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Evaluation of Urban Air Quality Simulation Models

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by

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PREFACE

TRC Environmental Cnsultants, Inc. has produced a set of model performance statistics for urban Gaussian dispersion models. This work has been perormed for the U.S. Environmental Protection Agency (EPA), Office of Air Quality Planning and Standards (OAQPS), under EPA Contract 68-02-3614, Work Assignment 13, "Evaluation of Urban Air Quality Simulation Models."

DISCLAIMER

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SECTION 1

INTRODUCTION

In March 1980 EPA published a notice in the Federal Register which provided an opportunity for organizations to submit dispersion models for possible inclusion in the next revision of EPA's "Guideline on Air Quality Models."[1] A large number of models were submitted in response to this notice, including six in the "urban model" category (four annual average and two short-term models). To decide in an objective manner which models should be included in the guideline and what recommendations should be made concerning the use of these dispersion models for regulatory applications, EPA has undertaken a systematic evaluation of urban models. TRC, working under contract to EPA, has assembled an air quality data base, set up and run the dispersion models, and produced statistical comparisons of observed and predicted air quality. These comparisons have been summarized in tabular form and have been forwarded to the reviewers.

In September 1980 the American Meteorological Society (AMS) organized a workshop to consider the issue of model performance evaluation. The 1980 workshop held at Woods Hole, Massachusetts, produced a report entitled "Judging Air Quality Model Performance".[2] This report contains recommended statistical procedures for comparing observed air quality with model predictions. The procedures recommended by the Woods Hole workshop provided the basis for the statistical comparisons presented in this report. In 1982, TRC performed a similar study for EPA to evaluate eight rural models.[3] On the basis of that study and subsequent comments by the AMS peer reviewers, TRC recommended a series of changes to simplify and streamline the statistical calculations. These changes have been adopted for the urban model evaluations.

The air quality data base to which model predictions were compared was acquired with a 13-station network of continuous SO_2 monitors, operated in metropolitan St. Louis. The data were obtained from the EPA RAMS/RAPS archive. Coincidental air quality and emissions data for calendar year 1976 were used in this study. Specific features of the data base are described in Section 2.

In Section 3 the statistical approach is described. For the short-term models, the set of observed and predicted concentration values has been sorted in a variety of ways to provide statistical model performance comparisons that reflect either high concentration values or all concentration values, with and without pairing according to time and space. For the annual average models, only one observation and prediction are available for each monitor. These data sets are defined, and the specific statistical tests applied to each are outlined.

In Section 4 the distinguishing features of the urban models are summarized. Particular attention is devoted to describing the technical differences among the models (as run for this study), how model options were selected, and what modifications were required to obtain model predictions appropriate for this evaluation.

Prior to running the urban models for evaluation with the RAPS data base, it was desireable to confirm that the models would be run in accordance with the expectations of the model developers. To accomplish this, a test-run package was prepared by TRC and supplied to the model developers for their formal review and concurrence. The package supplied to each model developer contained the following information:

- Description of the urban-model evaluation data base;

- Summary of model-code modifications;
- Summary of input options;
- Test-run data (listings of all input and output data) for the model developer's particular model;
- Complete listing of the model code "as run," to enable the model developer to confirm the code line-by-line.

Comments on these documents from the model developers were addressed by TRC prior to executing the final model runs for the statistical evaluations.

The results of the study are described in Section 5. The tables of statistical comparisons for all six models, based on the performance measures recommended by the AMS workshop, are presented in this section. Appendix D provides tables of hour-by-hour model input and observed SO_2 air quality for each of 11 selected days when high SO_2 concentrations were measured.

Finally, in Section 6, conclusions from the work assignment are presented. These conclusions concern primarily the evaluation methods used in the study and how these methods may influence the results.

Four appendices contain tabulated data. Appendix A contains the annual average SO_x emissions inventory for all point and area sources as modeled. The annual average meteorological joint frequency function used as input to the annual average models is listed in Appendix B. Tables of highest and second highest observed and predicted concentrations for 1-, 3-, and 24-hour periods at each station are presented in Appendix C. Appendix D provides hourly meteorological and observed concentration data for selected days with high predicted or observed concentrations.

SECTION 2

URBAN MODEL EVALUATION DATA BASE

The data base used for urban model evaluations is a subset of the extensive data archive established by the EPA for the Regional Air Pollution Study (RAPS),[4,5] a series of monitoring programs conducted between 1973 and 1978 for the St. Louis area. The RAPS data base was previously reviewed and recommended as an appropriate data base for evaluating the urban models.[6] Data for calendar year 1976 were selected for the model evaluation data base because the quality of the emissions data is better than for other years,[7] and because the 1976 data year provided all requisite model input. The criteria pollutant sulfur dioxide (SO_2), was selected for the model evaluations. The SO_x emissions inventory of the RAPS data base represents all area sources and point sources in both the Missouri and Illinois portions of the St. Louis metropolitan area. The RAPS data base includes measurements of meteorology and total sulfur or SO_2 concentrations made at the 25 Regional Air Monitoring System (RAMS) stations operated in association with the RAPS program. The map shown as Figure 2-1 depicts the RAMS station locations and geographic extent of the RAPS study area.

EMISSIONS AND SOURCE DATA

The RAPS emissions inventory contains 480 point sources and 1989 area sources in the St. Louis metropolitan area, including 235 point sources with non-zero SO_x emissions. The general locations of these point sources are shown in Figure 2-2. For ease of graphical presentation, multiple sources at

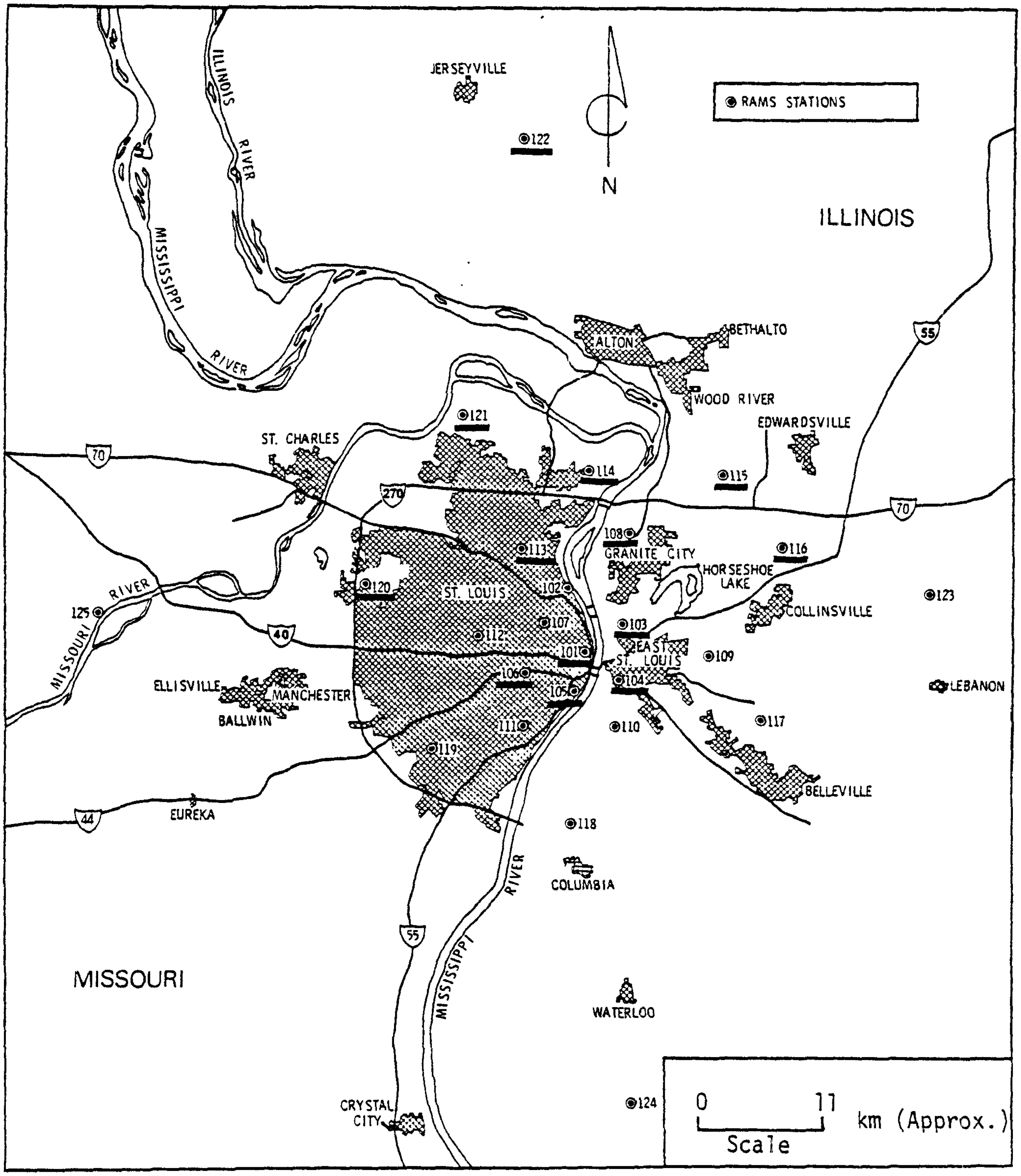

Figure 2-1. Location of the regional air monitoring system (RAMS) stations with SO_2 monitors indicated by underlines. (from "Documentation of the Regional Air Pollution Study," December, 1979, EPA-600/4-79-076)[4]

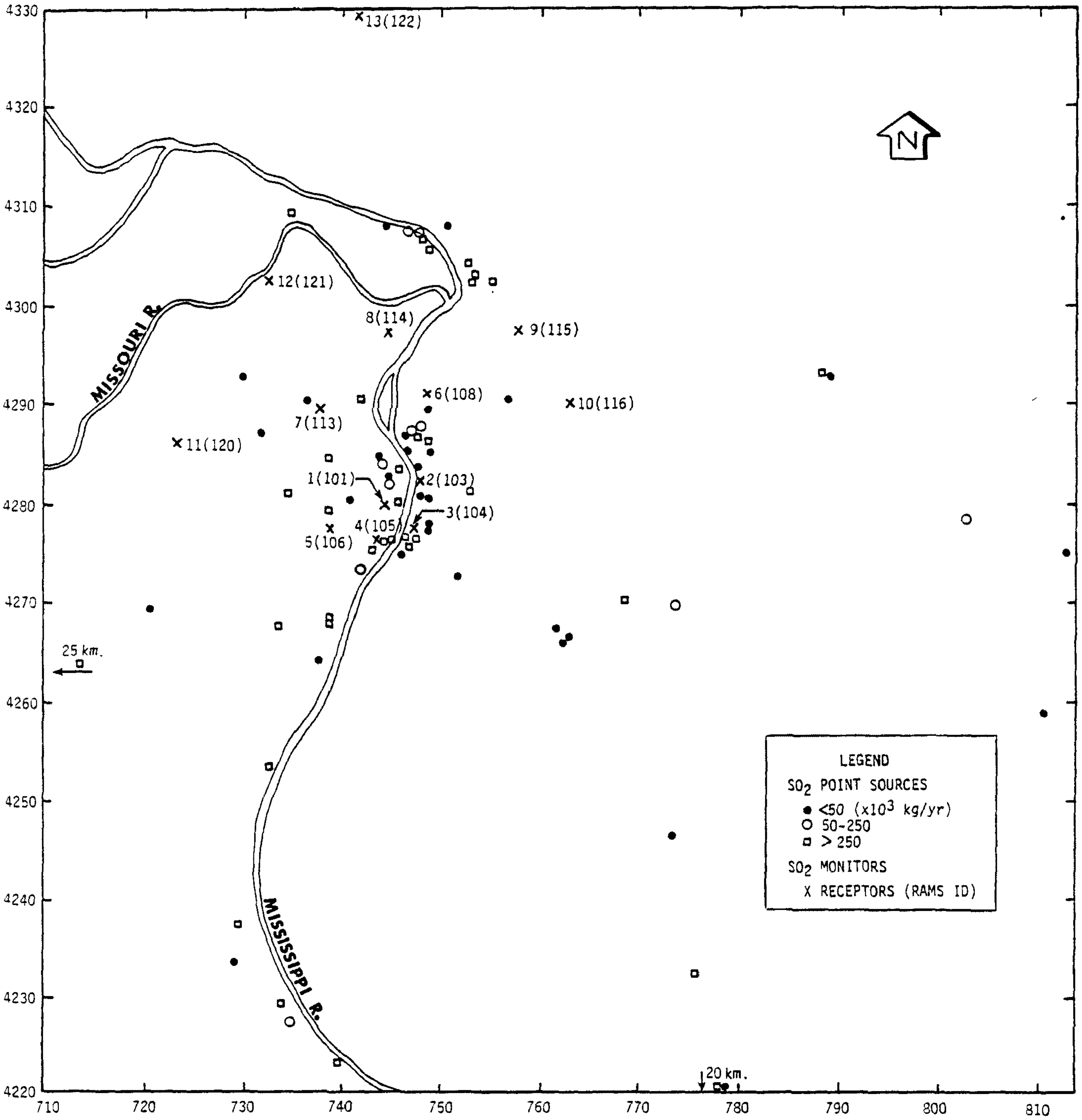

Figure 2-2. Locations of SO_2 point sources in the 1976 RAPS inventory. (Multiple sources at the same facility, while modeled separately, are shown combined for ease of graphical presentation).

the same facility were combined in this figure. A table of annual average point source emissions and source characteristics is presented in Appendix A.

