UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

October 14, 2022

MEMORANDUM

SUBJECT: Model Clearinghouse review of the use of case-specific alternative approaches to demonstrate modeled attainment of the 2010 SO_2 NAAQS at the Alcoa West aluminum smelter in Massena, New York

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INTRODUCTION

The New York State Department of Environmental Conservation's (NYSDEC) formally submitted a request[1] to the U.S. Environmental Protection Agency (EPA) Region 2 on June 28, 2022, to use alternate modeling approaches to conduct its modeled attainment demonstration of the 1-hour Sulfur Dioxide (SO_2) National Ambient Air Quality Standard (NAAQS) for the Alcoa Massena West (hereafter, Alcoa Massena) aluminum smelter located in St. Lawrence County, New York. The modeled attainment demonstration is a required component for approval and incorporation into the NYSCEC's State Implementation Plan (SIP) with respect to the portion of St. Lawrence County that was designated as non-attainment through the Round 4 1-hour SO_2 NAAQS designation process.

The NYSDEC is requesting approval to use two case-specific alternative model approaches which modify inputs to the EPA preferred model, AERMOD (American Meteorological Society/Environmental Protection Agency Regulatory Model). Specifically, the two requested alternative model approaches include the (1) substitution of a neutral temperature lapse rate in the lower 100 meters of the atmosphere and (2) use the 2019 draft version of BPIPPRM

[1] https://gaftp.epa.gov/Air/aqmg/SCRAM/mchisrs/22-II-03_NYSDEC_Alcoa_Massena_Request_28jun22.pdf.

(Building Profile Input Program for PRIME, Plume Rise Model Enhancements)[2]. The NYSDEC is seeking alternative model approval under the under the *Guideline on Air Quality Models* (40 CFR Part 51, Appendix W, hereafter referred to as the *Guideline*) Section 3.2.2(b), Condition (2)[3].

As discussed in the EPA Region 2 Alternative Model Concurrence Request Memorandum[4], the Alcoa Massena aluminum smelter 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.

For more information regarding the NYSDEC's model attainment demonstration strategy and additional aspects of the Alcoa Massena facility, please reference the EPA Region 2 Alternative Model Concurrence Request Memorandum and the associated AECOM Modeling Protocol for Alcoa Massena Operations – West Plant[5]. The focus of the remainder of this Model Clearinghouse Alternative Model Concurrence Response Memorandum will focus on the two approaches being requested for alternative model approval.

REGIONAL OFFICE REVIEW

The EPA Region 2 Alternative Model Concurrence Request Memorandum nicely presents each of the two proposed alternative model approaches, "Neutral Lapse Rate" and "2019 Draft BPIPPRM," and provides sufficient review of the theoretical basis and supporting scientific justification for the use of these model approaches in the modeled attainment demonstration for the Alcoa Massena aluminum smelter. The Regional Office review of the alternative model approaches is supported by the fact that there are two site-specific SO_2 ambient monitors immediately nearby the facility that were installed by NYSDEC in 2017. These site-specific SO_2 ambient monitors were critical in statistically demonstrating that there is improved model performance with the alternative model approaches from the original preferred AERMOD modeling runs.

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[2] While BPIPPRM is not technically a regulatory portion of the AERMOD Modeling System and does not require alternative model approval by EPA, the transmittal memorandum associated with the release of the 2019 draft BPIPPRM does state that the draft version of BPIPPRM cannot be used in regulatory applications of AERMOD. Thus, any potential regulatory use of the 2019 draft BPIPPRM can only be done through coordination and consultation with the appropriate reviewing authority, EPA Regional Office, and the Model Clearinghouse.

[3] https://www.epa.gov/sites/production/files/2020-09/documents/appw_17.pdf.

[4] https://gaftp.epa.gov/Air/aqmg/SCRAM/mchisrs/22-II-03_Region2_MCHRequest_AlcoaMassena.pdf.

[5] https://gaftp.epa.gov/Air/aqmg/SCRAM/mchisrs/22-II-03_SO2_Modeling_Protocol_for_Alcoa_Massena_10jun22.pdf.

In its review, EPA Region 2 highlights the model performance procedures and results provided by NYSDEC and Alcoa based on the site-specific SO_2 ambient monitoring data. 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 these statistical tests showed improvement in model performance with the proposed alternative model approaches.

