UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
290 BROADWAY
NEW YORK, NY 10007-1866

**September 20, 2022**

**MEMORANDUM**

**SUBJECT:** Concurrence Request to Use Site Specific Alternative Approaches to Demonstrate Modeled Attainment of the 2010 $SO_2$ NAAQS at the Alcoa West Aluminum Smelter in Massena, New York

**FROM:** Annamaria Colecchia, Regional Air Quality Modeler *Annamaria Colecchia*
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**THRU:** Richard Ruvo, Director *Richard Ruvo* Digitally signed by RICHARD RUVO Date: 2022.09.20 10:00:06 -04'00'
Air and Radiation Division
EPA Region 2, New York, New York

**TO:** George Bridgers, Director of Model Clearinghouse
Air Quality Modeling Group, Office of Air Quality Planning and Standards

The U.S. Environmental Protection Agency (EPA) Region 2 seeks concurrence from the Model Clearinghouse regarding the prospective EPA Region 2 approval of alternative modeling approaches as part of New York State Department of Environmental Conservation's (NYSDEC) attainment demonstration of the 2010 $SO_2$ National Ambient Air Quality Standard (NAAQS). As part of EPA's Round 4 $SO_2$ NAAQS designation process, a portion of St. Lawrence County, New York surrounding the Alcoa Massena facility was designated as non-attainment with respect to the 1-hour $SO_2$ NAAQS. NYSDEC is requesting approval to use two site-specific alternative modeling approaches which modify inputs to the EPA preferred guideline model, AERMOD (**A**merican Meteorological Society/**E**nvironmental Protection Agency **R**egulatory **Mod**el). The two modeling approaches modify inputs to AERMOD. These include the substitution of a neutral temperature lapse rate in the lower 100 meters of the atmosphere and using the 2019 draft version of BPIPPRM (**B**uilding **P**rofile **I**nput **P**rogram for PRIME, **P**lume **Ri**se **M**odel **E**nhancements). NYSDEC has sought approval to allow the use of these alternate modeling approaches for their air quality modeling analysis, under 40 CFR Part 51, Appendix W §3.2.2(b), Condition (2), for their attainment demonstration. Under Condition (2), an alternative model may be used if the Regional Office finds the conditions specified in Appendix W §3.2.2(d) are satisfied.

NYSDEC submitted their alternative model request on June 28, 2022 and included a June 10, 2022 Modeling Protocol that included the technical analyses prepared by Alcoa Massena (attached). Additional modeling files were provided on August 30$^{th}$ and September 9, 2022. The request provided evidence and justifications supporting approvability of the alternative modeling approaches under Appendix W §3.2.2(b), Condition (2). EPA Region 2 has conducted a thorough review of the request and intends to approve the use of these alternate modeling approaches for the Alcoa Massena West attainment demonstration of the 2010 $SO_2$ NAAQS. Region 2 found the proposed application of the model is satisfactory under the requirements of §3.2.2(d). A technical analysis summarizing our review of the submittal is below. Please feel free to contact Annamaria Colecchia or Neha Sareen at (212) 637-4016, and (212) 637-4074, respectively, if you have any questions regarding the request.

**EPA Region 2's Technical Review of New York State Department of Environmental Conservation's Request to Use Two Site-Specific Alternative Modeling Approaches in AERMOD**

## 1. Background and Project Overview

NYSDEC has requested to use alternate modeling approaches, as provided in §3.2 of the Guideline on Air Quality Models (40 CFR Part 51, Appendix W, hereafter referred to as the *Guideline*), to conduct its modeled attainment demonstration of the 1-hour $SO_2$ National Ambient Air Quality Standard (NAAQS) for the Alcoa Massena West (hereafter, Alcoa Massena) aluminum production facility located in St. Lawrence County, New York. The Alcoa Massena facility has a capacity to produce 136,000 metric tons of primary aluminum per calendar year (full capacity). The area surrounding the facility is rural with simple terrain within several kilometers and is located along the St. Lawrence Seaway. The facility has one potline building consisting of two long rooms with 36 dry scrubber stacks between them. Emission from the dry scrubber stacks comprise most of the $SO_2$ emissions at the smelter, with one bake oven stack also emitting $SO_2$. Roof vents emit a small fraction of the stack emissions. Emission rates were found to be approximately uniform across a monthly basis.

There are two site-specific $SO_2$ ambient monitors near the facility that were sited by NYSDEC using the BLP option in AERMOD in 2017. The area was designated nonattainment with respect to the 1-hour $SO_2$ NAAQS on April 30, 2021 since the two site specific ambient monitors measured concentrations above the 1-hour $SO_2$ NAAQS between 2017 and 2019.

