the value used for determining whether modeled impacts exceed the NAAQS.[4] The 99th-percentile of the annual distribution of daily maximum 1-hour concentrations corresponds to the fourth-highest value at each receptor for a given year.

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[1] http://www.epa.gov/scram001/so2_modeling_guidance.htm
[2] http://www.epa.gov/oaqps001/sulfurdioxide/pdfs/SO2ModelingTAD.pdf
[3] USEPA, Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 National Ambient Air Quality Standard, August 23, 2010.
[4] The ppb to $\mu g/m^3$ conversion is found in the source code to AERMOD v. 15181, subroutine Modules. The conversion calculation is 75/0.3823 = 196.2 $\mu g/m^3$.

2.2 Modeling Results

Modeling results for the three Maryland generating stations are summarized in Table 1. It was determined that based on measured actual emissions, the three Maryland generating stations are estimated to create downwind SO_2 concentrations which exceed the 1-hour NAAQS.

More specifically, the modeling results presented in Table 1, show exceedences of the NAAQS by the plants' actual emissions. "Actual" represents the emissions which occurred during each hour of two 3-year periods: 2012-14 and 2013-15. Actual emission measurements were taken from two databases, USEPA *Clean Air Markets Program Data (CAMD)* [5] and the Emissions Modeling Clearinghouse State-Level Hourly Sulfur Dioxide (SO_2) Data. [6]

For the 2012-14 period, two scenarios were evaluated. The first used the actual hourly emissions provided by the CAMD and fixed stack exit velocities. The second used the actual hourly emissions provided by the Clearinghouse with variable stack exit velocities. The velocities were derived from the hourly flow rates reported in the Clearinghouse. Total emissions for the 3-year period reported by CAMD were identical to those reported in the Clearinghouse.

For the 2013-15 period, two scenarios were also evaluated using fixed and variable stack exit velocities. For this period, the Clearinghouse emissions and exit velocities for 2013-14 were supplemented with CAMD emissions for 2015. The velocities for 2015 were derived from the hourly heat input reported in CAMD.

Air quality impacts in Maryland are based on a background concentration of 28.8 $\mu g/m^3$. This is the 2012-14 design value for Prince George's, Maryland (Monitor ID #3-24-033-0030) - the lowest measured background concentration in the state. See Section 5 for further discussion of the background concentrations used for this analysis.

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[5] http://ampd.epa.gov/ampd/
[6] https://www3.epa.gov/ttn/chief/emch/so2naaqs/index.html

Table 1 - SO_2 Modeling Results for the Three Maryland Generating Stations

Scenario	Facility	99th Percentile 1-hour Daily Maximum (µg/m3)			NAAQS	Meets NAAQS?
		Impact	Background	Total	(µg/m3)	(µg/m3)
2012-14 CAMD Actual Emissions Fixed Velocity	All	267.7	28.8	296.5	196.2	No
	Crane	103.9	28.8	132.7	196.2	Yes
	Brandon/Wagner	265.3	28.8	294.1	196.2	No
2012-14 Clearinghouse Actual Emissions Variable Velocity	All	225.3	28.8	254.1	196.2	No
	Crane	87.3	28.8	116.1	196.2	Yes
	Brandon/Wagner	225.2	28.8	254.0	196.2	No
2013-15 Clearinghouse/CAMD Actual Emissions Fixed Velocity	All	229.6	28.8	258.4	196.2	No
	Crane	102.0	28.8	130.8	196.2	Yes
	Brandon/Wagner	229.5	28.8	258.3	196.2	No
2013-15 Clearinghouse/CAMD Actual Emissions Variable Velocity	All	224.1	28.8	252.9	196.2	No
	Crane	91.9	28.8	120.7	196.2	Yes
	Brandon/Wagner	224.0	28.8	252.8	196.2	No

Predicted exceedences of the 1-hour NAAQS for SO_2 based on actual emissions extend to a distance of 35 kilometers from the Brandon Shores/Wagner plants.

