Summary Evaluation of the Golden Valley Electric Association
Proposal for Use of the ISC-PRIME Model
Robert B. Wilson
U.S. Environmental Protection Agency, Region 10
April 29, 1998

Introduction

In a letter dated February 4, 1998, the Alaska Department of Environmental Conservation (ADEC) requested EPA Region 10 approval of the use of a model, 1SC-PRIME, which is not currently recommended a EPA's Guideline on Air Quality Models (40 CFR 51, Appendix W. The Golden Valley Electric Association has employed the ISC-PRIME model in its request to ADEC for a revision to its operating permit for its power plant in Healy, Alaska. Specifically, GVEA is seeking higher limits on the short-term emissions of sulfur dioxide (SO2) from Unit I of the Healy Power Plant. The use of the ISC-PRIME model, in lieu of the EPA recommended ISCST3 model, indicates that additional amounts of S02 can be emitted from the Healy Unit I stack without causing exceedances of the National Ambient Air Quality Standards.

The ISC-PRIME model was developed by the Electric Power Research Institute (EPRI) and its contractors over the past approximately four years. GVEA has been one of several sponsors of this effort. EPRI and its contractors have compared the ISC-PRIME model to EPA's ISC3 model, and evaluated the performance of the two models against observed concentrations. The technical reports of EPRI's form the basis for GVEA's requested approval of the use of the ISC-PRIME model.

This submittal of ISC-PRIME to EPA Region 10 is the first time the model has been considered for approval In a regulatory action. EPA Region 10's evaluation of GVEA's submittal is presented below. EPRI has subsequently submitted the ISC-PRIME model to EPA's Office of Air Quality Planning and Standards (OAQPS), requesting that ISC-PRIME be listed as a generically recommended model in EPA's Guideline on Mr Quality Models. If appropriate,

OAQPS will formally propose ISC-PRIME for Guideline status later this year.
Documents Reviewed
I) "Air Quality Construction Permit Application," submitted to
Alaska Department of Environmental Conservation, Air Quality Control Permit to Operate, No 9431-AAOOI, for the Healy Power Plant, submitted from Golden Valley Electric
Association, Inc., Fairbanks, Alaska, December 24, 1997, which includes:
a) Cover letter from Kathryn Lamal, GVEA, to John Stone, ADEC,
dated December 24, 1997.
b) "Air Quality Dispersion Modeling Report to Support Request for Modification of Air Quality
Control Permit to Operate No. 9431-AAOO1 for the Golden Valley Electric Association, Inc
Healy Power Plant, submitted to the ADEC, prepared for Alaska Industrial Development and
Export Authority and GVEA, prepared by RTP Environmental Associates, Inc., Boulder,
Colorado, and Steigers Corporation, Englewood, Colorado, December 1997.
c) ADEC Air Quality Control Permit to Operate No. 9431-AAOO1, May 12, 1994, and cover
letter from Leonard Verelli, ADEC, to Frank Abogg, GVEA, dated May 12, 1994.
d) ADEC Final Supplemental Technical Analysis Report, May 6, 1994, for Healy Power Plant.
e) Electronic files Containing the ISC-PRIME model and associated programs, input. and output
files, developed in support of the modeling documented in Item b above.
f) Results of the Independent Evaluation of ISCST3 and ISC-PRIME,"
prepared by Robert Paine and Frances Lew, ENSR, Electric Power Research Institute
Report TR-2460026, W03527-02, November 1997, including Appendices A through EE
2) "Consequence Analysis for ISC-Prime," prepared by Robert J. Paine and Frances Lew,
ENSR, Electric Power Research: Institute Report TR-2460026, W03527-02,
November 1997, including Appendices A through EE.
3) PRIME Model & Documentation,' CD-ROM, EPRI, January 16, 1992, and PRIME Model &
Documentation - Addendum Diskette,~ January 20, 1998.
4) Letter from Kathryn Lamal, GVEA, to James Baumgartner, ADEC, dated February 18, 1998,
regarding revision to GVEA's Air Quality Construction Permit to Amend Alaska Air Quality
Permit to Operate 9431-AA001 for the Healy Power Plant, Healy, Alaska.
5). "Development and Evaluation of the PRIME Plume Rise and Building Downwash Model," by
Lloyd L. Schulman, et al., Earth Tech, Concord, Massachusetts, undated, draft

journal article
submitted to Atmospheric Environment, EPA Region 10 Review Copy, received March 1998.

