UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

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OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

MEMORANDUM

SUBJECT: Release of BPIPPRM, Version 19191_DRFT, for Public Review and Comment

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TO: EPA Regional Dispersion Modeling Contacts

The United States Environmental Protection Agency (EPA), Office of Air Quality Planning and Standards (OAQPS) is releasing a draft version (19191_DRFT) of the Building Profile Input Program for PRIME (BPIPPRM) preprocessor for informal public review, testing, and comment. This memorandum provides information on this draft release including the intended purpose of this version of BPIPPRM, the nature of the updates, and details on providing informal public comments.

Background and Status of BPIPPRM

In 2005, the EPA promulgated the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) as the preferred near-field dispersion model for regulatory applications in the *Guideline on Air Quality Models* (Appendix W to 40 CFR Part 51), replacing the Industrial Source Complex (ISC) model. Incorporated into AERMOD was the Plume Rise Model Enhancements (PRIME) model (Schulman et al., 2000) to account for building downwash effects when the air flow encounters a building in its path. PRIME included enhanced plume dispersion coefficients for the turbulent wake and reduced plume rise caused by a combination of the descending streamlines in the lee of the building and the increased entrainment in the building wake. BPIPPRM was originally adapted from the Building Profile Input Program (BPIP), the building preprocessor for the ISC model, with the addition of parameters required by the PRIME algorithm, including the along-flow effective length of the building (BUILDLEN), the along-flow distance from the stack location to the center of the upwind face of the projected building (XADJ), and the across-flow distance from the stack location to the center of the upwind face of the projected building (YADJ). BPIP only calculated the across-flow building width (BUILDWID) and the building height (BUILDHGT), as required by the ISC model. Both BPIP and BPIPPRM process the building input data to determine these parameters for 36 wind directions at 10-degree intervals.

Analyses have shown AERMOD to both overpredict and underpredict ground-level concentrations in the building wake, depending on the building dimensions, stack height, stack location, and the orientation of the building relative to the wind direction. Overprediction and underprediction have been demonstrated for single, one-tiered rectangular buildings, specifically, elongated buildings that are oriented at an angle, rather than perpendicular, to the wind (Perry et al., 2016; Petersen et al., 2017).

Recently, the EPA has collaborated on two separate research initiatives to improve AERMOD's performance for point emission sources that are subject to building downwash. One was led by the EPA's Office of Research and Development (ORD). The ORD has performed wind tunnel experiments and embedded large eddy simulations (LES) to better understand how to parameterize buildings that are elongated and angled relative to the wind flow and the parameterization of the plume in the cavity and far wake regions. The ORD studies are concentrated on single rectangular buildings, specifically investigating changes in plume parameters at discrete downwind distances from the building and source, longitudinal and lateral plume profiles, the lateral plume shift on the lee side of rotated buildings, and building characterization in BPIPPRM (Heist et al., 2016). This research has led to recommended changes to the formulation of the PRIME building downwash algorithm in AERMOD, as well as changes to the building preprocessor, BPIPPRM (Monbureau et al., 2018).

A second initiative was led by the PRIME2 Advisory Subcommittee (PRIME2) within the Air and Waste Management Association's (AWMA) Atmospheric Modeling and Meteorology (APM) Committee. This effort involved the collaboration of technical experts, industry groups, and representatives from the regulatory agencies with the purpose of (1) providing a technical review forum to improve the PRIME building downwash algorithms in AERMOD; and (2) establishing a mechanism to review, approve, and implement new science into the model. AWMA's research has included the reanalysis of existing wind tunnel data, as well as the completion of new wind tunnel experiments to investigate the decay of the building wake above the top of the building, appropriate height at which approach turbulence and wind speed are calculated, the reduction of wake effects for streamlined structures, and the effect of approach roughness on the wake. Their analyses have led to recommendations for new turbulence enhancement and velocity deficit equations that address these aspects (Petersen and Guerra, 2018).

Based on the findings of these two research efforts and the recommendations of the researchers, several options have been implemented in AERMOD version 19191 that affect the formulation of the PRIME algorithm. These options have been made available to the user community as ALPHA options for testing, review, and comment only and should not be used for applications of AERMOD in a regulatory context. Refer to the updated AERMOD User's Guide, dated August 2019, for more information on these ALPHA options related to building downwash.

In addition to the AERMOD ALPHA options recommended by the ORD and AWMA, the ORD also recommended changes to BPIPPRM that affect the how the effective building dimensions are determined for a rectangular building that is oriented at an angle to the wind flow. The recommended updates to PRIME in AERMOD and test results, published by the ORD, include these modifications to BPIPPRM. The AWMA used a similar but manual approach, apart from BPIPPRM, to adjust the effective building dimensions for a rectangular building oriented at an angle to the wind. While this draft version of BPIPPRM can and should be tested and evaluated independently of the new ALPHA options that have been implemented in AERMOD, it is being released simultaneously with AERMOD version 19191 primarily to facilitate the testing and evaluation of these new building downwash ALPHA options. Just as the building downwash ALPHA options in AERMOD cannot be used in a regulatory context, this draft version of BPIPPRM be cannot be used in a regulatory application of AERMOD.