Figures 1 through 4 show the extent of predicted exceedences of the 1-hour NAAQS for SO_2 based on actual emissions from all three plants. Figure 1 is based on 2012-14 actual emissions from CAMD measurements with a fixed stack exit velocity. Figure 2 is based on 2012-14 actual emissions from the Clearinghouse measurements using a variable stack exit velocity. Figure 3 is based on the 2013-15 actual emissions using a combination of the Clearinghouse and CAMD measurements using a fixed stack exit velocity. Figure 4 is based on the 2013-15 actual emissions using a combination of the Clearinghouse and CAMD measurements using a variable stack exit velocity.

2.3 Conservative Modeling Assumptions

A dispersion modeling analysis requires the selection of numerous parameters which affect the predicted concentrations. For the enclosed analysis, several parameters were selected which under-predict facility impacts.

Assumptions used in this modeling analysis which likely under-estimate concentrations include the following:

- No evaluation has been conducted to determine if the stack height exceeds Good Engineering Practice or GEP height. If the stack height exceeds GEP, the predicted concentrations will increase.
- No consideration of off-site sources. These other sources of SO_2 will increase the predicted impacts.

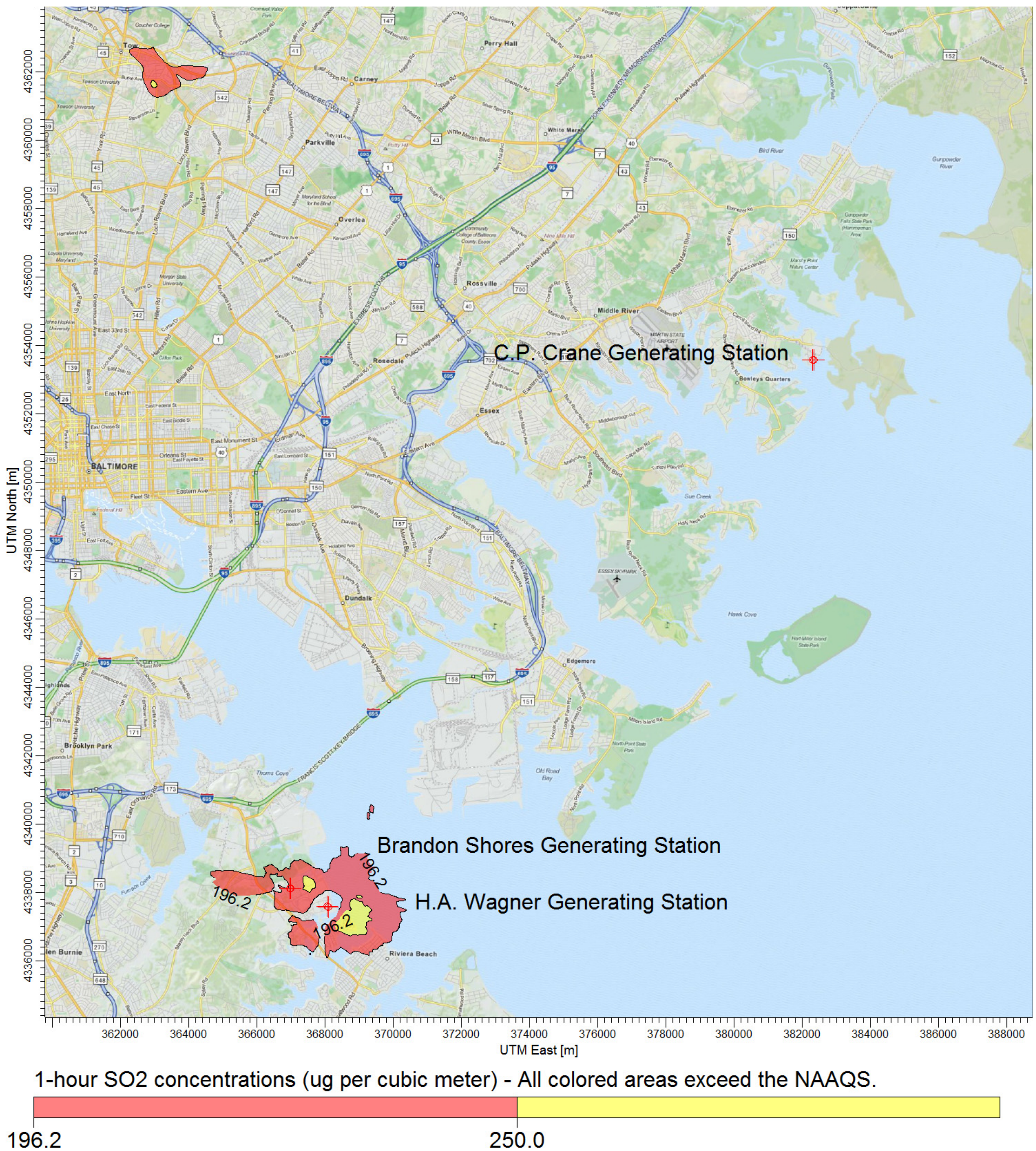

Figure 1 - Regional View of Impacts Due to 2012-14 CAMD Actual Emissions and Fixed Exit Velocities