Alcoa's proposed strategy to bring the area into attainment is to physically merge the 36 stacks into smaller clusters of 4 and raise the stack height. The current stack height is 23 meters and will remain less than the 65 meter de minimis Good Engineering Practice (GEP) stack height. The merging and raising of the stacks are creditable under the Clean Air Act since the total tons of $SO_2$ emissions are less than 5000 tpy and the stack heights will be under 65 meters.

A modeled attainment demonstration is required for the approval of this strategy into its State Implementation Plan (SIP). NYSDEC and Alcoa found that the EPA regulatory default AERMOD model overpredicted concentrations when compared to measurements at the two site-specific $SO_2$ ambient monitors. NYSDEC and Alcoa initially believed that the downwash algorithm in AERMOD was the leading cause of the overpredictions. However, in coordination with modelers from NYSDEC, Alcoa, Region 2 and OAQPS the AERMOD debug files were reviewed and found that the plume rise was underestimated. This was likely due to the excess fugitive heat loss emanating from the building itself which is not accounted for in AERMOD. However, the building configurations represented in AERMOD were also further evaluated. To address these issues, two alternative approaches that modify inputs to AERMOD are proposed in this case.

As discussed below, the two modifications served to improve the model performance when compared to measured values at the two site specific ambient monitors. EPA Region 2 has reviewed NYSDEC's request to implement the two alternative model approaches and determined that the use of the proposed alternatives is acceptable.

Figure 1: Alcoa Massena facility and location of the two $SO_2$ monitoring sites


2. **NYSDEC's Proposed Modeling Approach**

Aluminum smelters generate much fugitive heat and in some cases the facility could be considered an urban like source creating a local heat island. AERMOD contains an urban source option to account for this effect. However, NYSDEC found that in the case of the Alcoa Massena facility, the surface temperature difference between the facility and the outer surrounding area was too small to justify this option. Further the footprint of the Massena facility is much smaller than other aluminum facilities where the urban source option was used. NYSDEC also noted that in earlier test cases for this facility where it was modeled as an urban source, the modeled concentrations were too low and not supportable. Therefore, the facility was modeled as a rural source.

To address the underpredictions in nighttime plume rise gathered from the review of AERMOD's debug file, the NYSDEC and Alcoa propose to modify the vertical temperature lapse rate produced by AERMET (AERMOD's meteorological data preprocessor) in the lower 100 meters of the atmosphere. A neutral lapse rate of 0.0098 degree C per kilometer which corresponds to a dry adiabatic lapse rate was substituted in the AERMET vertical temperature profile output. Since AERMET begins the lower level temperature profiles at 10 meters, a 90 meter vertical length was modified. This resulted in a 0.88 degree C drop in temperature at the 100 meter level. The modified 100 meter temperature was substituted in the vertical temperature profile produced by AERMET keeping the actual measured temperature at the 10 meter level and all other levels above 100 meters.

Regarding the modification to BPIPPRM, NYSDEC and Alcoa propose to use of the updated 2019 draft BPIPPRM to calculate the building dimensions which simulate building downwash in AERMOD. The key update in the draft BPIPPRM is that the preprocessor restricts the building dimensions to the actual building footprint for any wind angle that approaches the building. The current default BPIPPRM calculates a width and length based on a diagonal measurement that is perpendicular to the wind which could overstate the true length or width of a long narrow building and thereby overstate the downwash effects.

## 3. Region 2's Review of the Alternative Model Proposal

(i) Neutral Lapse Rate:

Region 2 agrees with NYSDEC's assessment that the Alcoa Massena facility is located in an area defined as rural and that the urban source option or urban dispersion mode is not appropriate in this case. However, Alcoa estimates that the fugitive heat loss is 50 MW per year through the roof vents and building. Region 2 agrees that the large fugitive heat loss could affect the plume rise of the pollutants from the stacks and that AERMOD does not directly account for this effect on the plume rise. The lower plume rises from the default AERMOD likely contributes to the overpredictions of the modeled concentrations when compared to measured concentrations at the two site specific ambient monitors. A review of the debug files found that the proposed approach of a neutral lapse rate in the lower 100 meters provided a correction to the modeled plume rise.