A map showing the distribution of RAPS area sources is presented in Figure 2-3. The RAPS study employed a fine-mesh source grid in the portion of metropolitan St. Louis with highest emissions density. The grid for the high-density region is detailed in Figure 2-4. For purposes of this study, TRC reduced the number of area sources from 1989 to 1536 by excluding 453 RAPS sources located more than 30 kilometers from the nearest SO_2 monitoring station. The rationale for this reduction is that the excluded RAPS SO_x area sources are too distant to have any significant impact at the RAMS monitors. (This assumption was confirmed by comparing results of CDM annual average model runs based on 1536 area sources versus 1989 area sources.) A table of annual average area source emissions is presented in Appendix A.

Hourly source data consist of SO_x emission rate, stack temperature and volume flow rate for each of the point sources, and SO_x emission rate for each of the area sources. For the long-term models, annual averages of these variables were also available. The requisite fixed source data, including geographic coordinates, stack diameter, stack height and area source width, were also included in the model evaluation data base.

EPA compiled and made available to TRC a set of area source heights for use with the RAPS emissions inventory. The area source heights range from 10 meters in rural areas to as high as 23 meters in the St. Louis downtown areas. The heights were assigned based on land use patterns, starting from values determined by Turner and Edmisten[8] for an earlier St. Louis area source inventory. This earlier inventory, however, did not encompass the full region of the RAPS inventory. Area sources not in the original inventory were later classified by EPA either as rural, suburban, or urban, with a height of 10 meters, 14 meters, or 18 meters, respectively.

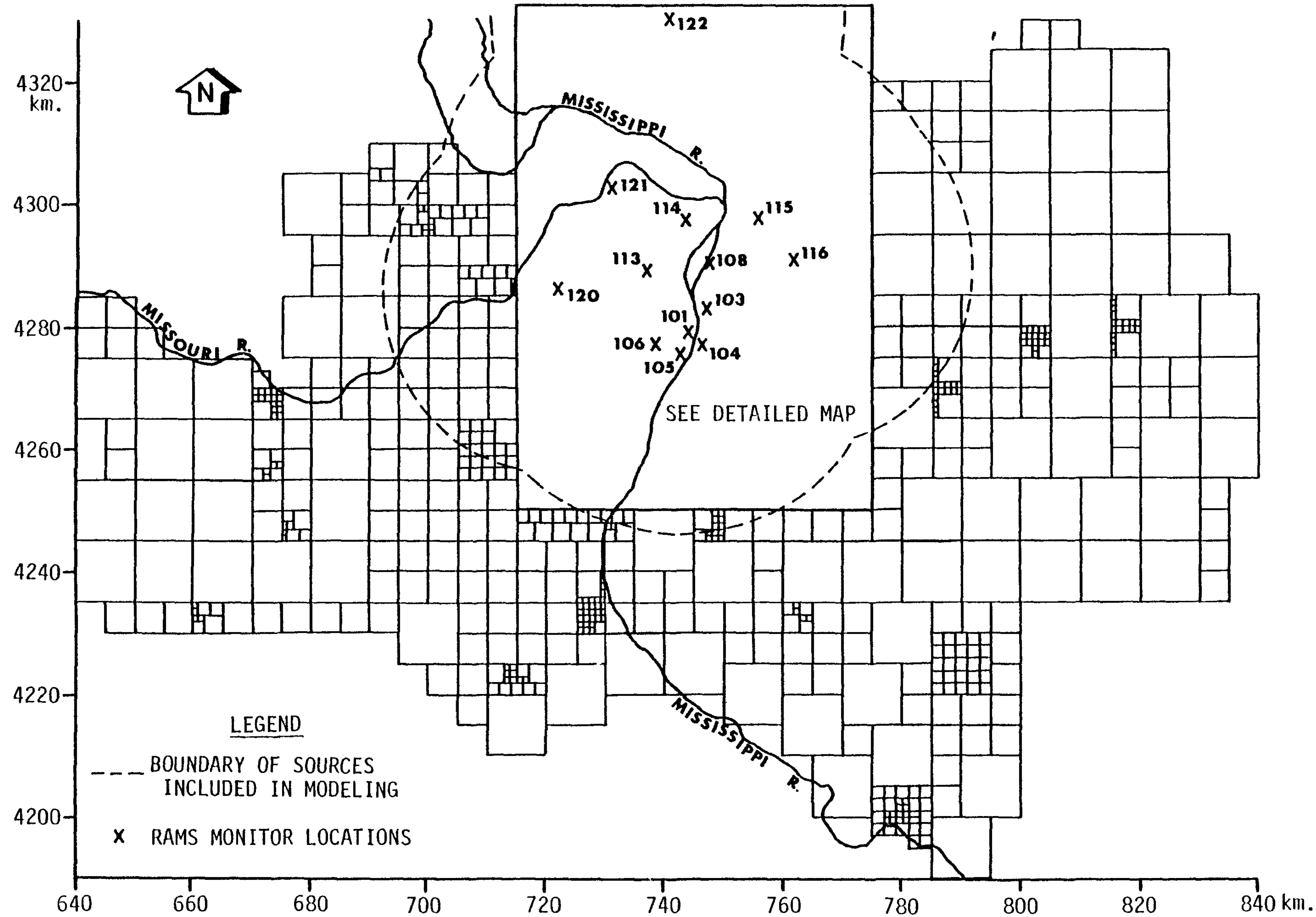

Figure 2-3. Geographic distribution of all RAPS area sources including those in the study subregion.

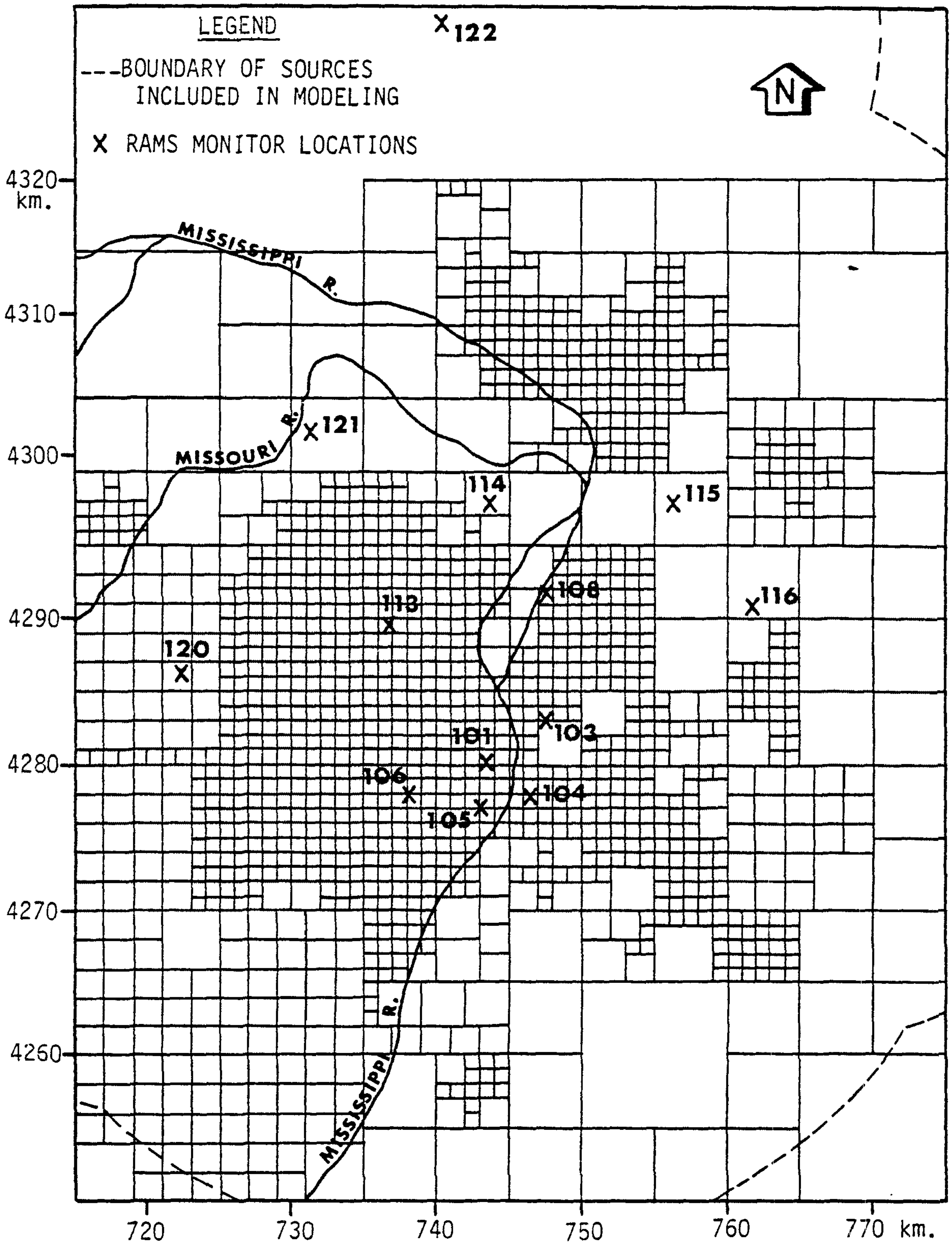

Figure 2-4. Detail of the distribution of RAPS area sources (1 km square) in the region of high source density.

METEOROLOGICAL DATA

A composite meteorological data set was made available by EPA for input to the models. This data set contains hourly values of temperature, pressure, wind speed and wind direction spatially averaged from the 25 RAMS stations. Temperature and pressure in this data set were calculated as hourly arithmetic means over the RAMS network. Hourly vector mean wind speeds (WS) and wind directions (WD) were calculated from horizontal components of the wind vector (u_i and v_i) at each station (i = 1 to N) as follows:

$$WS = \left[\left(\frac{1}{N} \sum_{i=1}^{N} u_i \right)^2 + \left(\frac{1}{N} \sum_{i=1}^{N} v_i \right)^2 \right]^{1/2}$$

$$WD = \text{Arc tan} \frac{\left(\frac{1}{N} \sum_{i=1}^{N} u_i \right)^2}{\left(\frac{1}{N} \sum_{i=1}^{N} v_i \right)^2} \times \frac{180}{\pi}$$

If WS or WD differed by more than 4 m/sec or 75 degrees, respectively, from the observed value at any given station, the data from the outlier station was excluded and the vector wind components were reaveraged.

Wind measurements were taken from the 30 meter tower level at 17 of the 25 meteorological monitoring locations and from 10 meters at the other eight locations. Most of the wind measurements made in the St. Louis urban area, where the majority of the SO_2 sources are located, were at 30 meters. A height of 30 meters was therefore used for models requiring measurement height as input.

Hourly values of stability were available based on the "Turner method"[9] using the composite wind speeds as well as cloud-cover observations from the nearby National Weather Service station at Lambert Field.

Hourly mixing height values, calculated in the RAPS study, were also available. The hourly values had been determined by interpolation from measured morning and maximum afternoon mixing heights using the CRSTER preprocessor program. Measurements of the morning mixing height were based on acoustic-sounder data. The afternoon mixing height was measured in the RAMS/RAPS study with radiosondes. Where acoustic-sounder or radiosonde data were missing, the monthly mean mixing height value had been substituted.

Meteorological data for the annual models was available in the form of a 6-category day/night STAR deck (Stability Classes A, B, C, D-day, D-night, and E-F). A tabulation of this data is provided in Appendix B. Annual average temperature and mixing height values were obtained from climatic records and the standard Holzworth tables,[10] respectively.

AMBIENT SO_2 DATA

Hourly average SO_2 concentrations were available for the 13 SO_2 monitoring stations in the RAPS/RAMS network. In order to allow a direct comparison between the standard model predictions and the observations, TRC converted these concentrations from parts per million to micrograms per cubic meter using hourly pressure and temperature. Annual average SO_2 concentrations were calculated for each of the 13 stations. Figure 2-1 shows the RAMS network, with the 13 SO_2 monitor locations underlined. Table 2-1 gives the modeling receptor number corresponding to each SO_2 monitoring location.

For the urban model evaluation study, background levels of SO_2 are assumed to be zero. The comprehensive regional emissions inventory minimizes the likelihood of a significant background level. For many transport wind directions, none of the RAPS stations is located upwind of the source region. It is therefore extremely difficult to quantify whatever background there may be with any confidence.

TABLE 2-1

RAMS SO_2 MONITORING STATIONS AND CORRESPONDING MODELING RECEPTOR NUMBER USED IN THE STUDY

RAMS Station	Receptor Number
101	1
103	2
104	3
105	4
106	5
108	6
113	7
114	8
115	9
116	10
120	11
121	12
122	13

In reviewing the results of the performance evaluation, the reader should be aware of the criteria used for selection of data for the analysis. After discussions with EPA personnel, acceptance criteria were established for the hourly data that are based on the size of the instrument span drift and the completeness of sampled data. Specifically, hourly SO_2 concentrations were deemed acceptable if both of the following conditions were met:

(1) Span drift did not exceed 15 percent.

(2) The number of one-minute concentration samples making up the hourly average value is 30 or greater.

Data recovery figures for the 13-station network are summarized in Table 2-2. The hours of SO_2 concentrations, categorized as either missing, excluded or accepted for analysis, are shown for the 13-station total and as ranges across the individual stations. Approximately half of the missing hours are attributed to the month of July. The reader should also be aware that the operating range of the SO_2 monitors was such that no hourly measurements exceeding 1 ppm were reported, i.e., values above this level are "missing".

TABLE 2-2

PERCENTAGE OF 1976 RAPS/RAMS HOURLY SO_2 MONITORING DATA ACCEPTED FOR URBAN MODEL EVALUATIONS

	13 Station Average (%)	Station-by-Station Range (%)
Missing Data	16	11-21
Data Excluded by acceptance criteria	13	10-17
Total Data Loss	29	23-34
Accepted Data	71	66-77

SECTION 3

STATISTICS APPROACH

The 1980 AMS Woods Hole workshop on model performance evaluation[2] recommended a comprehensive list of performance measures and statistics for evaluating air quality models. In addition, the workshop recommended comparisons of the full set of observed-predicted data pairs, of the highest observed and predicted concentration per event and of the highest N values (unpaired in time or space), plus comparisons for subsets representing individual monitoring stations or selected meteorological conditions.

