UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

OCT 24 2011

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

MEMORANDUM

SUBJECT: Model Clearinghouse Review of Equivalent Building Dimensions for AERMOD

FROM: George Bridgers, Model Clearinghouse Director
Air Quality Modeling Group, C439-01

TO: Michael Jay, Chief
Atmospheric Programs Section, EPA Region 7

Richard Daye, Regional Meteorologist
Atmospheric Programs Section, EPA Region 7

INTRODUCTION

In response to your Model Clearinghouse request memorandum of June 23, 2011, the Model Clearinghouse has reviewed Region 7's position on the proposed use of equivalent building dimensions (EBDs) derived from a wind tunnel fluid modeling study for the Alcoa Davenport Works facility located in Davenport, IA. The proposed EBDs would be used in place of building parameters derived from the Building Profile Input Program for PRIME (BPIPPRM) building processor as input to the AERMOD dispersion model to inform the PRIME building downwash algorithms incorporated in AERMOD. The wind tunnel study for Alcoa Davenport Works had been undertaken due to concerns regarding the limitations of the PRIME downwash algorithms to account for downwash influences associated with buildings with large aspect ratios of building width (W) and/or length (L) divided by building height (H), such as the Alcoa facility, which are well beyond the range of aspect ratios used in the development and evaluation of the PRIME algorithms.

As noted in your memo, the use of a wind tunnel fluid modeling study to determine equivalent building parameters to replace actual parameters from a complex building area presents many technical challenges, and these challenges have increased with the promulgation of the AERMOD dispersion model with the PRIME downwash algorithms as compared to earlier wind tunnel studies conducted for use with the ISC dispersion model. Due to concerns regarding some of the technical issues associated with this application, most notably the inclusion of additional surface roughness elements to account for the surface roughness of the actual facility for the tests conducted to demonstrate the equivalency of the EBDs, Region 7 proposes to disapprove the use of EBDs derived from the referenced wind tunnel study for use in place of BPIPPRM-derived building parameters in AERMOD for this application.

MODEL CLEARINGHOUSE RESPONSE

We concur with Region 7's position that insufficient technical justification has been provided to support the use of the EBD parameters determined in the wind tunnel study for Alcoa Davenport Works in place of BPIPPRM-derived building parameters in AERMOD. We also agree that one of the most significant flaws with the design of the Alcoa Davenport wind tunnel study was the practice of including additional roughness elements to simulate the surface roughness of the actual facility along with the EBD structure for those tests intended to demonstrate that the downwash effect of the EBD structure is "equivalent" to the downwash effect of the actual facility, especially given the fact that the additional roughness elements appear to be larger than the EBD structure in some cases, as shown in Figures 16(d) and 16(e) of Attachment A (CPP, 2009). We believe that this approach compromises the conclusions from the study since it is impossible to determine the extent to which the "equivalency" of the single EBD structure is due to the influence of the EBD structure itself, the additional roughness elements intended to simulate the roughness of the actual facility, or both.

We also agree with Region 7's assessment that additional technical challenges with this approach to determining alternative building parameters have been introduced with the promulgation of the AERMOD model, with PRIME downwash algorithms, replacing ISCST3 as the preferred near-field dispersion model under the EPA's "Guideline on Air Quality Models," published as Appendix W to 40 CFR Part 51. One of the key enhancements of the PRIME downwash algorithms compared to the Huber-Snyder and Schulman-Scire algorithms incorporated in the ISCST3 model is the ability of the model to account for the location of the stack in relation to the controlling structure. The PRIME algorithm also simulates the 3-dimensional structure of the building wake, including the near-wake or cavity region immediately downwind of the structure, and the far wake region beyond the cavity. The magnitude and character of the downwash influence can be significantly influenced by the relative stack-building geometry reflected in the additional building parameters provided by the BPIPPRM program, as compared to the original BPIP program developed for ISCST3. These enhancements associated with the PRIME downwash algorithms raise serious concerns regarding the standard practice used in past EBD wind tunnel studies of locating the stack on the downwind edge of the EBD structure, regardless of the actual stack-building geometry.

Given the potential importance of the additional technical challenges introduced with the promulgation of AERMOD and the fact that the most recent guidance from the EPA Model Clearinghouse on the use of EBDs dates from 1994 (EPA, 1994), we also feel that it is imperative to reassess the past guidance and practices more broadly to ensure that future studies provide a viable basis for determining equivalent building parameters that are appropriate for use with the AERMOD model. <u>Therefore, all past EPA guidance related to determining EBDs through wind tunnel modeling is hereby suspended until further notice.</u> Please note that this should not be taken to imply that all such studies will be summarily rejected until the process of reassessing the guidance has been completed, but rather to indicate that any EBD studies being considered should be discussed with the appropriate reviewing authority as early in the process as possible and that the Model Clearinghouse should also be engaged as early as possible. In fact, we anticipate that such studies may provide important opportunities to work through many of these issues in the context of specific proposed applications. We also note that the 1994 memo on EBDs clearly acknowledges the evolving nature of the guidance, stating for example that "[w]e anticipate clarification of this issue as more cases are examined" and that "[i]t is anticipated that these criteria will become more refined as more cases are examined."

While we concur with Region 7's disapproval of the use of EBDs derived from the wind tunnel study as an alternative to BPIPPRM-derived parameters for this application, we do acknowledge the limitations of the wind tunnel and other field study data on which the PRIME downwash algorithms were developed and evaluated, and that there are legitimate concerns regarding the appropriateness of building parameters derived from BPIPPRM for some cases. We shared some of these potential concerns at the 9th Modeling Conference in October 2008 (EPA, 2008), including concerns regarding the basic criterion in BPIPPRM (inherited from the original BPIP program) for selecting the dominant structure and concern regarding treatment of the source/building/wake geometry for long narrow buildings with winds oriented diagonally to the building orientation. We also expressed concern at the 9th Modeling Conference regarding the need to reassess the appropriateness of the standard procedures and guidance related to EBDs derived from wind tunnel studies in relation to the PRIME downwash algorithms.