The correction at the 100-meter level is reasonable given AERMOD's formulation. While this is not an urban source, the residual excess fugitive heat results in enhanced dispersion at night similar to an urban environment. AERMOD uses population as a means to define the degree of urbanization that defines the enhance turbulence at night. In this case, there is a 10 degree C temperature difference between the facility and the outer surrounding area. According to equation 107 of the AERMOD Formulation document, this corresponds to a population of 250,000. A population of this size relates to a vertical mixing height of around 200 meters using equation 110. Therefore, 100-meter correction in the temperature lapse rate is reasonable. Correcting the model in this manner was also supported by Dr. Steven Hanna in a February 6, 2022 opinion paper regarding the Alcoa Massena facility where the use of LIFTOFF was previously proposed but not found supportable.

Further, it is noted that most of the observed maximum concentrations occur at night when stable conditions at this facility are not likely. All of the top 25 measurements at site 1, and 22 out of 25 at site 2 occur at night. While the modified lapse rate was applied to all hours, the modification only effected the plume rise and dispersion during nighttime conditions. This is because the daytime hours were dominated by convective conditions where the buoyant flux remained the same.

A review of the September 9th debug files was made. It was found that the modeled plume rises during the dates and times that the default model calculated maximum concentrations showed increased plume rise and decrease in concentrations in the corresponding modified model. Wind speeds and mixing heights also increased which led to better dispersion. This affirmed the modified AERMOD model served to enhance nighttime turbulence and improved performance when compared to model to monitor concentrations.

It is also important to note that modifying the vertical temperature lapse rate in this manner would not be appropriate in a multisource modeling analysis where other nearby sources that are not subjected to the same effects of excessive heat loss are included in the modeling domain. In this case, there are no other significant sources of $SO_2$ in the vicinity to the Alcoa Massena facility. The modification to the ambient temperature lapse rate would only apply to the Alcoa Massena facility. Contributions from distance or minor sources are accounted for in the ambient background which would simply be added to Alcoa's modeled impacts.

(ii) <u>2019 Draft BPIPPRM</u>:

The second alternative modeling technique involves the use of the 2019 draft BPIPPRM. This preprocessor revises the building dimensions with respect to the wind direction to better match the actual dimensions of the building. This is important for the downwash assessment particularly in long narrow buildings. The current version of BPIPPRM may overestimate the length or width of a building when a long narrow building is present. This could misrepresent the amount of downwash that occurs. Wind tunnel studies have been performed with single tiered, long narrow buildings and is a basis for the draft BPIPPRM. Since the Alcoa Massena building is a single tiered, long narrow building Region 2 agrees that the 2019 draft BPIPPRM should be considered in this case. We recognize that the draft BPIPPRM has only had limited testing. However, in this case the availability of two ambient monitors were used to perform statistical evaluations using the draft BPIPPRM and the neutral lapse rate and found that the modified AERMOD model performed better (see below). Further, the downwash algorithm itself was not changed and will remain as the default. This alternative is only for the building dimension inputs.

On August 30, 2022, at the request of EPA, Alcoa provide isopleths of the concentrations using the default AERMOD impacts and AERMOD with the modified preprocessors. EPA requested this information to better understand the effects of the draft BPIPPRM on the modeling domain. As seen in Figure 2, the plots of the isopleth show a shift in the maximum impact location downwind of the lee side of the long narrow single tiered building to the lateral edge of that downwind side. This is what has been shown in the wind tunnel studies to date indicating the draft BPIPPRM is working better in this case. Further as seen in Figure 3, the isopleths also align with the prevailing southwest/northeast wind direction that would be expected along the nearby St. Lawrence Seaway river valley.

Figure 2: Isopleths of default Aermod (left) and Modified Aermod with draft BPIPPRM (right)