TRC and EPA reviewed the workshop report and formulated a statistical approach for the rural model evaluations[3] based on workshop recommendations. The approach was modified, following the rural model evaluations, primarily to reduce the volume of information by eliminating redundant performance measures and statistics. The statistical approach followed for the urban evaluation is described below.

DATA SETS FOR COMPARISON OF OBSERVED AND PREDICTED CONCENTRATIONS

The data sets listed in Table 3-1 represent the different types of comparisons recommended by the AMS workshop. In each instance, comparisons were recommended for the basic 1-hour unit for model predictions and also for 3- and 24-hour averaging times. The numbering scheme in the table is derived from a summary prepared by William Cox of EPA[11] of the data sets and statistics recommended by the AMS workshop. For annual average comparisons,

TABLE 3-1

SUMMARY OF DATA SETS FOR URBAN MODEL EVALUATION WITH RAPS BASE*

A. Peak Concentration Comparisons	(A-1) Compare highest observed value for each event with highest prediction for same event (paired in time, not location)	B. All-Concentrations Comparisons	(B-1) Compare observed and predicted values at a given station, paired in time (a total of 13 data sets).
	(A-2) Compare highest observed value for the year at each monitoring station with the highest prediction for the year at the same station (paired in location, not time)		(B-2) Compare observed and predicted values for a given time period, paired in space (not appropriate for data sets with few monitoring sites).
	(A-3a) Compare maximum observed value for the year with highest predicted values representing different time or space pairing (fully unpaired; paired in location; paired in time; paired in space and time)		(B-3) Compare observed and predicted values at all stations, paired in time and location (one data set) and by time of day.
	(A-3b) Compare maximum predicted value for the year with highest observed values for various pairings, as in (A-3a)		(B-4) Same as (B-3), but for subsets of events by meteorological conditions (stability and wind speed) and by time of day.
	(A-4a) Compare highest N (=25) observed and highest N predicted values, regardless of time or location		
	(A-4b) Compare highest N (=25) observed and highest N predicted values, regardless of time, for a given monitoring location. (A total of 13 data sets.)		
	(A-5) Same as (A-4a), but for subsets of events by meteorological conditions (stability and wind speed) and by time of day.		

* Nomenclature is taken from a letter of October 20, 1981 from William M. Cox (EPA) to Richard Londergan (TRC) summarizing the presentation format for the performance statistics.

the data set consists of one pair of observed and predicted values for each monitor, directly analogous to set (A-2) for the peak concentration comparisons.

For some hours during a year, none of the monitoring stations experienced significant observed or predicted SO_2 impact. These hours of effectively zero observed and zero predicted impact are relatively uninteresting for the evaluation of air quality models for regulatory purposes. Including those hours in statistical analyses adds to the computational burden and tends to dilute the model performance results from hours with significant impact. Consequently, threshold values were imposed to screen the data base for statistical analyses. If, for a given time period, both the observed concentration and the predicted concentration at a station were below the threshold, that data pair was excluded from further analysis. A threshold value of 25 $\mu g/m^3$ was used for 1- and 3-hour averages, and a value of 5 $\mu g/m^3$ was used for 24-hour averages.

Peak Concentrations

For peak concentrations, comparisons are made to determine model performance both on an unpaired basis and for various pairings in time and space. The first two items in Table 3-1 represent a comparison of the highest observed and highest predicted concentrations, paired in time (A-1) and paired in location (A-2). For the RAPS data set, these two comparisons provide quite different measures of performance since the number of events is large (1 year represents 366 days or 8,784 hours) while there are only 13 stations. An additional (A-2) data set was added for the urban evaluation, representing the second-highest values observed and predicted at each station.

Item A-3a represents a comparison of the highest observed concentration values, regardless of time or space, and predicted values representing different time and space pairing. Item A-3b is directly analogous to A-3a, but starts from the highest predicted value. Results for data sets (A-3a) and (A-3b) for the rural evaluation were relatively uninformative. These sets were therefore dropped from the urban evaluations.

Items A-4 and A-5 involve comparisons of the "N" highest observed and predicted values, unpaired in time or space. The AMS workshop recommended that such comparisons be based on the upper 2 to 5 percent of concentrations, rather than on one or two extreme values. As an alternative to the percentile approach, TRC recommended using a small number (N=25) which would more appropriately represent the set of highest observed and predicted values, while still providing a statistical basis for establishing confidence limits. On a percentage basis, 25 values represent roughly 7 percent of the 365 24-hour values in a year, about 1 percent of the 3-hour values, and about 0.3 percent of the 1-hour values. The statistical methods recommended by the AMS workshop for these data sets assume that each data point is independent. This assumption is not strictly valid, however, since the ranking process introduces a dependence among the data values. The confidence intervals calculated assuming independence will, therefore, tend to be too narrow.

Air quality data often exhibit spatial and temporal correlation, particularly over time periods of a few hours. For 1- and 3-hour periods, the highest 25 values were screened to eliminate cases with two or more high values from the same period, or with two consecutive high values at the same location. This screening is intended to reduce the effect of auto-correlation and to avoid double-counting a single event. For non-overlapping 24-hour averaging periods (midnight to midnight), less correlation is expected, and this screening was not included.

Comparisons of the highest 25 observed and predicted values were performed for all stations combined (A-4a), for each station individually (A-4b) and for subsets of events corresponding to time of day and to selected meteorological conditions (A-5). For 1-hour periods, data subsets were established by dividing the total data set into groups according to time of day or to the model input wind speed or atmospheric stability class for each period. The time of day subsets were not used for the rural evaluation but were added for the urban evaluation. Hours of the day were divided into four groups: 0000 to 0600 hours; 0600 to 1200 hours; 1200 to 1800 hours; and 1800 to 2400 hours. Three wind speed groups were defined: low wind speed (less than 2.5 m/sec); moderate (2.5 to 5 m/sec); and high (greater than 5). Four atmospheric stability groups were defined: unstable (class A or B); slightly unstable (class C); neutral (class D); and stable (class E, F, or G).

Comparisons of All Concentrations

In addition to peak concentration analyses, the AMS workshop recommended that comparisons be made based upon all observed and predicted concentration values. Table 3-1 lists four items of this type. Item B-1 is the comparison of observed and predicted values at a given monitoring station (for all data pairs above the threshold values). Item B-2, comparison of observed and predicted values for a given time period, was recommended by the AMS workshop but was not implemented for this study. With relatively few monitors and many time periods, separate statistics for each time period are not practical. Item B-3 represents comparisons based on the set of values from all 13 stations combined. Item B-4 represents subsets of B-3 to reflect time of day and specific meteorological conditions. The same wind speed, atmospheric stability, and time of day criteria described for item A-5 above were used to define subsets for 1-hour averaging periods here.

STATISTICAL ANALYSIS OF MODEL PERFORMANCE

The statistical measures employed in the rural model evaluation were based on the 1980 AMS Woods Hole Workshop recommendations, as summarized in W. Cox's letter of September 1981.[11] In preparing for the urban evaluation, TRC proposed a modified list of statistical measures and analyses. The basic set of estimators used for comparisons of observed and predicted concentration values are summarized in Table 3-2, together with the statistical methods recommended for establishing confidence intervals.

For paired comparisons, the performance measures are based on an analysis of residuals. Model bias is indicated by the average and/or the median residual, with a value of zero representing no bias. The characteristic magnitude of the residuals is an indicator of the scatter between observed and predicted values on an event-by-event basis. Three measures of noise or scatter were computed:

- o Variance $\frac{1}{N-1} \sum_{i} (d_i - \bar{d})^2$

- o Gross variability $\frac{1}{N} \sum_{i} d_i^2$

- o Average absolute residual $\frac{1}{N} \sum_{i} |d_i|$

where d_i is the residual (observed minus predicted) for data pair i, d is the average residual, and N is the number of data pairs. The correlation of paired observed and predicted values is measured by the Pearson correlation coefficient.

For unpaired comparisons, the list of performance measures is somewhat shorter. Model bias is indicated by the difference between the average (or median) observed value and the average (median) predicted value. A ratio of

TABLE 3-2

STATISTICAL ESTIMATORS AND BASIS FOR CONFIDENCE LIMITS ON PERFORMANCE MEASURES

Performance Measure	Estimator	Basis for Confidence Interval	
		Paired Comparison	Unpaired Comparison
Bias	Average	One sample "t," with adjustment for serial correlation	Two sample "t"
	Median	Wilcoxon matched pair	Mann-Whitney
Noise/Scatter	Variance	Chi-squared test on variance of residuals	F test on variance ratio
	Gross variability	None	Not applicable
	Average absolute residual	None	Not applicable
Correlation	Pearson correlation coefficient	Fisher "z"	Not applicable
Frequency distribution comparison	Maximum difference between two cumulative distribution functions	Not Applicable	Kolmogorov-Smirnov (K-S) test on f(obs.) vs. f(pred.)

the variances of the observed and predicted values is provided to indicate whether the distribution of values in the two data sets is comparable. Similarly, the frequency distribution of observed values is compared with that for predicted values.

Standard statistical methods have been used to estimate confidence limits for each of the performance measures. Discussion of the statistical procedures may be found in most statistics textbooks. For parametric procedures, the reader is referred to Snedecor and Cochran (1967),[12] while for nonparametric procedures Hollander and Wolfe (1973)[13] provide an appropriate description.

For paired comparisons, the confidence interval on the average residual can be estimated using the one-sample t test. This parametric test incorporates the assumption that the residuals follow a normal distribution, but for large N, departures from normality are not critical when the number of events is large. Serial correlation can affect results significantly, however, since the number of "independent events" will be overestimated and the calculated variance may understate the magnitude of the actual random error component. The AMS workshop recommended the adjustment of confidence limits for serial correlation. A method described by Hirtzel and Quon (1981)[14] has been used to adjust the confidence interval from the one-sample t test. The interval given by the standard one-sample t test is multiplied by the factor $[(1+r)/(1-r)]^{1/2}$, where r is the lag-one autocorrelation coefficient of the residuals.

An analogous nonparametric indicator of model bias is the median residual. The statistical method for estimating a confidence interval on the median residual is provided by the Wilcoxon matched-pairs test. No straightforward method of adjusting the confidence intervals from the Wilcoxon test for serial correlation has been identified.

A confidence interval for the variance of the residuals is calculated using a chi-squared test. No adjustment was made for serial correlation. No standard method is available for estimating confidence intervals for the gross variability or average absolute deviation measures. For the Pearson correlation coefficient, the Fisher z test provides a method of estimating the confidence interval.

Comparison of two cumulative distribution functions is accomplished using the Kolmogorov-Smirnov (K-S) test. For this test, the two distribution functions are compared across the full range of concentration values, and the maximum frequency difference between the two functions is identified.

For unpaired comparisons, two bias measures are computed. The average of the observed values is compared with the average of the predicted values. The confidence interval on the difference of the averages is estimated with a two-sample t test. The difference of the medians is also computed, and the confidence interval is estimated using the Mann-Whitney nonparametric test. As noted previously, assumptions regarding data independence are not strictly valid for the "highest 25 value" data sets.

The variance of observed values is compared with the variance of predicted values for unpaired data sets. The performance measure is the ratio of the variances; the F test provides confidence limits on the ratio. The frequency distribution comparison for unpaired data sets provides a measure of the difference between the observed and predicted distribution functions. The K-S test is again used to assess the statistical significance of the maximum frequency difference.

The specific performance measures and statistics calculated for each data set are summarized in Tables 3-3 and 3-4. The notation for identifying

TABLE 3-3

PERFORMANCE MEASURES AND STATISTICS FOR UNPAIRED (25 HIGHEST) DATA SETS

	Average Observed	Average Predicted	Difference of Averages	Difference of Medians	Variance Ratio	Freq. Dist. Comparison
All stations/ all events (A-4a)	✓	✓	✓(C.I.)*	✓(C.I.)*	✓(C.I.)	✓(C.I.)
By Station/ all events (A-4b)	✓	✓	✓	X	✓	X
Subsets by met. conditions (A-5)	✓	✓	✓	X	✓	X

* C.I. = confidence interval

TABLE 3-4

PERFORMANCE MEASURES AND STATISTICS FOR DATA SETS PAIRED IN TIME OR LOCATION

	Highest Per Event Paired in Time (A-1)	Highest Per Station Paired by Location† (A-2)	All Events Paired in Time and Location (B-3)	All Events at Each Station Paired in Time (B-1)	Subsets of Events Paired in Time and Location (B-4)
Number	✓	✓	✓	✓	✓
Average Observed	✓	✓	✓	✓	✓
Average difference	✓(C.I.)*	✓(C.I.)	✓(C.I.)	✓	✓
Fraction Co > Cp	x	✓	✓	x	x
Characteristic Discrepancies					
σ_d	✓(C.I.)	✓(C.I.)	✓(C.I.)	✓	✓
RMSE	x	✓	✓	x	x
AAR	x	✓	✓	x	x
Correlation Coefficients					
Pearson R	x	✓	✓	x	x
Spearman ρ	x	✓	✓	x	x
Variance comparison	x	✓(C.I.)	✓(C.I.)	x	x
Maximum Frequency	✓(C.I.)	✓(C.I.)	✓(C.I.)	x	x

* C.I. = confidence interval
† These performance statistics were also provided for annual averages and for the second-highest values per station.

data sets corresponds to that employed in Table 3-1. Table 3-3 indicates that the full set of estimators and confidence interval calculations will be provided for the 25 highest values over all stations and events (A-4a), but only a partial set of measures is provided by station (A-4b) or for subsets by time of day or meteorology (A-5).