Updates Included in this Draft Version of BPIPPRM

Based on a wind tunnel study of elongated buildings (Perry et al., 2016), the ORD recommended a modification to BPIPPRM's effective along-flow length when winds are not directly incident on the face of the building. The PRIME algorithm assumes the upwind building face is always perpendicular to the wind flow. To meet this criterion for PRIME, BPIPPRM determines an effective along-flow building length and an effective cross-flow building width for the same building rotated such that the upwind building face is perpendicular to the wind. The current version of BPIPPRM (04274) sets the effective along-flow building length and effective cross-flow building width as the distance between the original longitudinal and lateral boundaries of the building vertices based on the original building orientation, prior to rotating the building perpendicular to the wind. For an elongated building with a large incident angle, the effective building dimensions represent a much larger building footprint relative to the actual building footprint, which may overstate the effects of the building influence on air flow and subsequently, modeled concentrations.

In this draft version of BPIPPRM, for rectangular buildings (and rectangular tiers) only, the along flow effective building length is set as the actual distance a parcel travels across the building that is angled to the wind. This reduces the effective building length which consequently, reduces the size of the near-wake recirculation region. Figure 1 from Monbureau et al. (2018), illustrates the original building (light gray lines) at 15°, 30°, 45°, and 60° relative to the wind blowing from the west to the east and the effective, rotated building (dotted lines) prior

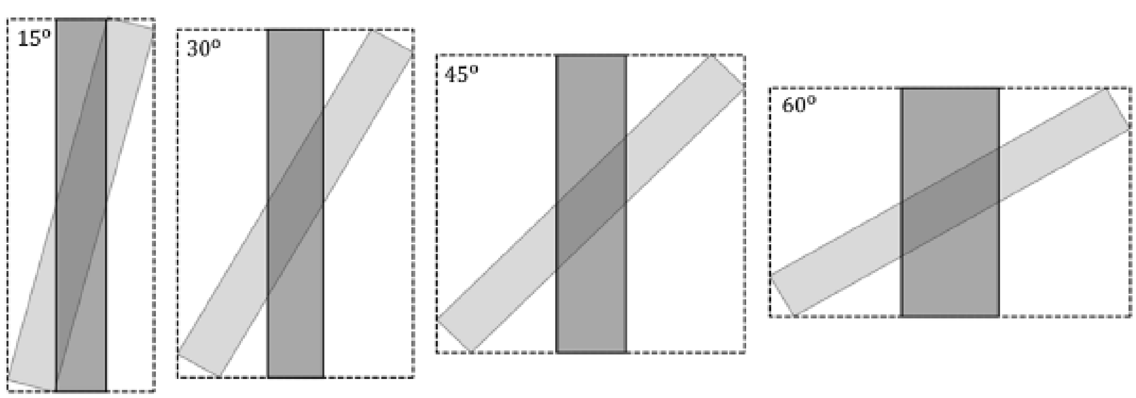

Figure 1. Actual Building (light gray) Compared to Projected Building using the BPIPPRM Version 04727 (dotted line) vs 19191_DRFT (dark gray). (Monbureau et al., 2018).

to updating BPIPPRM. The dark gray lines illustrate the effective building based on this draft version BPIPPRM (19191_DRFT).

This change in the along-flow effective building length subsequently required a change to the computation to relocate the stack based on the degree of building rotation to determine the along-flow and cross-flow distances between the stack and the center of the upwind face of the effective building for rectangular buildings and tiers only.

User Input and Running this Draft Version of BPIPPRM

The updates in the draft version of BPIPPRM (19191_DRFT) do not require any additional user input parameters and the program can be executed on the command-line within a Microsoft Windows command window, consistent with the current version of BPIPPRM (04274). Refer to the existing BPIP and BPIPPRM User's Guides on the EPA's Support Center for Regulatory Atmospheric Modeling (SCRAM) website for information on setting up and running BPIPPRM at https://www.epa.gov/scram/air-quality-dispersion-modeling-related-model-support-programs.

Limitations of this Draft Version of BPIPPRM

The updates in this draft version of BPIPPRM apply only to rectangular buildings and rectangular building tiers. The program performs a check on the building or individual tier vertices. For updates to BPIPPRM to apply, there must be only be four vertices and the opposing sides must be parallel. For a building or tier that is found not to be rectangular, this draft version will use the methods for determining the effective along-flow length and flow distance parameters in the same way they are determined in version 04274.

This draft version of BPIPPRM has been tested on a limited set of simple building configurations, i.e., single tiered, rectangular buildings. Complex, multi-tiered buildings or sites with multiple sources and complex building configurations have not been tested or evaluated.

Use of this Draft Version of BPIPPRM

The EPA is releasing this draft BPIPPRM version 19191_DRFT simultaneously with AERMOD version 19191 to facilitate testing and evaluation by the user community of the new building downwash ALPHA options in AERMOD. As previously stated, this draft version of BPIPPRM is not a replacement of BPIPPRM version 04274 and cannot be used with AERMOD in a regulatory context. Testing and evaluation has been limited to simple single-tiered rectangular buildings with a small set of aspect ratios, stack configurations, and stack locations. The consequences of using this draft version of BPIPPRM for more varied building and stack configurations is not fully known.

User Feedback Requested

Feedback from the scientific and user communities is critical to inform the EPA for continued development and refinement, prior to adopting updates that will become options that can be used in a regulatory context. The EPA is requesting feedback on the updates in this draft version of BPIPPRM, as well as the ALPHA downwash options in AERMOD version 19191 from the scientific and user communities including academia, private researchers, industry consultants and advocates, and State/Local/Tribal government agencies by November 4, 2019.

Please send questions and provide feedback to Clint Tillerson through email at tillerson.clint@epa.gov.

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