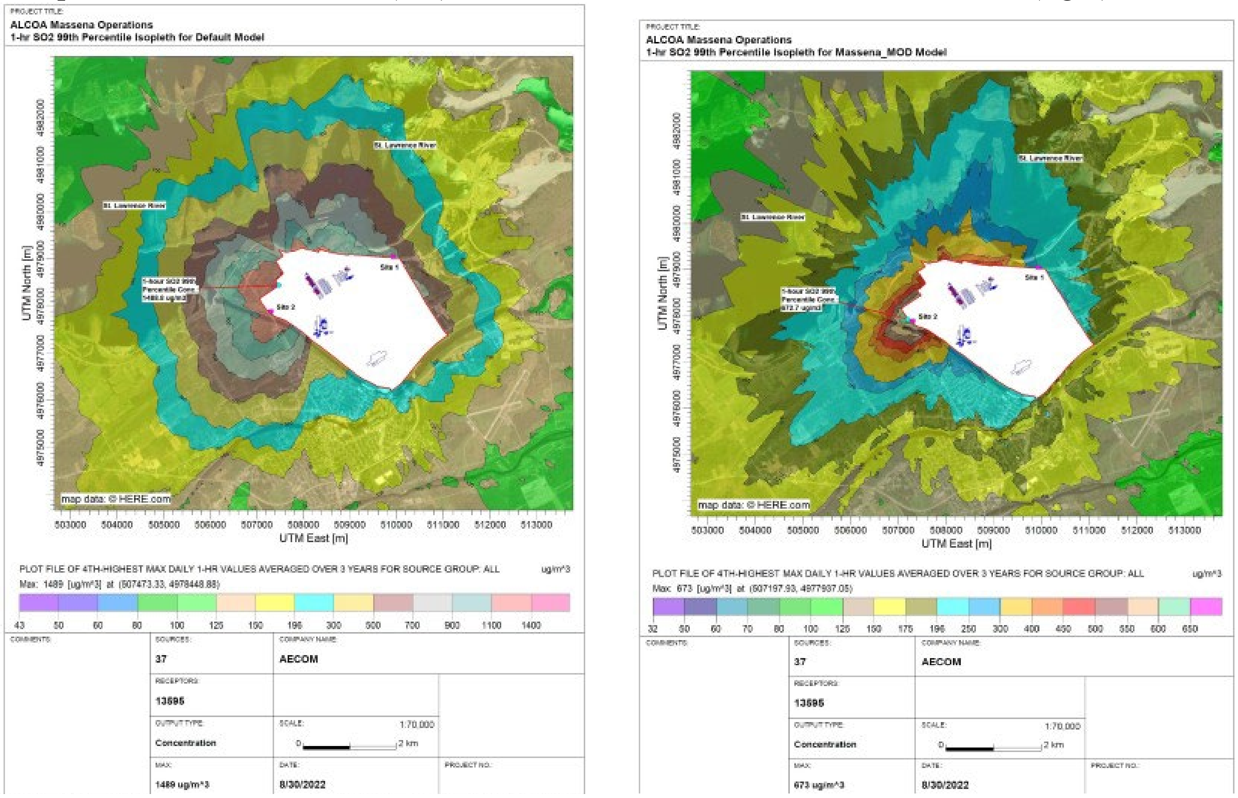
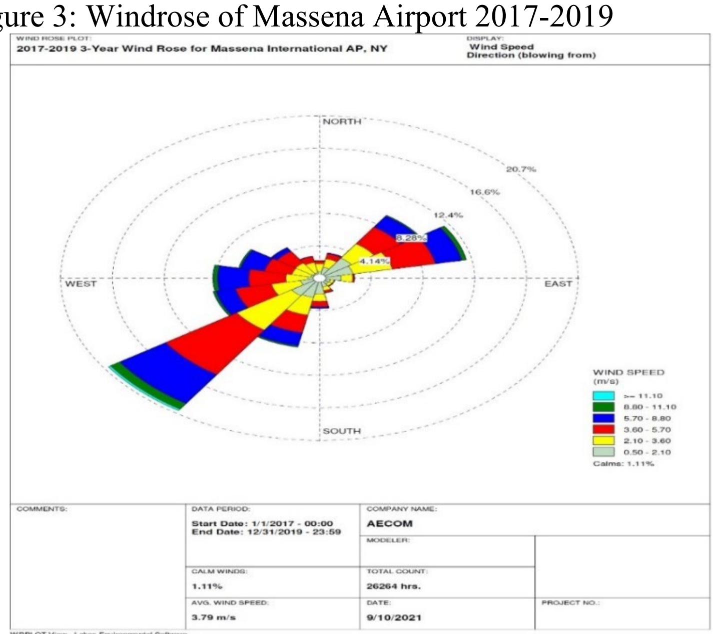



Figure 3: Windrose of Massena Airport 2017-2019




**Regulatory Analysis and Background**

40 CFR Part 51.166(l) states that all applications of air quality modeling shall be based on the applicable models specified in the *Guideline*. However, Part 51.166(l) also provides that on a case-by-case basis a modification or substitution of an air quality model may be used following written

approval. In addition, the use of a modified or substituted model is subject to notice and opportunity for public comment. The alternative model approval process and conditions are outlined in Section 3.2 of the *Guideline*. Section 3.2.2(a) specifies that the determination of acceptability of an alternative model is a Regional Office responsibility in consultation with EPA's Model Clearinghouse (MCH). An alternative model may be used subject to Regional Office approval if found to satisfy the requirements listed in Section 3.2.2. Section 3.2.2(b) states the alternative model shall be evaluated from both a theoretical and performance perspective before regulatory use and outlines the three separate conditions where an alternative model may be approved. Condition 2 under Section 3.2.2(b), where a statistical performance evaluation using measured air quality data and the results of that evaluation indicate that the alternative model performs better for the given application than a comparable model in appendix A, applies to this case.