With an appropriate theoretical and scientific justification provided and thoroughly reviewed, EPA Region 2 finds that the proposed alternative model approaches adequately address the requirements of the *Guideline*, Section 3.2.2(b)(2) and Section 3.2.2(d). As such, pursuant to Sections 3.0(b) and 3.2.2(a) of the *Guideline*, EPA Region 2 intends to approve the alternative model approaches proposed for the modeled attainment demonstration for the Alcoa Massena aluminum smelter.

MODEL CLEARINGHOUSE REVIEW

Initial Modeling Context

The appropriate characterization and modeling of aluminum smelters emissions and assessment of the resulting pollutant impacts has been challenging for decades. These facilities are generally relatively single-tiered, elongated buildings that cover many acres of space and have elongated line emissions sources that emit from roof vents and potline stacks. To date, the majority of the field study and scientific research that has gone into regulatory dispersion models has been focused on facilities with tall stacks and more defined emissions sources. The Buoyant Line and Point Source (BLP) dispersion model was developed in the late 1970s to assist the regulatory modeling community with assessing facilities like smelters in the permitting process; however, the underlying scientific formulation that was the basis of the BLP model no longer represents the state-of-the-science in dispersion modeling. The BLP model was incorporated into the AERMOD Modeling System as the "BUOYLINE" option through a rule update[6] to the *Guideline* in 2017 but without any updates to its formulation. Thus, there remains constraints with the application of the "BUOYLINE" option in AERMOD.

Preliminary test modeling of the Alcoa Massena facility using the "BUOYLINE" option resulted in numerous concerns based on the irregular pattern of the projected pollutant impacts and a lack of acceptable model performance at the two site-specific SO_2 ambient monitors. Ultimately, a configuration of the 36 dry scrubber stacks in 3 merged groupings of 12 stacks along the potline building was decided for the modeled attainment demonstration.

Neutral Lapse Rate

Aluminum smelters can generate a significant amount of fugitive heat that can influence the plume rise behavior of the emissions from the facility by making them increasingly buoyant. For

[6] https://www.epa.gov/scram/2017-appendix-w-final-rule.

larger aluminum smelters, the fugitive heat loss can mimic that of a smaller urban area and create a localized heat island. AERMOD contains an urban source option ("URBANOPT") that accounts for the effects of an urban heat island, and this option has been appropriately used in the recent past to account for an industrial heat island in rural areas.

As noted in the EPA Region 2 Alternative Model Concurrence Request Memorandum, the Alcoa Massena facility has a smaller footprint than other aluminum facilities and measured fugitive temperature differences between the facility and the surrounding area were too small to justify the use of "URBANOPT" in AERMOD. Even though Alcoa Massena is to be modeled as a rural source, there still would be some localized influence of the fugitive heat releases from the facility on the emissions plumes. The lack of overall lower plume rise at critical times with the default application of AERMOD was identified as a likely contributor to a portion of the modeled overpredictions of pollutant impacts when compared to the two site-specific SO_2 ambient monitors.

To account for this localized fugitive heat release influence, NYSDEC and Alcoa propose to modify the vertical temperature lapse rate produced by AERMET in the lower 100 meters of the atmosphere. A neutral lapse rate of 0.0098 degree Celsius per kilometer, which corresponds to a dry adiabatic lapse rate, is used to modify the vertical temperate profile in the AERMET profile file. For each hour, the 10-meter temperature was retained, and a 100-m temperature was added to the profile file by subtracting 0.88 degrees Celsius from the 10-meter temperature. This modification does not impact the Monin-Obukhov stability value computed at each hour, which is recorded in the AERMET surface file, it will impact the plume rise calculations in AERMOD, which uses the vertical virtual potential temperature lapse rate computed from the temperature profile provided in the AERMET surface file. As a result, plume rise will be enhanced, as anticipated for this facility, but the stability and subsequent dispersion is not modified. During daytime conditions, the temperature lapse rate is not used in AERMOD. Thus, this alternative model approach only affected nighttime conditions.