Evaluation Criteria

The evaluation of the ISC-PRIME model, in comparison to the ISCST3 model, centers on two basic elements. The first is the technical basis of the model i.e. assessing which model is superior from a theoretical standpoint. The second is model performance, i.e.. determining whether ISC-PRIME performs as well or better than the ISCST3 model in comparisons of the models' predictions to observed concentrations. An important feature of a regulatory model's performance is the avoidance of a bias toward significant under-prediction.

Technical Evaluation

Two important capabilities offered by the ISC-PRIME model (and not offered by the ISCST3 model) are the ability to predict concentrations in the building cavity region, and the ability to assess the affects of actual stack location relative to the building. This second capability is especially important for the Healy case, where the Unit I stack is both separate and upwind from the Unit 2 boiler building during critical downwash conditions. The Unit 2 boiler building is the primary determinant of the near-field dispersion of the Unit 1 plume. The ISCST3 model is not able to explicitly account for the stack-building separation. Thus, ISCST3 would be expected to produce a less realistic simulation of near-field dispersion for the Healy case, in comparison with the ISC-PRIME model.

The downwash algorithms in both the ISC-PRIME model and the ISCST3 model are semi-empirical and therefore, the technical underpinnings of both models are based on the measurements of laboratory experiments (wind tunnel tests). The semi-empirical aspects of ISC-PRIME are based largely On an extensive series of wind tunnel experiments performed by EPA at its fluid modeling facility during 1992 and 1993. The development of the downwash algorithm in ISCST3 preceded the availability of these data sets, and it therefore does not reflect

the broader technical basis offered by these more recent wind tunnel data. Because ISC-PRIME is based on more extensive wind tunnel data sets, the technical basis for the ISC-PRIME downwash algorithm is stronger than that for the- ISCST3 model.

The plume rise algorithm in ISC-PRIME is based on numerical integration of theoretical equations for conservation of mass, momentum, and energy. The model accounts for streamline ascent over the building, and streamline decent in the lee of the obstruction ISC-PRIME also accounts for vertical wind shear effects caused by the wind flow about the building; in particular. the wind speed deficit in the lee of the building is modified as a function of downwind distance. These features of ISC-PRIME compose a more sophisticated treatment of the physics associated with downwash when compared to the simpler analytical treatments in the ISCST3 model. These factors should allow ISC-PRIME to produce a more realistic simulation of plume rise and dispersion from short stacks, such as, the Unit I stack at the Healy Power Plant.

Performance Evaluation

Several data bases, including observations from wind tunnel studies, numerical model results, and both short-term tracer and long-term operational field measurement programs, were employed by EPRI's contractors m the development and evaluation of ISC-PRIME. Four data bases were retained to perform an independent evaluation of the model after completion of the development phase. The evaluation was independent in that the data bases were not used in the model development and the effort was conducted by a contractor who was not the model developer. Model performance was evaluated against the four independent data bases according to a protocol previously reviewed by EPA Region 10. A number of performance measures were used in the evaluation, and statistical tests were employed to determine the significance of differences observed In model performance. Results of the independent evaluation demonstrated that the overall performance of the ISC- PRIME model is as good or better than

the ISCST3 model.

Meteorological conditions of near-neutral stability and moderate or higher wind speeds are traditionally considered most conducive to producing building wake effects (plume downwash conditions) and associated high ground-level concentrations. The occurrence of these conditions in the Healy area is not uncommon, and, in fact, both the ISCST3 and the ISC-PRIME model were consistent in producing the maximum 24-hour average concentrations during such near-neutral, moderate-to-high wind speed conditions. Thus, the performance of the models is most relevant under these downwash conditions as compared to other types of meteorological conditions. The evaluation of the models against the independent evaluation data bases showed that for near-neutral, moderate-to-high wind speed conditions, the two models' performances were comparable, with ISC-PRIME perhaps performing slightly better than ISCST3.