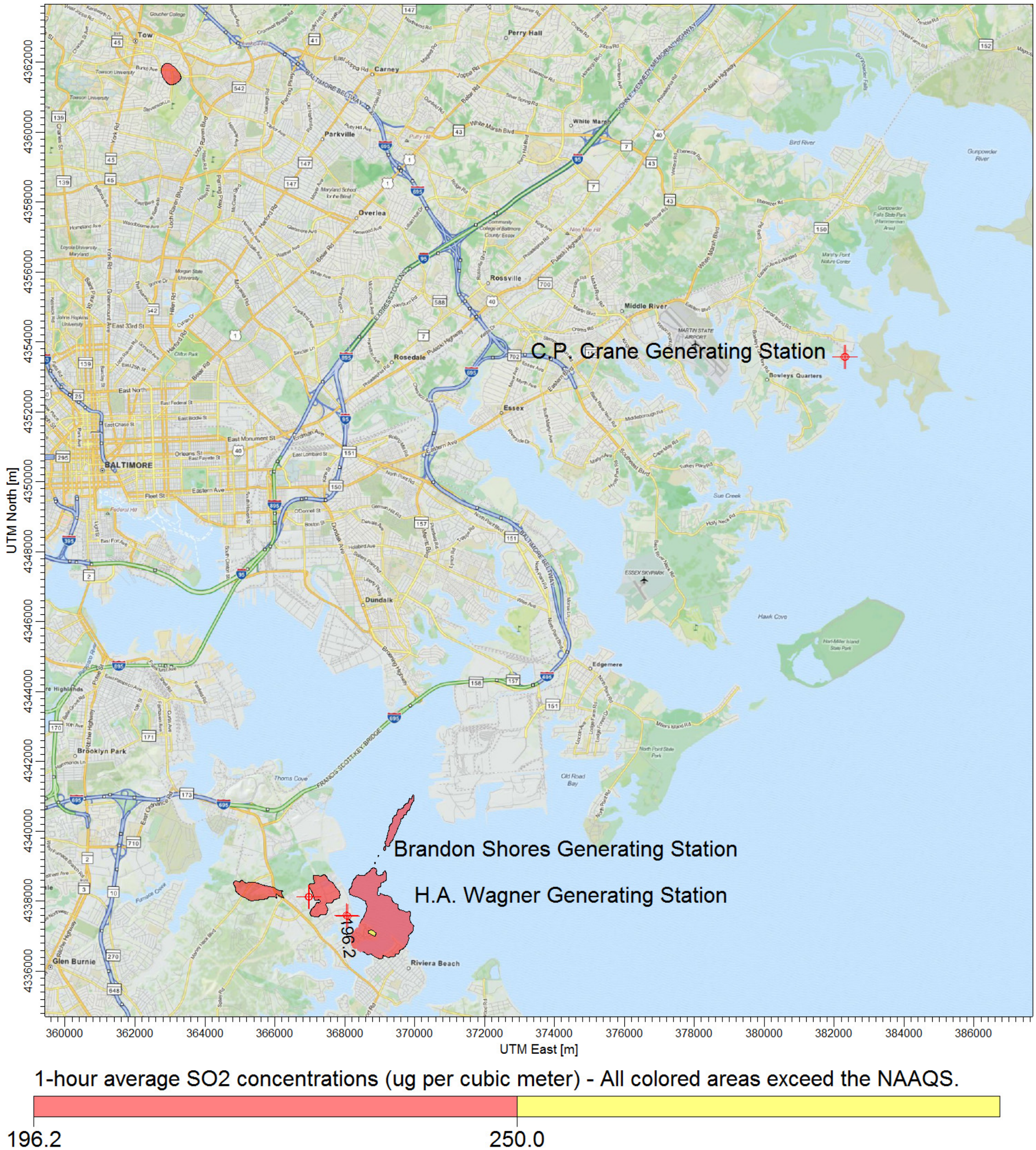

Figure 2 - Regional View of Impacts Due to 2012-14 Clearinghouse Actual Emissions and Variable Exit Velocities