a. **Evaluation of Approach under Section 3.2.2(d)**

An alternative model is evaluated from both a theoretical and a performance perspective before it is selected for use. The scientific justification provided above addresses the theoretical perspective. For this specific application, NYSDEC and Alcoa selected the model performance procedures for the second of three possible alternative model approaches (Appendix W section 3.2.2(b)(2)): "If a statistical performance evaluation has been conducted using measured air quality data and the results of that evaluation indicate the alternative model performs better for the given application than a comparable model in Appendix A"

Alcoa provided several statistical evaluations of the modified model performance. Evaluations of the top 25 observed and modeled concentrations were done comparing modeled wind speeds, mixing heights, and concentrations with observed values. Three sets of statistical evaluation tests were conducted: a) quantile-quantile (Q-Q) plots for each monitor, b) comparison of the modeled and observed 3-year average 1-hour average design concentration for each monitor, and c) the use of the Robust Highest Concentration (RHC) as part of EPA's Cox-Tikvart procedure. Each of the statistical tests showed improvement in model performance with the modified preprocessors.

As seen in Table 4-1 to Table 4-6 of the attached June 10, 2022 $SO_2$ Modeling Protocol, the AERMOD default wind speeds and mixing heights were considerably lower than the observed. Using a neutral lapse rated improved the model's wind speed and mixing height calculations which lead to better plume rise calculations and better correlations to measured concentrations.

The two QQ Plots below from Figure 4-5 and 4-6 of the June 10, 2022 Modeling Protocol illustrate the improved model performance when taking the modifications into account. A concentration closer to the 1:1 line indicates a better correlation with measured data. In this case, the modified model's maximum concentrations are closer to the 1:1 line with smaller overpredictions indicating that there is still a conservative bias.

Figure 4-5: Q-Q Plot For Site 1

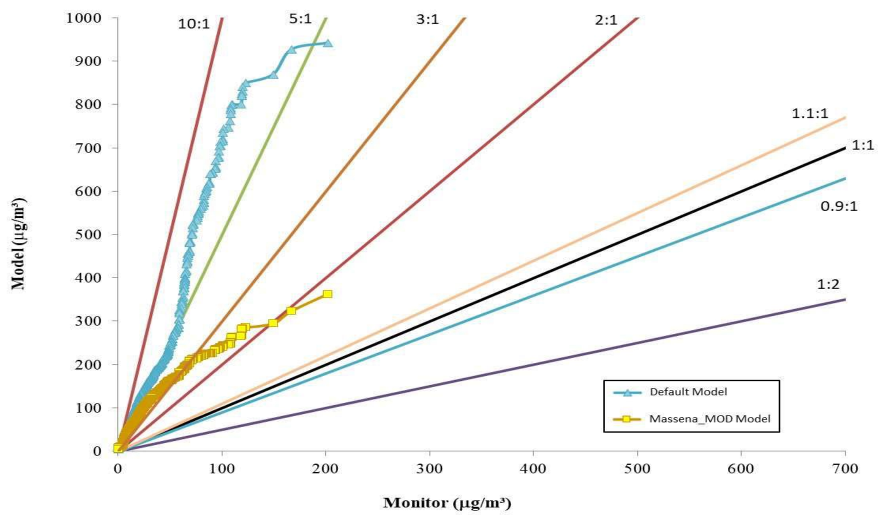
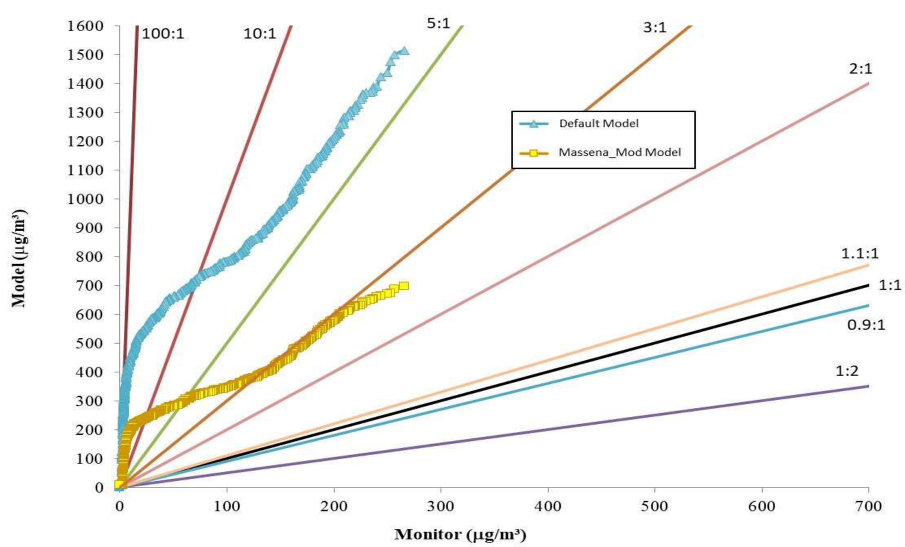