A site-specific data base from the Healy Power Plant, which would prove the most relevant basis to evaluate model performance, does not exist. Therefore, the similarity of the circumstances at the Healy Power Plant to the circumstances associated with the evaluation data bases is a factor in this evaluation. A comparison of stack parameters (buoyancy flux and momentum flux) shows that the Healy Unit 1 stack compares favorably with the stacks in two of the four independent evaluation data bases, namely, the Bowline Point and the Lee Power Plant data bases. [Note that since the Healy Unit 1 stack emissions were the only significant contributor to maximum modeled concentrations, the Healy Unit 2 stack is not considered in this comparison.] A comparison of stack height to building height ratios shows that the Healy case (Unit 1 stack height to building height ratio of 0.77) is comparable to the lower stacks in the AGA data base (ratios of 0.80, 0.86, and 2.00). None of the other three independent data bases had stack height to building height ratios less than one. Unfortunately, the AGA stack parameters (buoyancy and momentum fluxes)

are an order of magnitude less than the corresponding Healy Unit 1 parameters. Thus, none of the independent evaluation data bases are closely similar to the Healy case for
both stack parameters and stack/building geometry. To summarize the data bases against
which ISCST3 and ISC-PRIME were tested, we can classify them in three categories. in order of
decreasing technical primacy: on-site, closely similar, and other downwash data bases. Relative to
the Healy case, all of the independent evaluation data bases fal. into the last category, and the
model performance evaluation can not be as technically compelling as if the data bases were
developed from data obtained at the Healy site, or at plant sites that are more closely similar to
the Healy site.

The performance evaluations of the ISC-PRIME and ISCST3 models demonstrate that
'SC-PRIME generally performs as well or better than ISCST3 for predicting maximum impacts
during downwash conditions, with no apparent bias toward under-prediction. However, because
the data bases employed in the evaluations are not closely similar to the Healy site, the evaluation
results are only suggestive (rather than conclusive) evidence that ISC-PRIME would be expected
to perform better than ISCST3 for the Healy application.

Additional Notes

Some sensitivity testing of the ISC-PRIME model was performed by EPA Region 10 for
the Healy application. Several of the inputs to ISC-PRIME for the Unit 1 source (including stack
height, stack temperature, and exit velocity), and for the Unit 2 building dimensions, were
modified both slightly and significantly to investigate the sensitivity of the maximum concentration
estimates to these changes. The observed model sensitivity was judged to be physically
reasonable. Receptor spacing was also investigated in the area of maximum predicted
concentrations along the northwest plant boundary. By increasing the number of receptors in the
maximum impact area, maximum concentrations were identified that were slightly higher than
those reported by GVEA.

In addition to being submitted to EPA Region 10 for the Healy application, the ISC-PRIME model has been submitted to EPA's Office of Air Quality Planning and Standards (OAQPS) for their review and consideration of proposing the model as a preferred model the Guideline on Air Quality Models (40 CFR 51, Appendix W). In their review, OAQPS identified a coding error in the model, such that, when certain low wind speed, stable conditions are encountered, the model ceases to operate. This error has apparently been corrected by the model developer, and a revised version of the model will soon be available. These revisions to the model are not expected to cause substantive changes in the model predictions for the conditions that are critical to the permitting decision for the Healy case. This should, however, be verified by re-running the Healy case with the revised ISC-PRIME model when it becomes available.

Conclusions and Recommendations

On the strength of the data bases employed during the development of the ISC-PRIME model, and because of the improved and more physically realistic capabilities of the model, it is concluded that ISC-PRIME is technically superior to the JSCST3 model in this circumstance.

While there is no conclusive evidence from the performance evaluations that ISC-PRIME would be expected to be a more accurate predictor of maximum impacts for the Healy application, the performance evaluations with the independent data bases do suggest that ISC-PRIME is generally as good or better than the ISCST3 model for predicting maximum impacts during downwash conditions. Furthermore, while both the difficulties in modeling the complexities of plume downwash and the limitations of available data bases lead to uncertainties in the assessment of model performance for this application, it appears that ISC-PRIME has no significant bias toward under-prediction of maximum impacts. Therefore, it is recommended that the ISC-PRIME model, in lieu of the ISCST3 model, be considered acceptable for application to the Healy case

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4) Final Region IV approval letter for U.S. Sugar

November 4, 1999

4APT-ARB

Mr. A. A. Linero, P.E.
Administrator/New Source Review Section
Florida Department of Environmental Protection
Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

SUBJ: Use of ISC-PRIME
PSD Permit Application
U.S. Sugar Corporation Clewiston Mill
Clewiston, Florida

Dear Mr. Linero:

Thank you for providing the Prevention of Significant Deterioration (PSD) permit application for the U.S. Sugar Corporation - Clewiston Mill, dated June 1999. This application requests an increase in the operation of the sugar refinery and Boiler No. 4. Our review comments excluding the air quality impact assessment were provided in our September 20, 1999, letter. The purpose of this letter is to provide our evaluation of the appropriateness of the use of the none-guideline ISC-PRIME dispersion and transport model for the ambient air impact assessments resulting from the proposed Clewiston Mill modifications.