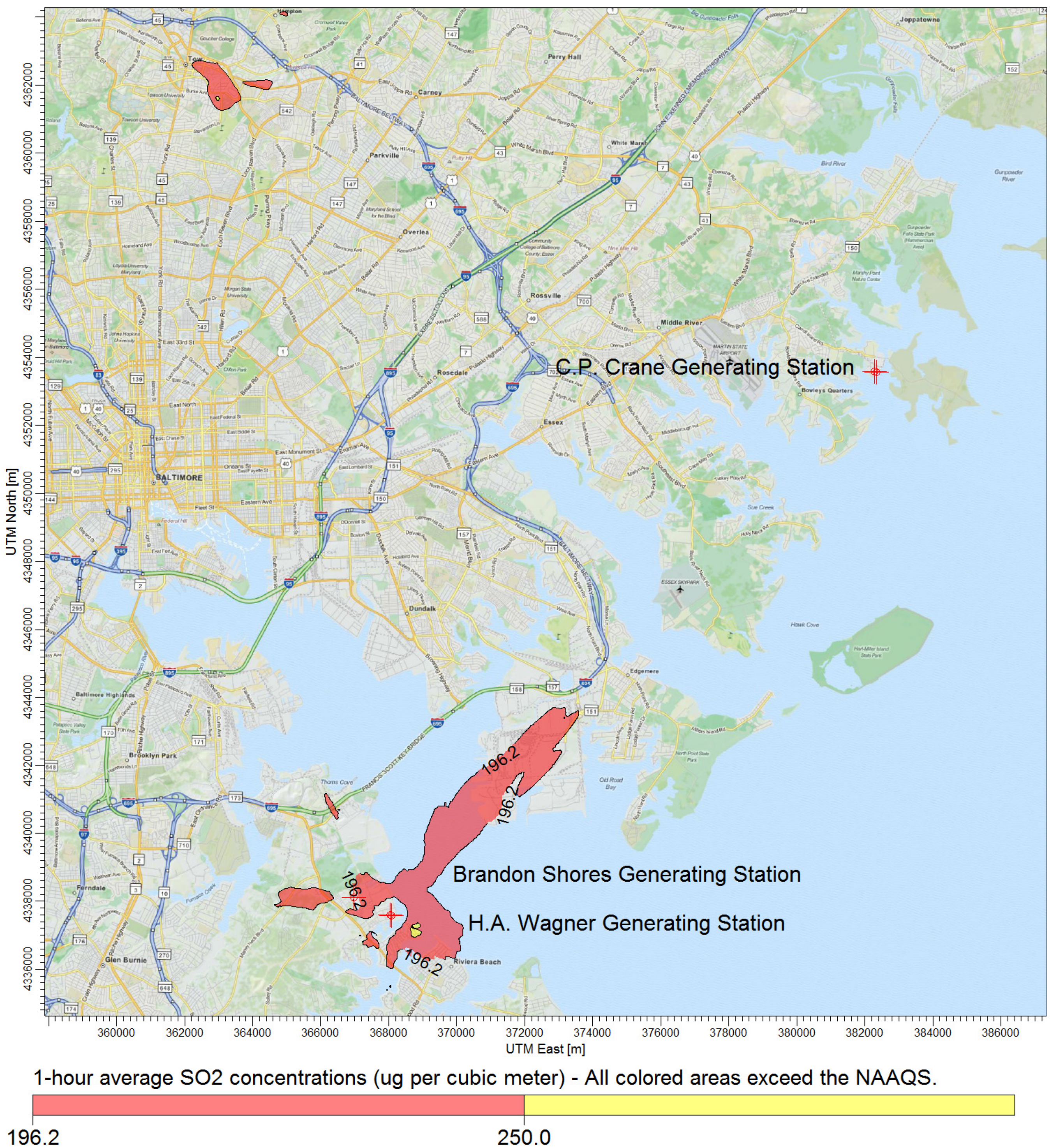

Figure 3 - Regional View of Impacts Due to 2013-15 Clearinghouse/CAMD Actual Emissions and Fixed Exit Velocities

