<u>Indian Point Nuclear Generating Units 2 and 3</u>
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NRC Staff's Response in Opposition to State of New York's Motion for Partial Summary Disposition of NYS Contention 16/16A

Exhibit R

AERMOD: A Dispersion Model for Industrial Source Applications. Part II: Model Performance against 17 Field Study Databases

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ABSTRACT

The performance of the American Meteorological Society (AMS) and U.S. Environmental Protection Agency (EPA) Regulatory Model (AERMOD) Improvement Committee's applied air dispersion model against 17 field study databases is described. AERMOD is a steady-state plume model with significant improvements over commonly applied regulatory models. The databases are characterized, and the performance measures are described. Emphasis is placed on statistics that demonstrate the model's abilities to reproduce the upper end of the concentration distribution. This is most important for applied regulatory modeling. The field measurements are characterized by flat and complex terrain, urban and rural conditions, and elevated and surface releases with and without building wake effects. As is indicated by comparisons of modeled and observed concentration distributions, with few exceptions AERMOD's performance is superior to that of the other applied models tested. This is the second of two articles, with the first describing the model formulations.

1. Introduction

In 1991, the U.S. Environmental Protection Agency (EPA) in conjunction with the American Meteorological Society (AMS) formed the AMS and EPA Regulatory Model (AERMOD) Improvement Committee (AERMIC) with the expressed purpose of incorporating the current understanding of the planetary boundary layer (PBL) into a state-of-the-art applied dispersion model, AERMOD.

AERMIC's work clearly has benefited from the model development activities worldwide over the past few decades, especially in the parameterization of mean winds and PBL turbulence, dispersion in the CBL, the treatment of plume/terrain interactions, plume–building interactions, and urban dispersion.

AERMOD (Cimorelli et al. 2003) is a steady-state plume model aimed at short-range (up to 50 km) dispersion from stationary industrial-type sources—the same scenarios that are currently handled by the EPA's Industrial Source Complex Short-Term model (ISCST3) (U.S. Environmental Protection Agency 1995). The meteorological conditions are assumed to be steady during the modeling period (typically 1 h) and horizontally homogeneous. Vertical variations in the PBL, however, are incorporated into the model's predictions. For flow in complex terrain AERMOD incorporates the concept of a dividing streamline (Snyder et al. 1985). The model considers the influence of building wakes on plume rise and dispersion using the algorithms of the Plume Rise Model Enhancements (PRIME) model (Schulman et al. 2000). In urban areas, AERMOD accounts for the dispersive nature of the "convective like" boundary layer that forms during nighttime conditions by enhancing the turbulence resulting from urban heat flux (Oke 1978, 1982).

This paper is the second of two describing the newly developed AERMOD modeling system. Cimorelli et al. (2005, hereinafter Part I) describe the model formula-

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TABLE 1. Description of field studies (without building wake effects).

Database	Description of field study
Prairie Grass (SO_2)	Very flat, rural (Nebraska); nonbuoyant single-point source; 0.46-m release; 44 data hours; SO_2 samplers in arcs out to 800 m; 16-m meteorological tower (wind, turbulence, and temperature data); Barad (1958) and Haugen (1959).
Kincaid (SF_6)	Flat, rural (Illinois), highly buoyant single source; tall stack release (187 m); 375 data hours; SF_6 samplers in arcs out to 50 km; 100-m tower (wind, turbulence, and temperature); Liu and Moore (1984) and Bowne et al. (1983).
Indianapolis (SF_6)	Flat, urban (Indiana), highly buoyant release (84 m); 170 data hours; SF_6 samplers in arcs out to 12 km; Urban tower (94 m); 10-m suburban and rural towers (wind, turbulence, and temperature); Murray and Bowne (1988).
Kincaid (SO_2)	Flat, rural (Illinois), highly buoyant single source; tall stack release (187 m); 4614 data hours; 30 samplers out to 20 km; 100-m tower (wind, turbulence, and temperature); Liu and Moore (1984) and Bowne et al. (1983).
Lovett (SO_2)	Hilly, rural (New York), highly buoyant release (145 m); 12 monitors out to 3 km; 1 yr of data; 100-m (wind, turbulence, and temperature); Paumier et al. (1992).
Baldwin (SO_2)	Flat, rural (Illinois); three highly buoyant stacks (184 m); 10 fixed samplers out to 10 km; 1 yr of data; 100-m (wind and temperature data); Hanna and Chang (1993).
Clifty Creek (SO_2)	Moderately hilly, rural (Indiana); three highly buoyant stacks (each 208 m); six fixed samplers out to 15 km; 1 yr of data; 60-m tower on nearby plateau, 115 m above stack base (wind and temperature data).
Martins Creek (SO_2)	Hilly, rural (Pennsylvania); multiple highly buoyant releases (122–183 m); 1 yr of data; seven fixed samplers out to 8 km; 10-m tower plus sodar (wind, turbulence, and temperature data).
Westvaco (SO_2)	Hilly, rural (Maryland); highly buoyant stack (183 m); 11 fixed samplers out to 3 km; 1 yr of data; two 30-m towers; 100-m tower (wind, turbulence, and temperature data); Strimaitis et al. (1987).
Tracy (SF_6)	Mountainous, rural (Nevada); moderately buoyant stack (91 m); 128 h of data; SF_6 samplers out to 8 km; 150-m tower (wind, turbulence and temperature data); tethersonde temperatures; acoustic sounder; DiCristofaro et al. (1985).