The justification for the use of the non-guideline model [i.e., model not recommended in the United States Environmental Protection Agency's (EPA) Guideline on Air Quality Models (40 C.F.R. 51, Appendix W)] was provided in the U.S. Sugar Clewiston Mill PSD permit application. This justification, combined with available articles and documents on the development and performance of the ISC-PRIME model, were the basis of our review and evaluation.

The reviewed articles and development documents reported ISC-PRIME to perform as well as or better than ISCST3 when predicted maximum concentrations are compared to observed measurements. ISC-PRIME was also found not to be significantly biased toward under-estimation of maximum concentrations. A summary of our case-by-case evaluation

of ISC-
PRIME for the U.S. Sugar Clewiston application is provided as an attachment.

Based on our evaluation of ISC-PRIME, EPA concurs with the use of this model for the Clewiston Mill air impact assessment. In accordance with EPA's division of responsibility with respect to non-guideline model approval, this EPA Region 4 case-by-case approval for the U.S. Sugar Clewiston application is not an endorsement for use by any other source. EPA's Office of Air Quality Planning and Standards (OAQPS) is currently considering a generic approval of ISC-PRIME. If generically approved, ISC-PRIME may become a guideline model for general application.

It should be noted that any public notice of this project must include the fact that the air quality impact assessment was performed using a case-specific approved non-guideline ISC-PRIME model. The public must be provided an opportunity to comment and have a public hearing on this matter.

Thank you again for the opportunity to review and comment on this PSD application. If you have any questions, or if we can be of further assistance, please contact Mr. Stan Krivo of the EPA Region 4 staff at (404) 562-9123.

Sincerely,
R. Douglas Neeley
Chief
Air and Radiation Technology Branch
Air, Pesticides and Toxics
Management Division

Attachment

cc: Joseph A. Tikuart, EPA/OAQPS
Cleve Holladay, FDEP
Tom Rogers, FDEP

Evaluation of ISC-PRIME For Application To
U.S. Sugar Corporation Clewiston Mill
Air Quality Impact Assessment

Introduction

The Florida Department of Environmental Protection (FDEP) has reviewed the Prevention of Significant Deterioration (PSD) permit application for a modification of U.S. Sugar Corporation (U.S. Sugar) Clewiston Mill. One of FDEP's concern is the application of the non-guideline ISC-PRIME dispersion and transport model to the ambient air quality assessment. The use of the guideline ISCST3 dispersion and transport model for the U.S. Sugar Clewiston Mill emission sources reveals very large predicted SO2 and PM10 concentrations at the site boundary - concentrations that exceed the PM10 and SO2 National Ambient Air Quality Standards (NAAQS). Use of the ISC-PRIME model with the same input emission and receptor values also predicts large concentrations but none that exceed the applicable PSD increments nor NAAQS.

The ISC-PRIME model has been submitted to United State Environmental Protection Agency's (EPA) Office of Air Quality Planning and Standards (OAQPS) for consideration as a guideline model. OAQPS have reviewed and tested this model. It was also reviewed at the 1998 Regional/State/Local Agency modelers workshop. With a few restrictions, the Workshop participants recommended ISC-PRIME be included as a guideline air quality model in the next revision to the Guideline on Air Quality Models (GAQM).

Although OAQPS may propose ISC-PRIME for inclusion as a guideline model, this has not officially been proposed and public comment solicited. Therefore, ISC-PRIME remains a non-guideline model that must be evaluated and approved for application on a case-by-case basis. The U.S. Sugar PSD application is the first time the ISC-PRIME model has been used in a regulatory application in EPA Region 4. The following is a summary of EPA Region 4's review of U.S. Sugar's justification of the appropriateness of ISC-PRIME for the assessment of ambient air

(GAQM). Section 3.2 presents three separate conditions under which an alternate model can be approved. The second condition is the basis for the justification of ISC-PRIME (i.e., statistical performance evaluation using measured air quality data results in the alternate model having better performance than a comparable guideline model). The issues addressed in Region 4's evaluation of the appropriateness and applicability of ISC-PRIME for the U.S. Sugar application include:

Technical appropriateness of the model for the application.

Appropriate data bases available to perform the modeling analysis.

Model performance evaluations appropriate to U.S. Sugar and demonstrate no bias toward underestimates of concentrations.

Better model performance when compared to reference guideline model.