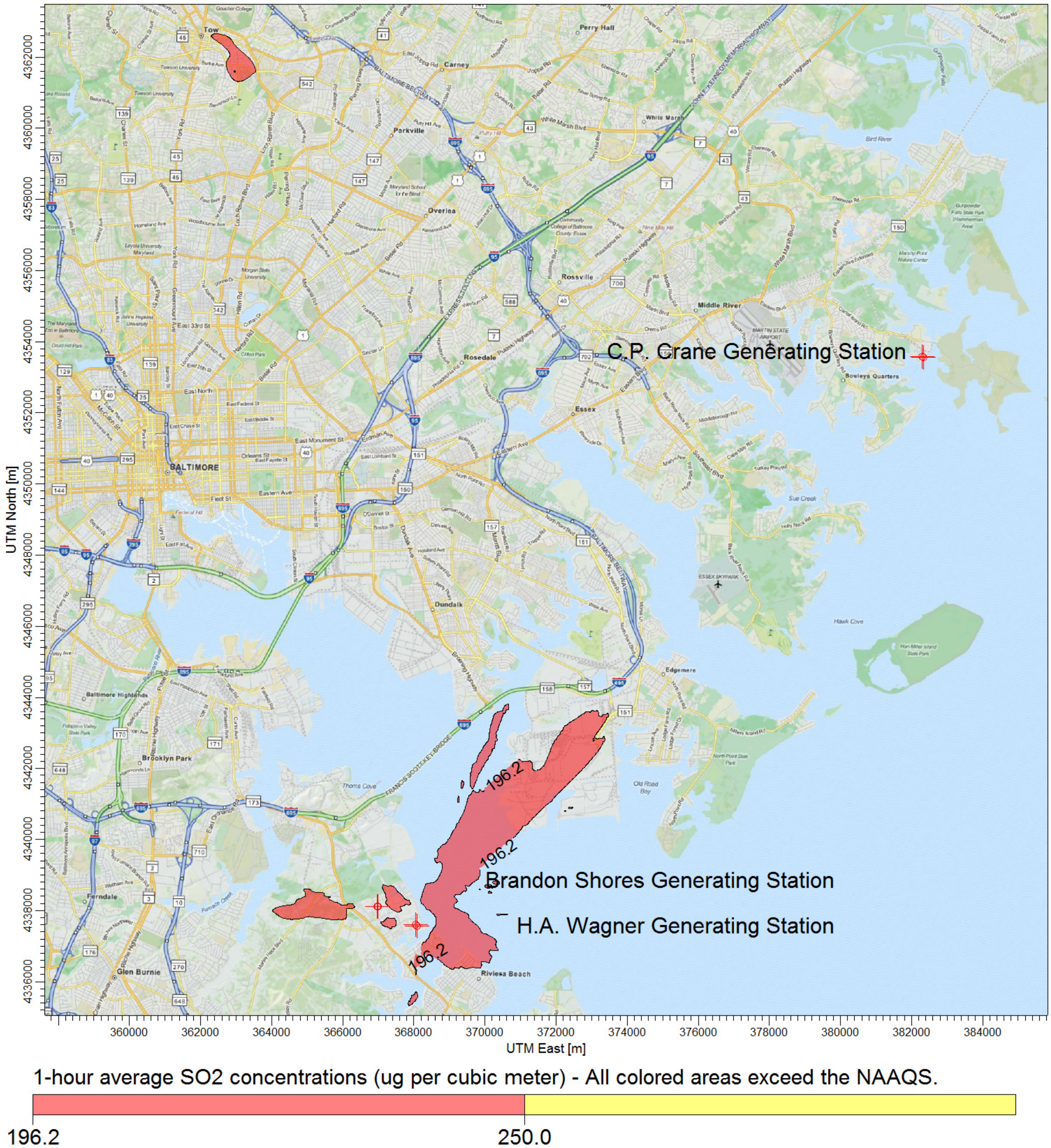

Figure 4 - Regional View of Impacts Due to 2013-15 Clearinghouse/CAMD Actual Emissions and Variable Exit Velocities

3. Modeling Methodology

3.1 Air Dispersion Model

The modeling analysis used USEPA's AERMOD program, v. 15181. AERMOD, as available from the Support Center for Regulatory Atmospheric Modeling (SCRAM) website, was used in conjunction with a third-party modeling software program, *AERMOD View*, sold by Lakes Environmental Software.

3.2 Control Options

The AERMOD model was run with the following control options:

- 1-hour average air concentrations
- Regulatory defaults
- Flagpole receptors

To reflect a representative inhalation level, a flagpole height of 1.5 meters was used for all modeled receptors. This parameter was added to the receptor file when running AERMAP, as described in Section 4.4.

An evaluation was conducted to determine if the modeled facilities are located in a rural or urban setting using USEPA's methodology outlined in Section 7.2.3 of the Guideline on Air Quality Models.[7] For urban sources, the URBANOPT option is used in conjunction with the urban population from an appropriate nearby city and a default surface roughness of 1.0 meter. Methods described in Section 4.1 were used to determine whether rural or urban dispersion coefficients were appropriate for the modeling analysis.

3.3 Output Options

The AERMOD analysis was based on two 3-year periods of recent meteorological data. The modeling analyses used one run with three years of sequential meteorological data from 2012-2014 and one run with data from 2013-15. Consistent with USEPA's Modeling Guidance for SO_2 NAAQS Designations, AERMOD provided a table of fourth-high 1-hour SO_2 impacts concentrations consistent with the form of the 1-hour SO_2 NAAQS.[8]

Please refer to Table 1 for the modeling results.

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[7] USEPA, Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions, Appendix W to 40 CFR Part 51, November 9, 2005.