For the paired data sets (Table 3-4), the highest priority is placed on comparisons of the highest value per station (A-2) and all events paired in time and location (B-3). The remaining data sets received a more limited analysis. For the annual average data set, the estimators and confidence intervals indicated for the (A-2) data set are provided.

STATISTICAL EVALUATION SYSTEM

The statistical evaluation system adapted for the model evaluations consists of two components: a preprocessor to sort the "work files" of observed and predicted hourly concentrations into data sets for statistical analysis; and a statistical package to compute values and confidence intervals for the performance measures. The work files, plus associated hourly meteorological parameters, are sorted by the statistics preprocessor into a number of data sets. The preprocessor computes block-average values, beginning each day at midnight, for 3- and 24-hour periods, screens each pair of measured and predicted concentrations according to threshold values, and then constructs the individual files required to perform each type of comparison listed in Table 3-1.

The statistical package then calculates the specific performance measures listed in Table 3-2. The statistical computations were performed on the EPA Univac 1110 computer, using the Statistical Package for the Social Sciences (SPSS).[15,16] TRC constructed two basic SPSS runstreams, one to implement the paired comparisons, the other for unpaired comparisons, and applied each as appropriate to the various data sets.

The SPSS output from the Wilcoxon matched-pairs test could not be used in the form provided by SPSS, and this comparison has therefore been dropped from the result tables. (The Wilcoxon results are generally redundant with the t test, and were therefore judged to be dispensable in light of the considerable effort required to recompute them separately.)

SECTION 4

DESCRIPTION AND ADAPTATION OF THE URBAN MODELS

TRC has evaluated the performance of six Gaussian urban air quality models using performance measures recommended by the American Meteorological Society. Four are annual-average climatological models (AQDM,[17] CDM,[18] ERTAQ[19] and TCM[20]) and two are hour-by-hour models (RAM[21] and TEM-8A[22]). AQDM, CDM and RAM are EPA models; TCM and TEM-8A were developed by the Texas Air Control Board; and ERTAQ was developed by Environmental Research and Technology, Inc. (ERT). (ERTAQ, while primarily a long-term model, does have a short-term mode. ERT, however, recommended that only the long-term mode be evaluated.) The distinguishing features of the urban models are summarized below, then the model input options and code modifications required to run the models are documented.

DISTINGUISHING FEATURES OF THE URBAN MODELS

Distinguishing features of the urban models as run for the current evaluation are listed in Table 4-1, and described briefly below. Particular model options and run modes were specified by the model developers. It is not the intent here to fully describe each of the urban models. In-depth technical discussions of each model can be obtained from the individual appropriate model-user guides. (Documentation for the current version of the RAM model is contained in comment statements embedded in the computer code.) The reader is encouraged to refer to the user's manuals for technical details and references.

TABLE 4-1

DISTINGUISHING FEATURES OF THE URBAN MODELS
AS RUN FOR THE CURRENT EVALUATION

AQDM

- Final plume rise
- Five-category regular (A-E) STAR deck
- Stability E is changed to stability D for σ_z calculations
- Mixing height varies with stability
- Area sources modeled as virtual point sources
- Rural vertical dispersion coefficients
- Linear interpolation between 22.5° sectors for horizontal distribution
- Total plume reflection at surface and mixing lid
- No increase in wind speed with height
- Uniform vertical mixing when downwind distance $\geq 2X_L$, where X_L = distance where $\sigma_z = 0.47*$ mixing layer depth
- Input area source heights

CDM

- Transitional plume rise
- Six-category day/night STAR deck
- Mixing height varies with stability
- E stability class changed to class D for point sources
- All stabilities (except A) are made one class less stable for area sources
- Rural vertical dispersion coefficients
- Linear interpolation between 22.5° sectors for horizontal distribution
- Wind speed increase with height is stability dependent
- Four-hour pollutant half-life input for half-life option
- Impact of area sources computed using sector integration
- Total plume reflection at ground and mixing lid
- Initial σ_z of 30 meters for area sources
- Initial σ_z for point sources is 30 m for stacks <20 m; 0 for stacks >50 m; and linearly interpolated in between
- Uniform vertical mixing when downwind distance $\geq 2X_L$, where X_L = distance where $\sigma_z = 0.47*$ mixing layer depth
- Input area source heights

ERTAQ

- Final plume rise
- Five-category regular (A-E) STAR Deck
- Mixing height varies with stability
- 45° triangular crosswind distribution
- Stability classes reduced by one class for urban modeling
- Initial σ_z = 30 meters for area sources
- Initial σ_z for point sources is a function of stack height
- Rural vertical dispersion coefficients
- Perfect reflection at ground and mixing lid
- Wind speed increase with height is stability dependent
- Infinite half-life used for pollutant decay
- Minimum allowable downwind distance = 10 meters
- Area source impacts computed using rectangular increments in the upwind direction
- Input area source heights

TABLE 4-1 (Continued)

DISTINGUISHING FEATURES OF THE URBAN MODELS AS RUN FOR THE CURRENT EVALUATION

RAM

- Final plume rise
- Stack tip downwash
- Buoyancy induced dispersion
- Hourly meteorological and source data
- Four-hour pollutant half-life input for half-life option
- Wind speed increase with height is stability dependent
- Input area source heights
- Urban horizontal and vertical dispersion coefficients
- Plume reflection at ground and mixing layer
- Plume penetration when effective plume height > mixing depth
- Minimum wind speed limited to 1.0 m/s for calculations

TCM

- Transitional plume rise
- Six-category day/night STAR deck
- Rural vertical dispersion coefficients
- E stability class changed to class D for point sources
- Stability class reduced by one for area sources
- Pollutant decay not used
- 22.5° sector averaging
- Area source contributions calculated only for a maximum of five basic area source grids upwind of receptor
- Wind speed increase with height is stability dependent
- Perfect reflection at ground
- No treatment of mixing lid
- Area source emissions assumed from ground level
- 10 meters $\leq$ effective stack height $\leq$ 2000 meters

TEM-8A

- Transitional plume rise
- Hourly meteorological and source data
- Stack tip downwash option not used
- Rural horizontal and vertical dispersion coefficients
- σ_y corrected for averaging times other than 10 minutes
- Pollutant decay option not used
- Area source contributions calculated only for a maximum of five area sources upwind of receptor
- Uniform vertical mixing when downwind distance $\geq 2X_L$, where X_L = distance where $\sigma_z = 0.47_*$ mixing layer depth
- Plume penetration of mixing lid (L) for effective stack height $\geq 2 * L$, when physical stack height < L
- Perfect plume reflection from ground but not from the mixing lid
- 10 meters $\leq$ effective stack height $\leq$ 2000 meters
- Area source emissions assumed from ground level
- Wind speed increase with height is stability dependent
- No minimum wind speed for calculations

Plume Rise

All of the models calculate an effective stack height for point source emissions based on various Briggs plume rise formulations (see appropriate user manuals for references). The transitional plume rise concept employed by CDM, TCM, and TEM-8A uses the distance-dependent plume rise formulations. AQDM, ERTAQ and RAM use final plume rise for calculating effective stack height at all distances from the source.

TCM does not include a limit to vertical mixing. TEM-8A allows plume rise through the top of the mixing layer only when the effective stack height is at least twice the mixing layer depth (see sub-section on mixing height). RAM, AQDM, ERTAQ, and CDM allow plume rise through the top of the mixing layer. RAM also computes the effect of stack tip downwash on plume rise.

Dispersion Coefficients

The rural, Pasquill-Gifford vertical dispersion coefficents are used by all of the urban models except RAM which uses the urban, McElroy-Pooler vertical dispersion coefficients. CDM and ERTAQ assume an initial $\sigma_z = 30$ meters for area sources, and an initial σ_z dependent on stack height for point sources.

TCM, AQDM and CDM employ 22.5° crosswind sector averaging, with AQDM and CDM using a linear interpolation between adjacent sectors. ERTAQ uses a 45° triangular crosswind distribution. RAM and TEM-8A use the urban, McElroy-Pooler and the rural, Pasquill-Gifford horizontal dispersion coefficients, respectively. The TEM-8A model enhances the horizontal dispersion coefficients as a function of stability to account for the dispersive effect resulting from atmospheric motions on time scales greater than 10 minutes. RAM contains an algorithm to account for enhanced horizontal and vertical dispersion resulting from buoyant plume rise.

Stability Classification

All of the urban models classify atmospheric stability as follows: A is extremely unstable, B is moderately unstable, C is slightly unstable, D is neutral, E is slightly stable, and F is moderately stable. ERTAQ and AQDM use 5 stability categories (A, B, C, D, E-F); CDM and TCM expect the neutral category, D, divided into day and night components, yielding six stability categories (A, B, C, DD, DN, E-F). Both RAM and TEM-8A accept 7 stability categories as input (A, B, C, D, E, F, G), where G represents extremely stability; RAM then treats stability G as equivalent to F. Additionally, TEM-8A internally splits the neutral category into daytime and nighttime components.

To simulate the effects of enhanced turbulence in urban environments, several models adjust input stability class to a less stable category. ERTAQ reduces each input stability category by one, except A stability. In AQDM, stability E-F is changed to stability D for σ_z calculations. TCM and CDM convert E and F stability to D for point source computations, and shift all input stabilities except A to the next less stable category for area source computations. TEM-8A (in the urban mode) treats stability classes E, F, and G as class D.

Meteorological Joint Frequency Function (STAR) for Annual Models

Wind speed, wind direction, and stability class data are input to the annual models AQDM, CDM, ERTAQ and TCM with the use of a joint frequency function (also known as a stability array or STAR deck). The STAR data, based on meteorological observations at Lambert field and at the 25 RAMS stations, consists of the fractional frequencies of occurrence for each possible combination of stability (5 or 6 categories), wind direction (16 categories), and wind speed (6 categories). Stability categories for the annual models are described above. TRC created a 5-stability category STAR deck for AQDM, and

ERTAQ by combining the D-day and D-night categories from the original (6 category, day-night) STAR deck. Wind speed and direction categories were identical for all of the long-term models, and are documented in Appendix B.

Mixing Height

All of the urban models, except TCM and TEM-8A, assume that a plume having an effective release height less than the mixing height will be reflected by the elevated stable layer. When the effective plume height exceeds the mixing height, however, these same models assume full plume penetration of the elevated stable layer, resulting in zero ground level concentrations.

Slightly different assumptions are made by the models TCM and TEM-8A. TCM does not include any treatment of mixing height for either plume reflection or plume penetration. TEM-8A uses an inversion penetration factor (I, set to I = 2). When the effective stack height exceeds twice the mixing height (L), TEM-8A assumes that the plume escapes the mixed layer (i.e., ground level concentrations are set to zero). Otherwise the effective stack height (with an upper limit of L) is used in the dispersion calculations.

In the models TEM-8A, AQDM, CDM and ERTAQ uniform vertical mixing is assumed to result beyond twice the distance where σ_z exceeds 0.47 times the mixing height. With RAM, uniform mixing is assumed beyond the distance where σ_z exceeds 1.6 times the mixing height. Uniform vertical mixing is not simulated in TCM.

Wind Profile

All the models except AQDM use a power law formulation to adjust wind speed from measurement height to stack height. The wind profile exponents, as used in this study, are shown below in Table 4-2.

TABLE 4-2

WIND PROFILE EXPONENT BY STABILITY

Model	A	B	C	D	E	F
RAM	.15	.15	.20	.25	.40	.60
CDM	.10	.15	.20	.25	.30	.30
TEM-8A	.10	.15	.20	.25	.30	.30
TCM	.10	.15	.20	.25	.30	.30
ERTAQ	.10	.15	.20	.25	.30	.30

Area Source Treatment

TCM and TEM-8A use a method developed by Gifford and Hanna to calculate area source contributions. These models require a rectangular grid of square area sources, with the grid size equal to the side length of the smallest area source. With these models, the simulation is limited to a maximum of five area sources for calculation of impact on a given receptor for a given wind direction. The five sources include the area source containing the receptor and up to 4 upwind area sources. If the area sources in question are larger than the basic grid size, fewer than 5 area sources may impact a receptor for a given wind direction. Also, area sources are assumed to emit at ground level in TCM and TEM-8A.

In ERTAQ, the contribution of each area source to each receptor is calculated by integrating over the total area of the area source. All area sources upwind of a receptor may have an impact on that receptor. Area source heights can be input separately for each source.

AQDM simulates area sources through the use of virtual point sources. The virtual emission point is located upwind from the area source such that the width of a 22.5° angle originating at the virtual point and extending to the midpoint of the area source equals the width of the area source. Area sources which do not fall entirely within a 22.5^{o} sector upwind of the receptor are reduced by a factor equal to the fraction of the area source contained within the 22.5^{o} sector. Area source heights are input by the user.

CDM performs an angular integration over the 22.5^{o} sector upwind of the receptor in question to compute area source impact at the receptor. The number of angular sections into which each 22.5^{o} sector is divided for integration, and the radial distance increment of integration are user inputs. Values of 4 angular sections and an initial radial increment of 250 meters were chosen for the integrations. Area source heights are input by the user.

RAM uses a narrow plume approximation to compute the concentration at a receptor due to area sources. As run, the RAM model places each area source into one of three area source height categories before performing the integrations.

Pollutant Half-Life

RAM and CDM were run using an exponential pollutant decay half-life of 4 hours. ERTAQ, TCM and TEM-8A used an infinite pollutant half-life. AQDM does not allow for pollutant decay.