Technical Consideration

The ISC-PRIME model was developed to improve the downwash algorithms of the ISCST3 regulatory guideline model. Two important short comings of the ISCST3 downwash treatment are the inability to predict concentrations in the building cavity (near wake) and to assess the affects of stack location relative to the influencing downwash structure. In addition, the downwash routines of ISCST3 were developed largely from ambient data representing neutral stability, moderate-to-high wind speeds, winds perpendicular to the building face, with non- or low-buoyant plumes. These limitations were addressed in the development of ISC-PRIME.

Of major concern at the Clewiston Mill are emissions from the boiler stacks. These stacks are located between 3 and 5 building lengths from the buildings controlling downwash. Although EPA studies of the effects of building downwash within wakes show reduction as the stack's distance from the controlling building is increased, ISCST3 uses the full downwash effects independent of stack location in the wake region. Thus, ISCST3 modeling of the Clewiston emissions may produce less realistic estimates of wake dispersion than ISC-PRIME. Ambient concentrations from these two models for the Clewiston facility show, ISC-PRIME with smaller

statistical tests
performed to determine the significance of performance differences observed. Thus, adequate
data bases exist for both the development and evaluation of model performance.
Performance Evaluations
Comparison With Data Bases
In the assessment of ISC-PRIME model performance, meteorological conditions that produce the
highest ground-level concentrations were used (e.g., near-neutral stability and moderate to high
wind speeds). Comparsion of both ISCST3 and ISC-PRIME predicted concentrations against the
independent data bases show that for these downwash producing meteorological conditions, the
two models's performances were comparable with ISC-PRIME performing slightly better (i.e.,
better agreement with observations) than ISCST3.
Site specific data from the Clewiston facility site would provide the most relevant basis for model
performance evaluation. These data were not available so a review of the similarity of the
emissions, plant configuration, and receptor conditions used in the ISC-PRIME model evaluation
was performed to determine applicability of the evaluation to the Clewiston application. Of the
evaluation data bases used, the Bowline Point and the Lee Power Plant data were the most similar
to the boilers at the Clewiston facility in terms of stack heights (87 and 65 meters respectively)
and stack to building ratios (1.3 and 1.5 respectively). The buoyant and momentum fluxes for
these power plants are expected to be representative of those at Clewiston. Although the
evaluation and development data bases were not obtained under the same plant configuration as
U.S. Sugar Clewiston, they are believed to relevant and representative of the U.S. Sugar
Clewiston.
Comparison With Reference Model
The performance evaluation comparisons of ISC-PRIME and ISCST3 models demonstrated ISC-
PRIME with generally as well or better agreement with observed maximum concentrations during
downwash conditions. ISC-PRIME did not demonstrate a bias toward under predictions. Thus,

an independent evaluation demonstrated ISC-PRIME with an overall performance as good as, or
better than ISCST3 in downwash conditions.
EPA performed its own consequence analysis of the ISC-PRIME software and EPRI reports.
This consisted of verifying that ISCST3 and ISC-PRIME produced the same results when no
building dimensions were included, confirming the independent modeling results, and determining
the consequences of using ISC-PRIME for building downwash applications.

The consequence analysis showed that both models produced the same results when run without building input data. The PRIME downwash algorithms do not interfere with the proper operation of the model under no downwash conditions.

The three field studies used in the EPRI independent evaluation showed ISC-PRIME tends to be less conservative than ISCST3 but more conservative (i.e., produce larger concentrations) than the observed values.

For cavity analyses, output differences between ISCST3 and ISC-PRIME were dependent on stack location, stack to building height ratios, urban/rural setting, and downwind distances. ISC-PRIME and ISCST3 converge on common concentrations beyond 1 km and are the same beyond 10 km.

In summary, ISC-PRIME provides overall conservative estimates of concentrations that are more
realistic than those provided by ISCST3.

Conclusion and Recommendation

Based on the application of Section 3.2 of 40 CFR Part 51, Appendix W (Guideline on Air
Quality Models) for the evaluation of the use of an alternate model, ISC-PRIME appears
appropriate and applicable for the U.S. Sugar Clewiston air quality impact assessment. ISC-
PRIME appears to be technically better than ISCST3 and is better at predicting maximum
concentrations during downwash conditions. In terms of application to the U.S. Sugar Clewiston
facility, it appears that ISC-PRIME would provide a more realistic but conservative estimate of
the maximum downwash concentrations from this facility while also providing concentrations

equal to ISCST3 predictions beyond the wake region. Therefore, ISC-PRIME is considered
applicable and appropriate for application to the air quality impact assessment for the U.S. Sugar
Company's Clewiston Mill.