Figure 4-6: Q-Q Plot For Site 2




A separate model to observed 99th percentile design concentration was also provided. Again predicted/observed ratio closer to 1 indicates better performance when compared to measured values. These ratios were provided for both monitoring sites in Table 4-7 and 4-8 of the modeling protocol. In each case, the correlation was improved and positive which demonstrates better correlation with the 99th percentile design values with a conservative bias.

Table 4-7: Modeled-to-Observed Design Concentrations at Site 1

| Model Option | 4th Highest Design Concentration µg/m$^3$ | | | | |
|---|---|---|---|---|---|
| | 2017 | 2018 | 2019 | 3-yr Ave | |
| Observed | 118.69 | 106.61 | 110.20 | 111.83 | Pre/obs |
| Default Model | 829.74 | 800.66 | 655.64 | 762.01 | 6.81 |
| Massena_MOD Model | 264.73 | 266.58 | 215.88 | 249.06 | 2.23 |

Table 4-8: Modeled-to-Observed Design Concentrations at Site 2

| Model Option | 4th Highest Design Concentration µg/m$^3$ | | | | |
|---|---|---|---|---|---|
| | 2017 | 2018 | 2019 | 3-yr Ave | |
| Observed | 237.14 | 226.71 | 214.89 | 226.25 | Pre/obs |
| Default Model | 1372.59 | 1388.18 | 1103.08 | 1287.95 | 5.69 |
| Massena_MOD Model | 653.06 | 660.54 | 589.46 | 634.36 | 2.80 |

A third statistic was presented using the Robust High Concentration in Table 4-10 and 4-11 of the modeling protocol. The predicted to observed concentrations were improved at both monitoring sites with the modified model with a conservative bias as seen below.

Table 4-10: 3-Year Averaged Robust High Concentrations (□g/m3) for Monitor 1

| Model Option | RHC | Pre/Obs Ratio |
|---|---|---|
| Observed | 149.92 | - |
| Default Model | 1066.46 | 7.11 |
| MASSENA_MOD | 298.44 | 1.99 |

Table 4-11: 3-Year Averaged Robust High Concentrations (□g/m3) for Monitor 2

| Model Option | RHC | Pre/Obs Ratio |
|---|---|---|
| Observed | 268.47 | - |
| Default Model | 1463.09 | 5.45 |
| MASSENA_MOD | 750.09 | 2.79 |

**Conclusions and Conditions for Use**

The statistical evaluations above were done for the current stack configuration. The attainment strategy in this case is to physically merge and raise the stack heights within the GEP stack heights. Emissions will remain below 5000 tons per year and be federally enforceable. Region 2 believes that the alternative model approaches will continue to apply to the Alcoa Massena facility under the proposed attainment strategy for the same reasons as above and may be used for the modeled attainment demonstration. This is particularly true given that alternative approaches were evaluated against two site specific ambient measurements and the alternative approached showed improved performance.

EPA Region 2 has reviewed the alternative model request submittal provided by NYSDEC and has determined that the proposed modeling approach is acceptable for the attainment demonstration showing how the Alcoa Massena West facility plans to achieve attainment with the 2010 $SO_2$ NAAQS. Based on our review, we find that the proposed approach addresses the elements contained in Section 3.2.2(d) of the *Guideline*. As such, pursuant to Sections 3.0(b) and 3.2.2(a), Region 2 currently intends to approve the use of the two site-specific alternative modeling approaches in AERMOD. We seek the concurrence from the Model Clearinghouse.