MODEL MODIFICATIONS AND OPTIONS

Certain modifications to the model codes were needed to carry out the evaluations. Modifications were required specifically:

- To adapt some models to the EPA UNIVAC computer.
- To enable particular models to accept the large source inventory.

- To format calculated concentrations for input to the statistics system.

Prior to running the urban models for evaluation with the RAPS data base, it was desireable to confirm that the models would be run in accordance with the expectations of the model developers. As described in Section 1, a model-specific test-run package was prepared and supplied to each model developer for formal review and concurrence. Comments received from the model developers were addressed by TRC prior to performing the final model runs for the statistical evaluations. The modifications required for each model are described below, and in addition, the user-supplied technical options selected for each model by its developer are listed.

CDM: Modifications and Options

a. Technical Modifications to CDM

EPA provided TRC with a version of CDM modified to increase the number of point and area sources which can be input to the model. This permitted modeling of the 235 point sources and 1536 area sources in the RAPS data base in a single run. TRC made several additional modifications to CDM. Code was added to facilitate writing calculated concentrations to a work file for subsequent statistical analysis. TRC modified the CDM program to replace dimensioned variables with simple variables when used as exponents. This change was necessary because the current EPA UNIVAC operating system does not correctly compute an arrayed exponential when more than 65 K words of core are required by the program. TRC also added statements to ensure that the model would run when input stack temperature is less than ambient temperature.

b. CDM Input Options and Variables

CDM Input Options and Variables	Description
• DELR = 250 meters	Initial area source integration increment.

- DINT = 4 — Number of intervals used to integrate over 22.5° sector.
- SA = 0 — Briggs plume rise used.
- HT = 1400 meters — Holzworth afternoon mixing height for St. Louis.
- HMIN = 400 meters — Holzworth morning mixing height for St. Louis.
- TOA = 13.3°C — Climatological mean ambient temperature for St. Louis.
- SZA (1-6) = 30 meters — Initial σ_z for each stability class for area sources.
- YD = 1.05, YN = 0.97 — Ratios of average daytime and nighttime emission rates to the 24-hour emission rate.
- GB (1) = 4 hours — Pollutant decay half-life.

AQDM (Briggs Plume Rise Version): Modifications and Options

a. Technical Modifications to AQDM

The version of AQDM was utilized that provides for use of Briggs plume rise. TRC modified AQDM to write calculated concentrations to an annual work file, to allow 13 non-grid receptors instead of 12, and to input data as formatted READ, rather than NAMELIST format.

b. AQDM Input Options and Variables — Description

- DPTHMX = 1400 meters — Holzworth average afternoon mixing depth for St. Louis.
- TA = 286.5 K — Climatological mean ambient temperature for St. Louis.
- PA = 1000 mb — Ambient pressure - model default value.

ERTAQ: Modifications and Options

a. Technical Modifications to ERTAQ

TRC altered ERTAQ in three areas. The model was adjusted to accept input data from the model input file on Unit 18 rather than Unit 5. Statements were added to facilitate writing calculated concentrations to an annual work file for subsequent statistical analysis. Finally, the model input read statements for source data were modified to accept more than 99 sources.

b. ERTAQ Input Options and Values — Description

ERTAQ Input Options and Values	Description
• A, B, C = default values	Vertical dispersion coefficients.
• X1, X2, X3 = default values	Crossover distances for vertical dispersion.
• EX = default	Exponents for wind profile.
• Z_0 = 30 meters	Reference height for wind profile.
• XMIN = 10 meters (default)	Minimum allowable downwind distance.
• NCOMP = 5 (default)	Maximum number of area source subdivisions.
• REGION = URBAN	Dispersion option.
• METHOD = 2	Triangular horizontal dispersion.
• WS = default	Wind speed for each class.
• DEPTH = 1400 meters	Mean mixing height.
• TAMB = 286.5 K	Climatological mean ambient temperature.
• PAMB = 1000 mb	Ambient pressure for printout.

TCM: Modifications and Options

a. Technical Modifications to TCM

The TCM model was modified to accept input data from a disk file, and to write calculated concentrations to an annual work file for subsequent statistical analysis. The TCM model assumes a fixed anemometer height of 10 meters, so code changes were made for the TCM model to assume an anemometer height of 30 meters (consistent with Texas Air Control Board recommendations).

b. TCM Input Options and Variables

TCM Input Options and Variables	Description
• LX = LY = 1	Number of rows and columns in the receptor grid.
• NPRISE = 0	Transitional plume rise used.
• IURBAN = 1	Urban dispersion used.
• TA = 13.3°C	Climatological mean ambient temperature for St. Louis.
• ASCALE = 1.0	Area source emission scaling factor.

c. Other TCM Technical Considerations

The specification of receptor locations in TCM is complicated by the linkage between the area source grid and receptor grid. In order to specify receptor locations exactly in TCM, only one receptor can be input for any given model run. Therefore, TCM was run 13 separate times, once for each of the 13 RAMS SO_2 monitor locations. TCM calculates impacts only for area sources located within four emission grid squares from the grid square in which a receptor resides. Since the emissions grid width for the RAPS area sources is one kilometer, only area sources within four to five kilometers of each receptor were considered by TCM. Potentially important impacts from area sources that exist beyond that distance would not be simulated.

The TCM and TEM-8A user's guides also recommend that the area source emissions grid be designed with the same spacing as the receptor grid, but displaced such that receptors (at the receptor grid intersections) are located at the center of the area-source grid squares. Restructuring of the 1,536 RAPS area sources with respect to each of the 13 monitoring stations in order to accomodate this recommendation would be prohibitively costly. Following discussions with EPA, the Texas Air Control Board agreed that use of the RAPS inventory, as originally structured, will result in a useful performance evaluation of the TCM and TEM-8A models.

TEM-8A: Modifications and Options

a. Technical Modifications to TEM-8A

TRC added code to TEM-8A to write calculated concentrations to hourly and annual work files for subsequent statistical analysis. The code was altered to allow input from disk file rather than cards. TRC also inserted logic to read in hourly values of point and area source emissions, stack temperature, and volume flow rate, and to convert these values into TEM-8A compatible units. As with TCM, the TEM-8A model assumes an anemometer height of 10 meters. Code changes were made to the TEM-8A model to assume an anemometer height of 30 meters.

b. TEM-8A Input Options and Variables	Description
• NTOPT = 9	Hourly meteorological data on tape; plume penetration factor = 2.0.
• NSTDWN = 1	Stack-tip downwash algorithm not used.
• LX = LY = 1	Numbers of rows and columns in receptor grid.

- DTDZ = default — Potential temperature gradient for stable conditions.
- ASCALE = 1.0 — Area source emission scaling factor.
- IWIND = 1 — Measured wind direction entered to the nearest degree.

c. Other TEM-8A Technical Considerations

Considerations regarding the specification of receptor locations and area sources in TEM-8A are identical to those described previously for TCM.

RAM: Modifications and Options

a. Technical Modifications to RAM

TRC made modifications to RAM in five areas. The number of area sources allowed in the model was increased so that the 1536 RAPS area sources could be input in a single run. Statements were added to read in hourly source data, and to convert source data into units compatible with RAM. Code was inserted to compute and write calculated concentrations to an hourly work file for subsequent statistical analysis. As with CDM, the RAM model requires more than 65 K words of computer core. Therefore, use of arrayed variables as exponents (a problem with the current EPA-Univac 1100 system) can lead to computational errors. RAM was modified to circumvent this problem. Finally, TRC changed RAM so that actual, rather than interpolated, hourly stack data could be used in the calculation of plume rise.

b. RAM Input Options and Variables	Description
• MUOR = 1	Urban mode.
• Z = 0. meters	Receptor height.
• IOPT (1) = 0	Include stack downwash.

• IOPT (2) = 1	No gradual plume rise.
• IOPT (3) = 1	Include buoyancy-induced dispersion.
• HANE = 30 meters	Anemometer height.
• HALF = 14,400 seconds (4 hours)	Pollutant half-life.
• PL (1-6) = .15, .15, .20, .25, .40, .60	Wind profile exponents for stabilities A-F.
• FH = 0.75	Fraction of area source height which is physical height.
• XLIM = 115 kilometers	Distance limit on integration for area sources.
• NHTS = 3	Number of heights to be used for area sources.
• HINT = 10, 15, or 20 meters	Area source heights.
• PPH = 12 or 17 meters	Breakpoint heights between area source heights.

c. Other RAM Technical Considerations

The area source algorithm in the RAM model allows the definition of up to three area source height categories to be used in the integrations. Following discussions with Bruce Turner (EPA), the use of 10 meter, 15 meter, and 20 meter area source heights with breakpoints at 12 meters and 17 meters were recommended as input variables to the RAM model.

SECTION 5

MODEL PERFORMANCE RESULTS

Comparisons between observed and predicted concentrations have been produced for four annual average models and two short-term models. The performance measures and statistics calculated for each model are described in Section 3. The model performance results are organized into a series of tables. In this section, the results are presented and discussed.

ANNUAL AVERAGE MODELS

For the annual average models, the entire data set consists of one observed and one predicted concentration value for each of the 13 RAPS monitoring stations. These values are listed in Table 5-1. When observed and predicted annual concentrations are compared, several differences are evident. The highest measured annual value occurred at Station 104 and is more than twice as large as the second-highest value. The highest predicted values occurred at Station 101 for all four models. The highest predicted value for each model is lower than the highest observed value. The lowest predicted values occurred at the same two stations (120 and 122) for all of the models, while the lowest observed value occurred at Station 116.

Performance measures and statistics for the annual average models are presented in Table 5-2. The average difference between the observed and predicted values for all stations is a measure of model bias, i.e., whether the model systematically over- or underpredicts. ERTAQ gave the largest overprediction (a negative difference means predicted is greater than

TABLE 5-1

URBAN ANNUAL AVERAGE MEASURED AND PREDICTED SO_2 CONCENTRATIONS FOR ST. LOUIS 1976 ($\mu g/m^3$)

Station	Measured	AQDM	CDM	TCM	ERTAQ
1 (101)[a]	55	82.4	83.4	102.0	100.9
2 (103)	36	50.1	51.2	43.8	61.3
3 (104)	116	62.2	62.4	52.6	79.5
4 (105)	43	56.6	45.5	34.4	57.1
5 (106)	52	60.7	45.7	39.6	58.1
6 (108)	37	41.9	42.2	41.7	52.6
7 (113)	36	40.2	32.9	27.1	42.8
8 (114)	35	33.1	31.6	29.4	44.1
9 (115)	28	29.1	43.9	46.6	49.5
10 (116)	24	25.6	23.0	24.0	31.3
11 (120)	27	22.7	15.3	12.4	24.8
12 (121)	30	24.6	18.1	17.1	30.1
13 (122)	27	19.9	14.3	15.0	26.9
Average	42	42.2	39.2	37.4	50.7

[a]RAPS/RAMS monitoring ID codes in parentheses.

TABLE 5-2

COMPARISON OF ANNUAL AVERAGE OBSERVED AND PREDICTED
CONCENTRATION VALUES PAIRED BY STATION

MODEL	AVERAGE OBSERVED VALUE (UG/M**3)	AVERAGE DIFFERENCE* (OBS-PRED) (UG/M**3)	FRACTION OF POSITIVE RESIDUALS (OBS>PRED)	STANDARD DEVIATION OF RESIDUALS* (UG/M**3)	ROOT MEAN SQUARE ERROR (UG/M**3)	AVERAGE ABSOLUTE RESIDUAL (UG/M**3)	PEARSON CORR. COEF.	SPEARMAN CORR. COEF.	VARIANCE COMPARISON* (OBS/PRED)	FREQUENCY DISTRIBUTION COMPARISON* (FOBS-FPRED)
AQDM	42	-0 (-12, 11)	0.38	19 (13, 31)	18	11	0.64	0.94	1.61 (0.49, 5.28)	0.23 (.533)
CDM	42	3 (-9, 15)	0.62	20 (14, 32)	19	13	0.62	0.85	1.48 (0.45, 4.84)	0.31 (.533)
ICM	42	5 (-10, 19)	0.69	25 (18, 41)	24	17	0.46	0.73	1.09 (0.33, 3.56)	0.31 (.533)
ERTAQ	42	-9 (-20, 3)	0.23	19 (13, 31)	20	15	0.67	0.87	1.23 (0.37, 4.03)	0.38 (.533)

* 95 PERCENT CONFIDENCE INTERVAL IN PARENTHESES

observed) and TCM the largest underprediction. The average difference, however, is not significantly different from zero for any of the models, at a 95 percent confidence level. The fraction of positive residuals (stations with observed value larger than predicted) ranged from 0.23 to 0.69. (When this fraction is greatly different from 0.5, model bias is indicated.)

The magnitude of differences between observed and predicted annual-average values at each station is characterized by three measures: the standard deviation of residuals, root mean square error, and average absolute residual. AQDM has the smallest values for all three measures, and TCM has the largest. The confidence intervals on the standard deviation values indicate that differences between the models are not significant at a 95 percent confidence level.

The Pearson and Spearman correlation coefficient values indicate that correlation between observed and predicted values at the same station is comparable for AQDM, CDM, and ERTAQ, but somewhat lower for TCM. Conversely, the variance of the concentration values predicted by TCM is closer to the observed variance (the ratio is closer to one) than the variances predicted by the other three models. The confidence intervals indicate that none of the variance ratios are significantly different from one. The frequency difference comparisons indicate that the observed and predicted cumulative distributions (of 13 values) differ by at most 20 to 40 percent (0.2 to 0.4).

In summary, the performance statistics for the annual average models indicate some differences in performance among the models, but for this small data set none of those differences are significant at a 95 percent confidence level. All of the models underpredicted the highest annual average value, and none predicted the highest value where it was was observed.