[8] USEPA, Area Designations for the 2010 Revised Primary Sulfur Dioxide National Ambient Air Quality Standards, Attachment 3, March 24, 2011, pp. 24-26.

4. Model Inputs

4.1 Geographical Inputs

The "ground floor" of all air dispersion modeling analyses is establishing a coordinate system for identifying the geographical location of emission sources and receptors. These geographical locations are used to determine local characteristics (such as land use and elevation), and also to ascertain source to receptor distances and relationships.

The Universal Transverse Mercator (UTM) NAD83 coordinate system was used for identifying the easting (x) and northing (y) coordinates of the modeled sources and receptors. Stack locations were obtained from facility permits and prior modeling files provided by the state regulatory agency. The stack locations were then verified using aerial photographs.

The facility was evaluated to determine if it should be modeled using the rural or urban dispersion coefficient option in AERMOD. A GIS was used to determine whether rural or urban dispersion coefficients apply to a site. Land use within a three-kilometer radius circle surrounding the facility was considered. USEPA guidance states that urban dispersion coefficients are used if more than 50% of the area within 3 kilometers has urban land uses. Otherwise, rural dispersion coefficients are appropriate.[9]

USEPA's AERSURFACE v. 13016 was used to develop the meteorological data for the modeling analysis. This model was also used to evaluate surrounding land use within 3 kilometers. Based on the output from the AERSURFACE, approximately 2.6% of the land surrounding the C.P. Crane Generating Station and 13.4% of the land surrounding the Brandon Shores and H.A. Wagner Generating Stations were of urban land use types including Type 21 – Low Intensity Residential, Type 22 – High Intensity Residential and Type 23 – Commercial / Industrial / Transportation.