DISCUSSION OF TECHNICAL ISSUES

This section provides a more detailed discussion of some of the technical issues associated with the Region 7 Model Clearinghouse request. We hope that this discussion will provide better clarity to some of the key technical issues on which this Model Clearinghouse response was based and also provide some insight that may assist in determining appropriate alternatives to the proposed EBDs. As noted in past Model Clearinghouse guidance on the use of EBDs in dispersion models, the wind tunnel demonstration has been used to develop appropriate building dimensions for input to the dispersion model, and is not intended to replace the ambient air quality modeling based on an EPA-preferred air quality model. As such, these analyses have been viewed as source characterization studies which are generally under the purview of the Regional Office, and are not subject to the requirements under Section 3.2 of Appendix W on the use of alternative models.

This Model Clearinghouse response does not change the assessment of these wind tunnel EBD studies as source characterization studies. It also suggests that other alternatives to the use of BPIPPRM-derived building parameters to inform the downwash algorithms within the model may be considered on a case-by-case basis. It may also be appropriate in some cases to utilize a hybrid approach involving the use of BPIPPRM-derived building parameters for some sources and an alternative approach for other sources, with adequate justification. Similarly, it may be appropriate for a given source to use BPIPPRM for some wind direction sectors and an alternative approach for other sectors, with justification.

Attachment B provides a summary of AERMOD modeling that was conducted as part of our assessment of the Region 7 Model Clearinghouse request. This assessment examined the following two cases: 1) source S349 with winds from 240 degrees, a fetch straddling the river bank, simulated in the wind tunnel with a surface roughness length (z_0) of 0.084m; and 2) source S289 with winds from 150 degrees, an overwater fetch also simulated in the wind tunnel with z_0=0.084m. The 240-degree fetch is parallel to the long axis of the plant orientation from SW to NE, and the 150-degree fetch is perpendicular to the long axis. Meteorological parameters were selected for input to AERMOD to approximate the conditions simulated in the wind tunnel.

Note that the modeling results presented in Attachment B are only intended to provide a very general assessment of some of the issues of concern, and therefore the modeling results presented should only be viewed in a general sense. Given the number of issues and challenges associated with defining appropriate source and meteorological inputs for AERMOD that would replicate the conditions simulated in the wind tunnel, we would not expect the AERMOD-modeled results to precisely match results reported from the wind tunnel study. However, the AERMOD-modeled results presented in Attachment B do provide some indication of the potential influence of the derived EBD structure on modeled concentrations both with and without the additional roughness elements intended to account for the roughness of the actual facility, and we believe that the results do support our concerns regarding the potential influence of these roughness elements included in the tests intended to demonstrate equivalence of the proposed EBD. In both of the cases studied, these tests show that the EBDs derived from the wind tunnel study had no influence on the sources when modeled explicitly in AERMOD and significantly underestimate concentrations as compared to the reported wind tunnel results for the actual facility and as compared to wind tunnel results reported for the EBD structure. On the other hand, when the meteorological conditions were adjusted to reflect the increased roughness introduced in the wind tunnel study to account for roughness associated with the actual facility, the modeled concentrations for the derived EBDs show much better agreement with the wind tunnel results, especially for source S349. These results suggest that the additional roughness elements introduced in the wind tunnel tests may have influenced the plume dispersion more than the EBD structure by itself.

The modeling results shown in Attachment B for S349 and S289 also indicate that the use of BPIPPRM-derived building parameters may not always lead to overly conservative results for this facility. For source S349, the modeling results based on BPIPPRM inputs were about 20-25% higher than wind tunnel results for the actual facility, whereas as the BPIPPRM results for source S289 were about 20-25% lower than results for the actual facility. The attached modeling assessment also examined an alternative approach for determining appropriate building parameters for these two sources that attempts to account for some general aspects of how the flow across this sprawling structure would be affected by the long fetch across the building and focuses on the portions of the building that would be expected to influence the sources the most. The results from this alternative approach show generally good agreement with the wind tunnel results for the actual facility, but we stress that these results are very limited in scope and should not be interpreted too literally.

REFERENCES

CPP, 2009. Wind Tunnel Modeling to Determine Equivalent Building Dimensions for Alcoa Davenport Works. Report prepared for Alcoa, Inc, dated January 2009. CPP, Inc., Fort Collins, CO
(Available as Attachment A to this Model Clearinghouse Response)

EPA, 1994. Wind Tunnel Modeling Demonstration to Determine Equivalent Building Dimensions for the Cape Industries Facility, Wilmington, North Carolina. Joseph A. Tikvart Memorandum, dated July 25, 1994. U.S. Environmental Protection Agency, Research Triangle Park, NC
(Available @ http://cfpub.epa.gov/oarweb/MCHISRS/index.cfm?fuseaction=main.resultdetails&recnum=94-IV%20%20-09)

EPA, 2008. BPIP/PRIME Workgroup, presented at EPA's 9th Modeling Conference, October 9, 2008, Research Triangle Park, NC
(Available @ http://www.epa.gov/ttn/scram/9thmodconf/9thmc_bpip-prime_workgroup.pdf).

Attachments (2)

cc: Richard Wayland, C304-02
Anna Wood, C504-01
Tyler Fox, C439-01
Raj Rao, C504-01
Roger Brode, C439-01
EPA Air Program Managers
EPA Regional Modeling Contacts