From Table 5-1, the annual-average concentration observed at Station 104 is much larger than that observed at any other station. Also, the concentrations predicted by the models at Station 101 are much larger than at the other stations. In addition, from information presented in the next section it is apparent that Stations 104 and 101 dominate the 25 highest observed and predicted short-term concentrations, respectively. Model performance in relation to Stations 101 and 104 has recently been investigated by Ruff.[23] While the conclusions from this investigation are not definitive, Ruff does suggest that the aggregation of several small but distinct sources as one area source could be responsible for the overprediction at Station 101. For Station 104, Ruff believes that certain emission sources may have been inadequately quantified or were neglected in the RAPS inventory, leading to model underprediction. To the degree that the RAPS emissions inventory is subject to such shortcomings, the model evaluation results involving Stations 101 and 104 would be affected.

If Stations 101 and 104 were excluded from the analysis, many of the model performance statistics presented here for both the annual and short-term models would change significantly. For example, if Station 104 were excluded from the data set, the annual-average observed value (Table 5-2) would decrease from 42 to 36 $\mu g/m^3$, and the observed variance would decrease by a factor of five. Only the non-parametric measures (fraction of positive residuals, Spearman correlation, and frequency distribution comparison) would not change substantially if Station 104 is removed.

The present study is concerned with the operational evaluation of urban models, that is, as typically applied in the regulatory setting. From this standpoint, the limitations of the comprehensive RAPS emissions inventory are no greater (and likely fewer) than what one would encounter using any other urban emissions inventory in model applications. The model evaluation results presented here, therefore, are certainly representative in an operational sense.

SHORT TERM MODELS

For the two short term models, RAM and TEM-8A, a large number of performance measures have been calculated for data sets representing selected peak values and various data pairings for 1-, 3-, 24-hour averaging periods. Results are presented first for the unpaired (25 highest values) data sets and then for the paired data sets.

Unpaired Data Sets for 25 Highest Values

Table 5-3 summarizes results for the 25 highest observed and predicted values, over all events and locations, for all three averaging times. For TEM-8A, the average of the 25 highest predicted values is roughly twice as large as the average of the 25 highest observed values for each averaging time. For RAM, the average of the 25 highest predicted 1-hour values is lower than the observed average by about 15 percent; for 3-hour values, the average predicted by RAM is 40 percent lower than observed; and for 24-hour values RAM underpredicted by a factor of 2. Statistics indicate that the difference between the observed and predicted averages is non-zero at a 95 percent confidence level. Results for the difference of medians are very similar to those for the difference of averages.

The variance comparison results for TEM-8A indicate that the range of the 25 highest 1-hour and 3-hour values predicted by TEM-8A is much larger than observed. For 24-hour values, however, the variance ratio for TEM-8A is not significantly different from unity. Conversely, for RAM, the variance ratio is not significantly different from unity for 1-hour and 3-hour values, but the variance of predicted 24-hour values is much smaller than observed.

The frequency distribution comparison results indicate large differences (0.76 to 1.0) between the observed and predicted cumulative distributions for both models for all three averaging times. In general, there is little or no

TABLE 5-3

COMPARISON OF 25 HIGHEST OBSERVED AND PREDICTED SO_2 CONCENTRATION VALUES (UNPAIRED IN TIME OR LOCATION) FOR THE 1, 3, AND 24 HOUR AVERAGING PERIODS

RAPS (1976)

Model	Average Observed Value ($\mu g/m^3$)	Average Predicted Value ($\mu g/m^3$)	Difference of Averages* (Obs-Pred) ($\mu g/m^3$)	Difference of Medians* (Obs-Pred) ($\mu g/m^3$)	Variance Comparison* (Obs/Pred)	Maximum Frequency Difference
Averaging Time: 1 Hour						
TEM-8	1929	3998	-2069 (-2460, -1678)	-1838 (-2100, -1614)	0.07 (0.03, 0.16)	1.00 (0.385)
RAM	1929	1622	307 (137, 477)	325 (224, 456)	0.47 (0.21, 1.07)	0.76 (0.385)
Averaging Time: 3 Hours						
TEM-8	1351	2821	-1470 (-1757, -1183)	-1223 (-1493, -1101)	0.05 (0.02, 0.11)	1.00 (0.385)
RAM	1351	811	540 (457, 623)	584 (476, 614)	1.07 (0.47, 2.43)	1.00 (0.385)
Averaging Time: 24 Hours						
TEM-8	664	1312	-648 (-792, -504)	-647 (-750, -524)	0.61 (0.27, 1.38)	0.88 (0.385)
RAM	664	334	330 (237, 423)	282 (194, 357)	19.32 (8.51, 43.86)	0.96 (0.385)

*95 percent confidence interval in parentheses.

overlap between the distributions of the 25 highest observed and 25 highest predicted values.

As discussed previously, the upper range limit of the instrumentation used in the RAPS network to observe SO_2 was 1 ppm (approximately 2600 $\mu g/m^3$). In computing hourly average SO_2 concentrations for the RAPS archive, therefore, EPA deleted any 1-minute SO_2 concentrations in excess of instrument range.

Comparisons of the 25 highest observed and predicted values by monitoring station and for various data subsets reveal more detailed aspects of model performance. Results of such comparisons for 1-hour average values are presented in Table 5-4. For TEM-8A, comparisons by station indicate that the model overpredicted the average of the 25 highest values by more than a factor of two everywhere except at Station 104. At most stations, the variance of the 25 highest TEM-8A-predicted values was also larger than the observed variance. RAM overpredicted the average of the 25 highest values at 10 of the 13 stations; at 7 stations the predicted average was within 20 percent of the observed average, while three stations showed disagreement by more than a factor of two. Variance ratios for RAM showed large differences between the observed and predicted range of the 25 highest values, even at several stations where the average values were similar.

The results by station in Table 5-4 once again reveal the influence of Station 104 on peak observed concentrations. The average of the 25 highest observed values at Station 104 (1886 $\mu g/m^3$) is more than twice as large as that at any other station, and obviously dominates the average of the 25 highest values over all stations (1929 $\mu g/m^3$, from Table 5-3). For TEM-8A, the peak predicted values at Station 101 dominate the "all stations" results in a similar fashion.

TABLE 5-4

COMPARISON OF 25 HIGHEST OBSERVED AND PREDICTED SO_2 CONCENTRATION VALUES
(UNPAIRED IN TIME OR LOCATION) FOR THE 1 HOUR AVERAGING PERIOD

RAPS 1976

	TEM-8A				RAM			
Data Sets	Average Observed Value ($\mu g/m^3$)	Average Predicted Value ($\mu g/m^3$)	Difference of Averages (Obs-Pred) ($\mu g/m^3$)	Variance Comparison (Obs/Pred)	Average Observed Value ($\mu g/m^3$)	Average Predicted Value ($\mu g/m^3$)	Difference of Averages (Obs-Pred) ($\mu g/m^3$)	Variance Comparison (Obs/Pred)
By Station: (25 Highest Each Station)								
Station 1 (101)[a]	921	3940	-3019	0.18	921	904	17	10.50
Station 2 (103)	511	1678	-1167	0.54	511	599	-88	16.46
Station 3 (104)	1886	1721	165	0.23	1886	1133	753	1.72
Station 4 (105)	421	1798	-1377	0.11	421	884	-463	0.33
Station 5 (106)	652	1419	-767	1.78	652	603	48	16.10
Station 6 (108)	427	1595	-1168	1.61	427	626	-199	16.64
Station 7 (113)	440	1047	-607	1.43	439	514	-75	5.28
Station 8 (114)	452	1585	-1133	0.13	452	1053	-601	0.35
Station 9 (115)	353	2336	-1983	0.02	353	1461	-1108	0.04
Station 10 (116)	438	1351	-913	0.10	438	497	-59	3.12
Station 11 (120)	398	1093	-695	0.29	398	426	-28	4.66
Station 12 (121)	320	1139	-819	0.02	320	544	-224	0.19
Station 13 (122)	435	1022	-587	0.65	435	451	-16	9.11
By Time of Day: (25 Highest Each Period)								
0000-0600	1561	3801	-2240	0.11	1561	1424	137	0.60
0600-1200	1474	2274	-800	0.21	1474	881	593	1.55
1200-1800	1467	1443	24	1.11	1467	792	675	1.72
1800-2400	1329	2772	-1443	0.21	1329	1305	24	2.21
By Meteorological Condition: (25 Highest Each Category)								
A. Wind Speed								
<2.5 m/s	1671	3998	-2327	0.10	1671	1620	51	0.68
2.5 to 5 m/s	1696	1830	-134	3.87	1696	982	714	3.79
>5 m/s	881	977	-96	3.87	881	472	409	4.88
B. Stability Group								
Class A & B	657	784	-127	8.43	657	441	216	22.20
Class C	1333	1131	202	0.96	1333	539	794	15.21
Class D	1509	2463	-954	0.36	1509	688	821	6.49
Class E & F	1774	3970	-2196	0.09	1774	1622	152	0.65

[a]RAPS/RAMS monitoring ID codes in parentheses.

Results for subsets by time of day show a striking difference between observed and predicted behavior. Both models predicted higher peak values at night and lower peak values during the day, while peak observed values were very similar for all four time intervals.

Results for subsets by meteorological conditions show distinct differences in performance for the two models. TEM-8A overpredicted the 25 highest values for low wind speed conditions by more than a factor of two, but predicted the average of the 25 highest values for intermediate and high wind speeds within 10 percent. By contrast, RAM predicted the 25 highest values for low wind speeds within 10 percent, but underpredicted for highest wind speeds by about 40 percent. TEM-8A predicted the average of the 25 highest values for Classes A & B and Class C within 20 percent, but overpredicted for Class D by 60 percent and for Class E & F by more than a factor of two. RAM underpredicted the 25 highest values for Classes A & B (by 30 percent), Class C (by 60 percent) and Class D (by 55 percent), but predicted the average of the 25 highest values for Class E & F within 10 percent.

Station-by-station results for the 25 highest observed and predicted values for 3-hour and 24-hour averaging periods are presented in Tables 5-5 and 5-6. These tables reveal a pattern very similar to the 1-hour results. TEM-8A overpredicted the 25 highest values at all stations except Station 104, generally by more than a factor of two. By contrast, RAM predicted the average of the 25 highest values within 10 to 20 precent at roughly half of the stations for each averaging time. RAM underpredicted the peak 3- and 24-hour values at Station 104 by more than a factor of two and overpredicted consistently at Stations 101, 105, and 115.

TABLE 5-5

COMPARISON OF 25 HIGHEST OBSERVED AND PREDICTED SO_2 CONCENTRATION VALUES (UNPAIRED IN TIME OR LOCATION) FOR THE 3 HOUR AVERAGING PERIOD

RAPS 1976

	TEM-8A				RAM			
Data Sets	Average Observed Value ($\mu g/m^3$)	Average Predicted Value ($\mu g/m^3$)	Difference of Averages (Obs-Pred) ($\mu g/m^3$)	Variance Comparison (Obs/Pred)	Average Observed Value ($\mu g/m^3$)	Average Predicted Value ($\mu g/m^3$)	Difference of Averages (Obs-Pred) ($\mu g/m^3$)	Variance Comparison (Obs/Pred)
By Station: (25 Highest Each Station)								
Station 1 (101)[a]	453	2821	-2368	0.29	453	626	-173	8.87
Station 2 (103)	336	911	-575	1.65	336	372	-36	11.61
Station 3 (104)	1305	1121	184	0.47	1305	593	712	0.86
Station 4 (105)	269	949	-680	0.06	269	475	-206	0.39
Station 5 (106)	422	883	-461	0.60	422	338	84	2.80
Station 6 (108)	239	866	-627	0.05	239	330	-91	0.74
Station 7 (113)	254	623	-369	0.48	254	267	-13	1.21
Station 8 (114)	276	822	-546	0.21	276	408	-132	0.40
Station 9 (115)	221	1165	-944	0.04	221	633	-412	0.15
Station 10 (116)	245	728	-483	0.10	245	248	-3	2.12
Station 11 (120)	231	532	-301	0.35	231	171	60	9.89
Station 12 (121)	209	608	-399	0.05	209	253	-44	0.52
Station 13 (122)	237	582	-345	0.25	237	212	25	1.78

[a]RAPS/RAMS monitoring ID codes in parentheses.

TABLE 5-6

COMPARISON OF 25 HIGHEST OBSERVED AND PREDICTED SO_2 CONCENTRATION VALUES (UNPAIRED IN TIME OR LOCATION) FOR THE 24 HOUR AVERAGING PERIOD

RAPS 1976

	TEM-8A				RAM			
Data Sets	Average Observed Value ($\mu g/m^3$)	Average Predicted Value ($\mu g/m^3$)	Difference of Averages (Obs-Pred) ($\mu g/m^3$)	Variance Comparison (Obs/Pred)	Average Observed Value ($\mu g/m^3$)	Average Predicted Value ($\mu g/m^3$)	Difference of Averages (Obs-Pred) ($\mu g/m^3$)	Variance Comparison (Obs/Pred)
By Station: (25 Highest Each Station)								
Station 1 (101)[a]	135	1309	-1174	0.02	135	306	-171	0.36
Station 2 (103)	118	313	-195	1.92	118	149	-31	6.17
Station 3 (104)	661	482	179	4.92	661	215	446	17.45
Station 4 (105)	111	329	-218	0.13	111	200	-89	0.86
Station 5 (106)	171	344	-173	1.42	171	146	25	9.50
Station 6 (108)	104	274	-170	0.24	104	125	-21	0.54
Station 7 (113)	104	200	-96	0.37	104	93	11	1.07
Station 8 (114)	109	254	-145	0.20	109	117	-8	0.60
Station 9 (115)	88	460	-372	0.02	88	204	-116	0.13
Station 10 (116)	90	220	-130	0.53	90	85	5	6.36
Station 11 (120)	84	172	-88	0.18	84	61	23	2.90
Station 12 (121)	94	177	-83	0.12	94	77	17	1.34
Station 13 (122)	97	181	-84	0.47	97	76	21	2.30

[a]RAPS/RAMS monitoring ID codes in parentheses.