The Model Clearinghouse agrees with EPA Region 2's review and assessment of the proposed modification to vertical temperature lapse rate in the lower 100 meters of the atmosphere. We find that the modification is reasonable given other factors in AERMOD's formulation, as highlighted by EPA Region 2. We also appreciate the additional citation of the Dr. Steven Hanna, February 6, 2022, option paper[7] regarding the Alcoa Massena facility that helps bolster this proposed alternative model approach.

The Model Clearinghouse shares the concern expressed by EPA Region 2 that modifying the vertical temperature lapse rate in the manner proposed would not be appropriate in a multisource modeling analysis where other nearby sources that are not subjected to the same effects of the fugitive heat release at a facility are included in the modeling domain. Fortunately, Alcoa Massena is the only facility being assessed in this modeled attainment demonstration.

[7] https://gaftp.epa.gov/Air/aqmg/SCRAM/mchisrs/22-II-03_Steven_Hanna_Opinion_Paper.pdf.

2019 Draft BPIPPRM

In 2019, EPA released a revised draft version of the BPIPPRM preprocessor for the AERMOD Modeling System[8]. The 2019 draft BPIPPRM provided updates to the 2004 version of BPIPPRM by adjusting the effective building dimensions for a rectangular building oriented at an angle to the wind to better match the actual dimensions of the building. These updates were based on wind tunnel studies performed with single tiered, long narrow buildings. The 2004 version of BPIPPRM may overestimate the length or width of a building when a long narrow building is present, which could misrepresent the amount of downwash that occurs.

In the case of the Alcoa Massena facility, only the building dimension inputs will be altered based on the 2019 draft BPIPPRM. There will not be any changes to the downwash algorithm or other aspects of the AERMOD model formulation. Given that the impact of the recent revisions in BPIPPRM would be particularly important for the downwash assessment for long narrow buildings such as the Alcoa Massena facility, the Model Clearinghouse agrees with EPA Region 2 that the 2019 draft BPIPPRM is a reasonable consideration for this case-specific application in the modeled attainment demonstration. However, any potential future regulatory use of the 2019 draft BPIPPRM should only be done after coordination and consultation with the appropriate reviewing authority, EPA Regional Office, and the Model Clearinghouse.

Alternative Model Performance Evaluation

The model performance evaluation of the alternative neutral lapse rate approach and the use of the 2019 draft BPIPPRM based a comparison with observed data from the two site-specific SO_2 ambient monitors forms the essential basis for the necessary alternative model justification for the modeled attainment demonstration of the Alcoa Massena aluminum smelter. As presented in the three sets of model performance statistical evaluations in the EPA Region 2 Alternative Model Concurrence Request Memorandum, each of the statistical metrics presented demonstrated improved model performance of the proposed alternative model approaches over that of the default application of the preferred model, AERMOD. The results of the model performance evaluation are consistent with the requirements of the *Guideline*, Section 3.2.2(b)(2) and Section 3.2.2(d). Therefore, the Model Clearinghouse agrees with EPA Region 2 that the proposed alternative model approaches are approvable for the case-specific situation outlined in the NYSDEC, June 28, 2022, request.

CONCURRENCE SUMMARY

The Model Clearinghouse fully concurs with EPA Region 2's proposed approval of the two alternative model approaches, Neutral Lapse Rate and 2019 Draft BPIPPRM, for use by NYSDEC in its modeled attainment demonstration of the 1-hour SO_2 NAAQS for the Alcoa Massena aluminum smelter located in St. Lawrence County, New York. The EPA Region 2 review and the NYSDEC and Alcoa documentation provide a sufficient theoretical basis and supporting scientific justification for the use of these alternative model approaches. This Model

[8] https://www.epa.gov/scram/air-quality-dispersion-modeling-related-model-support-programs#drft-bpipprm.

Clearinghouse concurrence and the EPA Region 2 alternative model approval for these two alternative model approaches should be considered case-specific and any further regulatory application of these alternative model approaches would require further review and approval per the requirements of the *Guideline*, Section 3.2.

The Model Clearinghouse encourages EPA Region 2 to respond to NYSDEC and to the docket for federal actions related to the associated SIP revision with a letter of alternative model approval, as appropriate. The information associated with the EPA Region 2 alternative model approval and the Model Clearinghouse concurrence should be available for comment during the appropriate public comment period(s).

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