This is less than the 50% value considered appropriate for the use of urban dispersion coefficients. Based on the AERSURFACE analysis, it was concluded that the rural option would be used for the modeling summarized in this report. Please refer to Section 4.5.3 for a discussion of the AERSURFACE analysis.

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[9] USEPA, Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions, Appendix W to 40 CFR Part 51, November 9, 2005, Section 7.2.3.

4.2 Emission Rates and Source Parameters

The modeling analyses only considered SO_2 emissions from the three plants. Off-site sources were not considered.

Stack parameters and emissions used for the modeling analysis are summarized in Table 4.

Table 4 – Facility Stack Parameters and Emissions [10]

Stack	B01	B02	C01	C02	W02	W03
Generating Station	Brandon	Brandon	Crane	Crane	Wagner	Wagner
Boiler/Unit	Unit 1	Unit 2	Unit 1	Unit 2	Unit 2	Unit 3
X Coord. [m]	366970.5	366980.5	382293.8	382335.7	368092	368050
Y Coord. [m]	4338117.53	4338120.09	4353574.5	4353566.3	4337574	4337602
Base Elevation [m]	10	9.92	1.27	1.27	3.85	4.1
Release Height [m]	121.92	121.92	107.59	107.59	87.48	105.46
Gas Exit Temperature [°K]	326.483	326.483	427.594	427.594	409.817	418.706
Gas Exit Velocity [m/s]	13.023	11.96	29.942	29.071	22.692	28.733
Inside Diameter [m]	9.51	9.51	3.322	3.322	3.109	4.206
Actual Emission Rate [g/s]	-	-	-	-	-	-

The above stack parameters and emissions were obtained from regulatory agency documents and databases identified in Section 2.2. The analysis for both the 2012-14 and 2013-15 periods was conducted for two scenarios. The first assumed 100% operating load using maximum exhaust flow rates and temperatures. The second used variable hourly exit velocities with a fixed exit temperature. The velocities for the 2012-14 period were derived from the stack flow rates provided by the USEPA Clearinghouse database. The velocities for 2015 were based on the heat input provided by the CAMD database and flow rates estimated from these hourly heat inputs. Stack location, height and diameter were verified using aerial photographs, and flue gas flow rate and temperature were verified using combustion calculations.

4.3 Building Dimensions and GEP

No building dimensions or prior downwash evaluations were available. Therefore this modeling analysis did not address the effects of downwash and this may under-predict impacts.

[10] U.S. Energy Information Agency, Form EIA-860 detailed data, 2013, http://www.eia.gov/electricity/data/eia860/xls/eia8602013.zip

4.4 Receptors

For the three Maryland generating stations, two receptor grids were employed:

1. A 100-meter Cartesian receptor grid centered on the three Maryland generating stations and extending out 15 kilometers.
2. A 500-meter Cartesian receptor grid centered on the three Maryland generating stations and extending out 25 kilometers.

A flagpole height of 1.5 meters was used for all these receptors.

Elevations from stacks and receptors were obtained from National Elevation Dataset (NED) GeoTiff data. GeoTiff is a binary file that includes data descriptors and geo-referencing information necessary for extracting terrain elevations. These elevations were extracted from 1 arc-second (30 meter) resolution NED files. The USEPA software program AERMAP v. 11103 is used for these tasks.

4.5 Meteorological Data

To improve the accuracy of the modeling analysis, recent meteorological data for the 2012-2014 and 203-15 periods were prepared using the USEPA's program AERMET which creates the model-ready surface and profile data files required by AERMOD. Required data inputs to AERMET included surface meteorological measurements, twice-daily soundings of upper air measurements, and the micrometeorological parameters surface roughness, albedo, and Bowen ratio. One-minute ASOS data were available so USEPA methods were used to reduce calm and missing hours.[11] The USEPA software program AERMINUTE v. 15272 is used for these tasks.

This section discusses how the meteorological data was prepared for use in the 1-hour SO_2 NAAQS modeling analyses. The USEPA software program AERMET v. 15181 is used for these tasks.