Paired Data Sets for Peak Values

Comparisons of the highest observed and predicted concentration values, paired in location or time, utilize the same measures and statistics described earlier for annual average model results. Table 5-7 presents the results for the highest observed and predicted 1-hour concentration values at each station, plus similar comparisons of the second-highest values. For TEM-8A, the average difference between observed and predicted highest values is negative, indicating overprediction, and the magnitude of this difference is larger than the average observed value. Results for second-highest values for TEM-8A also show large overprediction. For RAM, the average difference between highest observed and predicted values is small, relative to the average observed value; the average difference for second-highest values is even smaller. Confidence intervals indicate that the overprediction by TEM-8A is significant at a 95 percent confidence level, while the average differences for RAM do not represent statistically-significant bias. The results for the fraction of positive residuals are consistent with the average differences. TEM-8A overpredicted the highest values at 11 of the 13 stations, and overpredicted the second-highest values at all 13 stations. RAM underpredicted the highest and second-highest values at more than half of the stations.

The standard deviation of residuals, root mean square error, and average absolute residual for TEM-8A are all larger than the average observed value. All of these measures are smaller for RAM, indicating less scatter between observed and predicted values. Correlation coefficient values for both models, however, are lower than 0.3 in every instance. For RAM, the correlation between highest observed and predicted values station-by-station is negative. The ratio of observed to predicted variance of concentration values for TEM-8A was significantly less than unity, reflecting the larger

TABLE 5-7

COMPARISON OF MAXIMUM (HIGHEST AND SECOND HIGHEST) OBSERVED AND PREDICTED CONCENTRATION VALUES, PAIRED BY STATION FOR THE 1 HOUR AVERAGING PERIOD

RAPS (1976)

Model	Number of Data Pairs	Average Observed Value (μg/m³)	Average Difference* (Obs-Pred) (μg/m³)	Fraction of Positive Residuals (Obs >Pred)	Standard Deviation of Residuals* (μg/m³)	Root Mean Square Error (μg/m³)	Average Absolute Residual (μg/m³)	Pearson Corr. Coef.	Spearman Corr. Coef.	Variance Comparison* (Obs/Pred)
(i) Highest										
TEM-8	13	1389	-1711 (-2674, -748)	0.15	1592 (1142, 2630)	2295	1719	0.06	0.08	0.18 (0.06, 0.59)
RAM	13	1389	183 (-451, 817)	0.69	1048 (751, 1730)	993	863	-0.30	-0.24	0.88 (0.27, 2.89)
(ii) Second Highest										
TEM-8	13	997	-1446 (-2137, -755)	0.00	1144 (821, 1890)	1816	1446	0.24	0.02	0.23 (0.07, 0.75)
RAM	13	997	-31 (-441, 379)	0.62	677 (486, 1119)	652	516	0.10	0.01	1.44 (0.44, 4.72)

*95 percent confidence interval in parentheses.

magnitude and range of predicted values; variance ratios for RAM were not significantly different from unity.

Results for the highest and second-highest values paired by station for 3- and 24-hour averaging periods are presented in Tables 5-8 and 5-9. In general, the results for average difference show model bias similar to that for 1-hour values. TEM-8A overpredicts for both 3- and 24-hour averages; the average differences are as large or larger than the average observed values. RAM underpredicts by less than 15 percent for 3-hour average values and by about 25 percent for 24-hour averages. Measures of scatter between observed and predicted values are larger than the average observed value for TEM-8A, but are much smaller for RAM.

Correlation coefficients for 3-hour values are noticeably higher than for 1.0-hour values, indicating somewhat better success at predicting how peak values vary from station to station; but correlation coefficents for 24-hour values are lower than for 3-hour values.

The variance comparison results for TEM-8A continue to show ratios less than 1, but for 24-hour values the confidence intervals include unity. For RAM, the variance ratios increase with averaging time; for 24-hour values, the predicted variances are significantly smaller than observed.

The highest and second-highest values observed and predicted at each station for each averaging time are listed in Appendix C. These values represent the basis for the measures and statistics presented in Tables 5-7, 5-8, and 5-9. Appendix D provides tables of hourly meteorological and observed concentration data for selected days with high modeled concentrations.

Current air quality standards are based on the highest, second-highest SO_2 concentration value at any station for 3-hour and 24-hour periods. For the reader's information, Table 5-10 lists the observed and predicted values corresponding to the air quality standards. These single-value comparisons

TABLE 5-8

COMPARISON OF MAXIMUM (HIGHEST AND SECOND HIGHEST) OBSERVED AND PREDICTED CONCENTRATION VALUES, PAIRED BY STATION FOR THE 3 HOUR AVERAGING PERIOD

RAPS (1976)

Model	Number of Data Pairs	Average Observed Value ($\mu g/m^3$)	Average Difference* (Obs-Pred) ($\mu g/m^3$)	Fraction of Positive Residuals (Obs >Pred)	Standard Deviation of Residuals* ($\mu g/m^3$)	Root Mean Square Error ($\mu g/m^3$)	Average Absolute Residual ($\mu g/m^3$)	Pearson Corr. Coef.	Spearman Corr. Coef.	Variance Comparison* (Obs/Pred)
(i) Highest										
TEM-8	13	757	-983 (-1545, -421)	0.00	932 (668, 1538)	1329	983	0.50	0.37	0.20 (0.06, 0.66)
RAM	13	757	102 (-138, 342)	0.54	395 (283, 652)	393	279	0.56	0.48	2.84 (0.87, 9.32)
(ii) Second Highest										
TEM-8	13	622	-835 (-1253, -417)	0.00	694 (497, 1145)	1069	835	0.60	0.47	0.23 (0.07, 0.75)
RAM	13	622	49 (-147, 245)	0.54	326 (233, 538)	317	263	0.62	0.34	2.46 (0.75, 8.07)

*95 percent confidence interval in parentheses.

TABLE 5-9

COMPARISON OF MAXIMUM (HIGHEST AND SECOND HIGHEST) OBSERVED AND PREDICTED CONCENTRATION VALUES, PAIRED BY STATION FOR THE 24 HOUR AVERAGING PERIOD

RAPS (1976)

Model	Number of Data Pairs	Average Observed Value ($\mu g/m^3$)	Average Difference* (Obs-Pred) ($\mu g/m^3$)	Fraction of Positive Residuals (Obs >Pred)	Standard Deviation of Residuals* ($\mu g/m^3$)	Root Mean Square Error ($\mu g/m^3$)	Average Absolute Residual ($\mu g/m^3$)	Pearson Corr. Coef.	Spearman Corr. Coef.	Variance Comparison* (Obs/Pred)
(i) <u>Highest</u>										
TEM-8	13	323	-310 (-643, 23)	0.08	552 (396, 912)	614	390	0.06	0.42	0.37 (0.11, 1.21)
RAM	13	323	75 (-93, 243)	0.62	279 (200, 460)	278	170	0.34	0.38	6.75 (2.06, 22.14)
(ii) <u>Second Highest</u>										
TEM-8	13	279	-270 (-562, 22)	0.08	483 (347, 798)	537	342	0.12	0.37	0.46 (0.14, 1.51)
RAM	13	279	64 (-99, 227)	0.54	270 (194, 446)	267	159	0.35	0.40	7.66 (2.33, 25.12)

*95 percent confidence interval in parentheses.

provide no basis for statistical measures, however, and the AMS workshop recommendations do not include evaluations based on a data set comprised of highest second-high values.

TABLE 5-10

OBSERVED AND PREDICTED HIGHEST SECOND-HIGHEST VALUES

	3-Hour Average	24-Hour Average
Observed	1609	1170
RAM	1127	424
TEM-8A	4108	1852

Another paired data set consists of the highest observed and predicted values over the monitoring network from each sampling period, paired in time. Results for all three averaging periods are presented in Table 5-11. While the data sets discussed up to this point contained relatively few points, event-by-event comparison for a year of data involve much larger volumes of data (i.e., a large "N").

Results for 1-hour average values show negative average differences for both models, indicating overprediction. Both values are significantly different from zero (the large N leads to a narrow confidence interval), but the average difference for TEM-8A is more than twice the average observed value, while for RAM it is only about 20 percent of the average observed value. (Because pairs with both observed and predicted values below 25 $\mu g/m^3$ were excluded from analysis, the number of events is slightly different for the two models.) The standard deviation of residuals for both models is larger than the average observed value; the standard deviation for TEM-8A is much larger than for RAM. The maximum difference between the observed and predicted cumulative frequency distributions is also much larger for TEM-8A.

TABLE 5-11

COMPARISON OF HIGHEST OBSERVED AND PREDICTED SO_2 CONCENTRATON VALUES EVENT-BY-EVENT (PAIRED IN TIME) FOR THE 1, 3, AND 24 HOUR AVERAGING PERIODS

RAPS (1976)

Model	Number of Events	Average Observed Value ($\mu g/m^3$)	Average Difference* (Obs-Pred) ($\mu g/m^3$)	Standard Deviation of Residuals* ($\mu g/m^3$)	Maximum Frequency Difference
Averaging Time: 1 Hour					
TEM-8	7891	165	-354 (-382, -326)	518 (510, 527)	0.52 (0.022)
RAM	7769	167	-35 (-49, -21)	290 (285, 295)	0.16 (0.022)
Averaging Time: 3 Hours					
TEM-8	2475	142	-320 (-350, -290)	455 (443, 468)	0.55 (0.039)
RAM	2431	145	-20 (-36, -4)	225 (218, 231)	0.17 (0.039)
Averaging Time: 24 Hours					
TEM-8	339	130	-317 (-366, -268)	290 (270, 314)	0.74 (0.104)
RAM	339	130	-5 (-34, 24)	165 (153, 178)	0.35 (0.104)

*95 percent confidence interval in parentheses.

Results for 3- and 24-hour average highest values paired in time are generally very similar. Both models overpredict on average, TEM-8A by a much larger degree than RAM. The standard deviation of residuals and the maximum frequency difference are also larger for TEM-8A. For 24-hour values, the average difference for RAM is not significantly different from zero at a 95 percent confidence level.

Paired Data Sets for All Values

The largest data sets considered in this evaluation represent all concentration values, paired in time and location. Results for these data sets, for all three averaging periods, are presented in Table 5-12. The size of the data sets for 1-hour values were so large that non-parametric statistics could not be calculated, due to computer work-space limitations. Results for the average difference between observed and predicted values indicate overprediction by TEM-8A (by a factor of 3) and by RAM (by 20 to 25 percent). The standard deviation, root mean square error, and average absolute residual values are generally larger than the average observed value for both models, but are substantially larger for TEM-8A than for RAM. Correlation between observed and predicted values increased with averaging time, but with little difference between the models. Variance ratios for TEM-8A were consistently less than 0.2, indicating a predicted variance five times larger than observed, while ratios for RAM were significantly greater than one for both 3-hour and 24-hour values. Maximum frequency differences are also larger for TEM-8A than for RAM.

Comparisons of all observed and predicted values were also made by station and for subsets of events based on time of day and meteorological conditions. Results for 1-hour values are presented in Table 5-13. For TEM-8A, the average difference is negative at every station and for every data subset,

TABLE 5-12

COMPARISON OF ALL OBSERVED AND PREDICTED CONCENTRATION VALUES, PAIRED IN TIME AND LOCATION

RAPS (1976)

Model	Number of Data Pairs	Average Observed Value (μg/m³)	Average Difference* (Obs-Pred) (μg/m³)	Fraction of Positive Residuals (Obs >Pred)	Standard Deviation of Residuals* (μg/m³)	Root Mean Square Error (μg/m³)	Average Absolute Residual (μg/m³)	Pearson Corr. Coef.	Spearman Corr. Coef.	Variance Comparison (Obs/Pred)	Maximum Frequency Difference
Averaging Time: 1 Hour											
TEM-8	51413	62	-139 (-143, -136)	**	308 (306, 309)	337	177	0.11	**	0.15 (0.14, 0.16)	** (0.008)
RAM	42990	72	-18 (-20, -16)	**	166 (165, 167)	167	94	0.09	**	1.02 (0.93, 1.12)	** (0.009)
Averaging Time: 3 Hours											
TEM-8	15832	58	-128 (-136, -120)	0.21	265 (262, 268)	294	157	0.14	0.13	0.14 (0.13, 0.16)	0.38 (0.015)
RAM	13474	66	-16 (-20, -12)	0.43	130 (128, 131)	131	76	0.13	-0.01	1.29 (1.17, 1.41)	0.11 (0.017)
Averaging Time: 24 Hours											
TEM-8	3487	42	-87 (-100, -74)	0.21	164 (160, 168)	185	98	0.29	0.59	0.16 (0.15, 0.18)	0.43 (0.033)
RAM	3487	42	-8 (-12, -4)	0.46	69 (67, 71)	70	34	0.37	0.61	1.68 (1.52, 1.85)	0.15 (0.033)

*95 percent *confidence* interval *in* parentheses.
**Not computed due to prohibitive size of data set.