tion, while this paper provides an overview of the model's performance against the concentration observations at 17 field study databases. The studies include sites with flat and complex terrain, urban and rural conditions, and elevated and surface releases with and without building wake effects. The evaluation measures are focused on those that are relevant to regulatory applications, that is, emphasis on ability of the model to simulate the upper end of the concentration distributions. AERMOD estimates have been compared with those of other applied models, including ISCST3 (U.S. Environmental Protection Agency 1995), the Hybrid Plume Dispersion Model (HPDM) (Hanna and Paine 1989), the Rough Terrain Diffusion Model (RTDM) (Paine and Egan 1987), and the Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations (CTDMPLUS) (Perry 1992).

2. Model evaluation field studies

Of the 17 databases that were considered, 10 were designed to collect data for overall model performance where building wakes were not an issue, while the remaining 7 were specifically focused on building influences. The studies are summarized in Tables 1 and 2. Maps of the various sites can be found in Paine et al. (1998, 2003). The first five databases listed in Table 1 were used during the AERMOD development process to identify major problems with the model algorithms but generally were not used to set empirical parameters to improve the model results. An exception is found with the use of the Prairie Grass Experiment data to specifically develop the formulation for the lateral dispersion parameter. The remaining five databases were independently applied to the developed model code. The first four building wake databases in Table 2 were each subdivided to provide data for both model development and evaluation of the PRIME building downwash algorithms. However, all of the data from the seven building wake databases were used in the performance results described in this paper.

3. Performance measures

Although the model evaluation examined the quality of the predictions relative to the model physics, the results reported here are focused primarily on answering the questions: how well does AERMOD predict the high-end, ground-level concentrations that are generally used to assess compliance with air quality regulations; and is AERMOD's performance distinguishably better than that of other applied models for this purpose? To answer these questions the analyses of the model's performance utilized all of the relevant input data that are available with each dataset. The performances of earlier versions of AERMOD were examined with reductions in the number of height levels in the measured profiles of PBL variables (e.g., wind, temperature). Paine (2003) found that the performance of the model tended to degrade as more and more levels of data were removed from the analysis. In general, the model predictions tended toward higher concentrations and, thus, provided more conservative results when compared to the observed concentrations.

In the absence of model formulation errors and stochastic variations, the major reasons for deviations between model estimates and observations are errors in the model inputs, and the concentration observations

This served to highlight the sensitivity of dispersion to local meteorological behavior and the geometry of the building wakes and cavities. Overall, the model found the representative high-end concentrations (i.e., RHC) within a factor of 2 or better. Although it seems rather obvious, the results here strongly suggest that specification of the cavity extent and plume material height and spread (near the building) is critical to appropriately simulating the downwash effect.

AERMOD (Part I) represents many formulation improvements over commonly applied regulatory models such as ISCST3. In model-to-model comparisons, AERMOD's performance is clearly superior to that of ISCST3. Models such as HPDM and CTDMPLUS perform similarly to AERMOD in the selected circumstances for which these models were designed. This is not surprising because many of the formulations of AERMOD are based, to some extent, on earlier work by others in developing these and other models.

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