4.5.1 Surface Meteorology

Surface meteorology was obtained for Baltimore Washington International Airport located near the the three Maryland generating stations. Integrated Surface Hourly (ISH) data for the 2012-2014 and 2013-15 periods were obtained from the National Climatic Data Center (NCDC). The ISH surface data was processed through AERMET Stage 1, which performs data extraction and quality control checks.

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[11] USEPA, Area Designations for the 2010 Revised Primary Sulfur Dioxide National Ambient Air Quality Standards, Attachment 3, March 24, 2011, p. 19.

4.5.2 Upper Air Data

Upper-air data are collected by a "weather balloon" that is released twice per day at selected locations. As the balloon is released, it rises through the atmosphere, and radios the data back to the surface. The measuring and transmitting device is known as either a radiosonde, or rawindsonde. Data collected and radioed back include: air pressure, height, temperature, dew point, wind speed, and wind direction. The upper air data were processed through AERMET Stage 1, which performs data extraction and quality control checks.

For the three Maryland generating stations, the concurrent upper air data from twice-daily radiosonde measurements obtained at the most representative location were used. This location was the Sterling, Virgina measurement station. These data are in Forecast Systems Laboratory (FSL) format and were downloaded in ASCII text format from NOAA's FSL website.[12] All reporting levels were downloaded and processed with AERMET.

4.5.3 AERSURFACE

AERSURFACE is a program that extracts surface roughness, albedo, and daytime Bowen ratio for an area surrounding a given location. AERSURFACE uses land use and land cover (LULC) data in the U.S. Geological Survey's 1992 National Land Cover Dataset to extract the necessary micrometeorological data. LULC data was used for processing meteorological data sets used as input to AERMOD.

AERSURFACE v. 13016 was used to develop surface roughness, albedo, and daytime Bowen ratio values in a region surrounding the meteorological data collection site. AERSURFACE was used to develop surface roughness in a one kilometer radius surrounding the data collection site. Bowen ratio and albedo was developed for a 10 kilometer by 10 kilometer area centered on the meteorological data collection site. These micrometeorological data were processed for seasonal periods using 30-degree sectors. Seasonal moisture conditions were considered average with winter months having continuous snow cover.

4.5.4 Data Review

Missing meteorological data were not filled as the data file met USEPA's 90% data completeness requirement.[13] The AERMOD output file shows there were 0.2% and 0.26% missing data for 2012-14 and 2013-15 periods, respectively.

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[12] Available at: http://esrl.noaa.gov/raobs/
[13] USEPA, Meteorological Monitoring Guidance for Regulatory Modeling Applications, EPA-454/R-99-05, February 2000, Section 5.3.2, pp. 5-4 to 5-5.

To confirm the representativeness of the airport meteorological data, the surface characteristics of the airport data collection site and the modeled source location were compared. Since the Baltimore Washington International Airport is located close to the three Maryland generating stations, this meteorological data set was considered appropriate for this modeling analysis. [14] Additionally, this weather station provided high quality surface measurements for the most recent 3-year time, and had similar land use, surface characteristics, terrain features and climate.

5. Background SO_2 Concentrations

Background concentrations were determined consistent with USEPA's Modeling Guidance for SO_2 NAAQS Designations.[15] To preserve the form of the 1-hour SO_2 standard, based on the 99th percentile of the annual distribution of daily maximum 1-hour concentrations averaged across the number of years modeled, the background fourth-highest daily maximum 1-hour SO_2 concentration was added to the modeled fourth-highest daily maximum 1-hour SO_2 concentration.[16] Background concentrations were based on the 2012-14 design value measured by the ambient monitors located in Maryland.[17]

6. Reporting

All files from the programs used for this modeling analysis are available to regulatory agencies. These include analyses prepared with AERSURFACE, AERMET, AERMAP, and AERMOD.

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[14] USEPA, AERMOD Implementation Guide, March 19, 2009, pp. 3-4.
[15] USEPA, Area Designations for the 2010 Revised Primary Sulfur Dioxide National Ambient Air Quality Standards, Attachment 3, March 24, 2011, pp. 20-23.
[16] USEPA, Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 National Ambient Air Quality Standard, August 23, 2010, p. 3.
[17] http://www.epa.gov/airtrends/values.html