TABLE 5-13

COMPARISON OF ALL OBSERVED AND PREDICTED 1 HOUR AVERAGE CONCENTRATION VALUES PAIRED IN TIME AND SPACE FOR SPECIFIC DATA SUBSETS

RAPS (1976)

Data Sets	TEM-8A				RAM			
	Number of Data Pairs	Average Observed Value ($\mu g/m^3$)	Average Difference (Obs-Pred) ($\mu g/m^3$)	Standard Deviation of Residuals ($\mu g/m^3$)	Number of Data Pairs	Average Observed Value ($\mu g/m^3$)	Average Difference (Obs-Pred) ($\mu g/m^3$)	Standard Deviation of Residuals ($\mu g/m^3$)
By Station:								
Station 1 (101)[a]	5880	57	-452	546	5374	61	-76	174
Station 2 (103)	5526	43	-115	207	4170	54	-36	125
Station 3 (104)	5554	128	-95	296	4754	148	36	287
Station 4 (105)	5499	51	-106	216	4537	60	-38	140
Station 5 (106)	5122	57	-109	195	3869	73	-7	129
Station 6 (108)	3888	56	-105	230	3434	63	-20	124
Station 7 (113)	3424	57	-75	179	2807	67	-1	116
Station 8 (114)	3529	57	-89	228	2959	66	-11	149
Station 9 (115)	2664	56	-191	369	2481	60	-60	210
Station 10 (116)	2700	46	-91	218	2186	55	-8	116
Station 11 (120)	2922	50	-63	170	2277	61	12	100
Station 12 (121)	2682	57	-58	189	2235	67	10	111
Station 13 (122)	2023	61	-56	194	1907	65	7	114
By Time of Day:								
0000-0600	13547	59	-242	413	11777	66	-55	184
0600-1200	13857	74	-85	243	11839	85	13	150
1200-1800	12856	58	-63	178	10309	70	10	138
1800-2400	11153	54	-169	308	9065	64	-44	176
By Meteorological Condition:								
A. Wind speed								
<2.5 m/s	16052	65	-226	439	13889	73	-46	207
2.5 to 5 m/s	24480	65	-112	237	21021	74	-12	154
>5 m/s	10881	51	-71	137	8080	64	12	95
B. Stability Group								
Class A & B	4216	67	-16	131	3523	78	• 31	106
Class C	6535	76	-28	166	5507	88	33	142
Class D	22157	56	-112	224	17263	70	9	123
Class E & F	18505	62	-239	413	16697	67	-74	203

[a]RAPS/RAMS monitoring ID codes in parentheses.

indicating further the systematic overprediction by this model. For RAM, average differences show a mixture of over- and underprediction; most average differences were less than the corresponding average observed values. Overprediction is indicated for RAM, and is especially large for TEM-8A, at Stations 101 and 115, during night-time hours (0000-0600 and 1800-2400), for low wind speeds, and for Class E & F stability. The largest standard deviation of residuals for RAM occurred at Station 104, where RAM underpredicted on average.

Results for all concentration values at each station for 3- and 24-hour periods are presented in Tables 5-14 and 5-15, respectively. The results for average differences are very similar to 1-hour results in Table 5-13. The number of data pairs is greatly reduced, however, and the standard deviation values decrease as the averaging time increases.

One additional paired data set was analyzed in this study. During the earlier evaluations of rural models, low correlation and large scatter between predicted and observed highest hourly values were noted. In order to explore whether significant improvements in model performance could be achieved by relaxing the time-pairing constraint, a data set was constructed for the urban study consisting of the highest observed and predicted 1-hour values for each day. Performance statistics for this "highest by day" data set are summarized in Table 5-16. Comparing these results with those for 1-hour values in Table 5-11, no reduction in data scatter is apparent. In fact, since the average values are much larger for the "highest-by-day" data set, both the average difference and the standard deviation of residuals are much larger in Table 5-16 than with the stricter time pairing of Table 5-11.

TABLE 5-14

COMPARISON OF ALL OBSERVED AND PREDICTED 3 HOUR AVERAGE CONCENTRATION VALUES PAIRED IN TIME AND SPACE FOR SPECIFIC DATA SUBSETS

RAPS (1976)

Data Sets	TEM-8A				RAM			
	Number of Data Pairs	Average Observed Value ($\mu g/m^3$)	Average Difference (Obs-Pred) ($\mu g/m^3$)	Standard Deviation of Residuals ($\mu g/m^3$)	Number of Data Pairs	Average Observed Value ($\mu g/m^3$)	Average Difference (Obs-Pred) ($\mu g/m^3$)	Standard Deviation of Residuals ($\mu g/m^3$)
By Station:								
Station 1 (101)[a]	1724	54	-437	513	1576	58	-74	146
Station 2 (103)	1693	42	-108	168	1313	51	-31	103
Station 3 (104)	1635	123	-95	256	1431	139	33	245
Station 4 (105)	1662	49	-101	169	1423	55	-34	105
Station 5 (106)	1501	57	-102	164	1165	70	-3	103
Station 6 (108)	1235	52	-96	173	1116	56	-17	84
Station 7 (113)	1073	50	-69	135	883	59	-2	78
Station 8 (114)	1106	53	-78	168	967	58	-7	100
Station 9 (115)	898	50	-162	269	831	53	-47	136
Station 10 (116)	899	40	-77	161	716	47	-6	79
Station 11 (120)	916	46	-52	121	722	56	14	67
Station 12 (121)	857	53	-48	136	728	60	12	76
Station 13 (122)	633	57	-52	148	603	59	7	77

[a] RAPS/RAMS monitoring ID codes in parentheses.

TABLE 5-15

COMPARISON OF ALL OBSERVED AND PREDICTED 24 HOUR AVERAGE CONCENTRATION VALUES PAIRED IN TIME AND SPACE FOR SPECIFIC DATA SUBSETS

RAPS (1976)

	TEM-8A				RAM			
Data Sets	Number of Data Pairs	Average Observed Value ($\mu g/m^3$)	Average Difference (Obs-Pred) ($\mu g/m^3$)	Standard Deviation of Residuals ($\mu g/m^3$)	Number of Data Pairs	Average Observed Value ($\mu g/m^3$)	Average Difference (Obs-Pred) ($\mu g/m^3$)	Standard Deviation of Residuals ($\mu g/m^3$)
By Station:								
Station 1 (101)[a]	260	51	-450	338	260	51	-73	81
Station 2 (103)	289	37	-95	80	289	37	-22	48
Station 3 (104)	261	122	-82	170	261	122	32	181
Station 4 (105)	292	43	-88	80	292	43	-26	51
Station 5 (106)	247	52	-97	85	247	52	-5	54
Station 6 (108)	276	37	-63	70	276	37	-9	29
Station 7 (113)	255	35	-43	53	255	35	1	26
Station 8 (114)	275	35	-43	73	275	35	-1	40
Station 9 (115)	278	28	-77	132	278	28	-20	52
Station 10 (116)	271	24	-37	63	271	24	-1	30
Station 11 (120)	280	27	-27	47	280	27	8	21
Station 12 (121)	256	30	-21	49	256	30	8	26
Station 13 (122)	247	28	-14	46	247	28	8	24

[a] RAPS/RAMS monitoring ID codes in parentheses.

TABLE 5-16

COMPARISON OF DAILY MAXIMUM OBSERVED AND PREDICTED 1 HOUR CONCENTRATIONS
(Highest by Day)

Model	Number of Data Pairs	Average Observed Value ($\mu g/m^3$)	Average Difference* (Obs-Pred) ($\mu g/m^3$)	Standard Deviation of Residuals* ($\mu g/m^3$)
TEM-8A	347	442	-952 (-1077, -827)	934 (870, 1010)
RAM	347	442	-202 (-299, -105)	599 (557, 647)

*95 percent confidence interval in parentheses.

SECTION 6

CONCLUSIONS

The performance evaluation of the urban models has produced a great variety of measures which compare observed and predicted concentration values. In this report, the results have been discussed and explained, but no attempt has been made to compare the performance of one model versus another. The conclusions and recommendations presented below are concerned with model evaluation methods and with the performance of the models as a group.

The evaluation of annual average urban models was based on a very limited number of data points. The following conclusions can be drawn from the results:

- In many respects, all four annual average models performed similarly. With few data points, it is difficult to discriminate effectively between models. Statistical confidence intervals for different models frequently overlapped.
- The observed concentration value at one station was large, relative to the remaining 12. Several measures were strongly influenced by this one value.

The evaluation of the short-term urban models involved the calculation of performance measures for a variety of data sets representing selected peak values, pairing in time or location, and subsets of events based on meteorology and time of day. Three general conclusions can be drawn from these results:

- Comparisons between observed and predicted extreme values, such as highest second-highest 3- and 24-hour concentrations (Table 5-10), provided distinctly different indications of model bias than statistical measures for peak values (Tables 5-7 through 5-9). Single-value comparisons, while pertinent to a specific regulatory application, provide an unreliable basis for inferring general performance characteristics. Conversely, good statistical performance is no guarantee of a model's success in a specific regulatory situation.

- Performance statistics for data sets representing all stations combined can be strongly influenced by high concentration values unique to a single station. The 25 highest observed values, for example, are dominated by Station 104, while the 25 highest predicted values for TEM-8A are dominated by Station 101 (see Tables 5-3 and 5-4). The results illustrate the importance of examining model performance at individual stations, as well as collectively.

- Both short-term models predicted substantial variation of peak 1-hour concentration values with time of day, but very little variation was observed (see Tables 5-4 and 5-13). The models also predicted more variation of peak values with wind speed and stability than was observed. Such discrepancies suggest serious problems with either model inputs or model formulation.

Comparison of results from the rural and urban model evaluation studies led to the following additional observations:

- The highest 1-hour values observed and predicted for the urban case are associated with light winds and stable (Class E & F) conditions. By contrast, peak values for the rural case were associated with Class A and B stability.

- Statistics for 1-hour values, paired in space and time, indicate little or no correlation between observed and predicted values for either urban or rural models. For the urban case, however, correlation for 24-hour values was significantly better than for the rural case.

- The reduction in the volume of statistics from the rural to the urban case was achieved without the apparent loss of essential information.

SECTION 7

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APPENDIX A

ANNUAL AVERAGE SO_x EMISSIONS INVENTORY FOR POINT AND AREA SOURCES

The point sources described in this section represent the 235 sources in the RAPS study which had non-zero SO_x emissions. The RAPS ID consists of a two digit state code, a four digit county code, a two digit plant code, and a two digit stack identifier. X and Y coordinates are kilometers in the Universal Transverse Mercator system. All stack parameters are annual average values with SO_x emissions in units of metric tons per year.

The 1536 area sources contained in this listing are those area sources in the RAPS study which lie partially or totally within 30 km of one or more of the 13 SO_2 monitors. Each area source is a square with a minimum side length of 1 km. A unique RAPS grid ID number was assigned to each area source by the EPA in their development of the inventory. X and Y coordinates are kilometers in the Universal Transverse Mercator system.

RAPS 1976 POINT SOURCES

POINT SOURCE	RAPS ID	Y (KM)	Y (KM)	HT. (M)	DIAM. (M)	FLOW (M3/MIN)	TEMP. (DEG C)	SO2 (MT/YR)
1	1414400201	802.71	4278.69	24.	1.2	283.	398.	70.84
2	1414400401	812.70	4275.10	12.	.2	28.	343.	.05
3	1446800101	748.71	4305.63	76.	4.7	4379.	164.	305.88
4	1446800102	748.75	4305.60	76.	5.2	7982.	148.	5987.37
5	1446800103	748.77	4305.58	106.	4.6	26599.	144.	21752.46
6	1446800201	756.72	4290.88	9.	2.3	7704.	485.	3.10
7	1446800202	756.75	4290.89	9.	2.3	7704.	485.	3.10
8	1446800203	756.79	4290.90	9.	2.3	7704.	485.	3.10
9	1446800204	756.82	4290.91	9.	2.3	7704.	485.	3.10
10	1446800301	745.52	4283.01	72.	2.9	8837.	193.	67.29
11	1446800302	745.52	4283.03	72.	2.9	8837.	193.	46.48
12	1446800303	745.52	4283.05	72.	2.9	8627.	182.	30.97
13	1446800304	745.52	4283.07	72.	2.9	8627.	182.	15.58
14	1446800305	745.52	4283.09	72.	2.9	8627.	182.	6.84
15	1446800306	745.52	4283.11	72.	2.9	8627.	182.	2.19
16	1446800307	745.52	4283.13	72.	4.1	19127.	165.	2268.37
17	1446800308	745.52	4283.15	72.	4.1	19127.	165.	2301.97
18	1446800401	752.33	4304.55	48.	3.6	3267.	198.	1403.25
19	1446800403	752.34	4304.55	48.	3.6	3267.	198.	1373.78
20	1446800405	752.36	4304.53	48.	2.6	2341.	198.	1171.44
21	1446800406	752.36	4304.57	48.	2.6	2341.	198.	1020.81
22	1446800407	752.22	4303.85	48.	3.5	3880.	290.	826.46
23	1446800409	752.19	4304.03	33.	1.9	1563.	482.	68.13
24	1446800410	752.19	4304.02	33.	1.9	1563.	482.	74.59
25	1446800412	752.19	4304.01	33.	1.9	1563.	482.	68.13
26	1446800414	752.18	4304.01	33.	1.5	576.	315.	14.04
27	1446800417	752.17	4304.31	23.	.7	105.	371.	30.31
28	1446800421	752.13	4303.57	45.	.5	0.	815.	3323.05
29	1446800422	751.88	4304.13	23.	1.7	137.	759.	58.01
30	1446800423	752.18	4304.30	15.	1.0	178.	648.	28.51
31	1446800424	752.02	4304.01	15.	.1	0.	13.	247.68
32	1446800426	752.20	4304.20	3.	.0	0.	13.	445.34
33	1446800464	751.96	4303.90	52.	2.4	5143.	301.	1267.59
34	1446800502	752.77	4302.15	24.	1.8	283.	259.	600.29
35	1446800509	752.87	4302.22	30.	1.2	162.	259.	329.77
36	1446800510	752.88	4302.22	30.	1.5	334.	259.	651.12
37	1446800511	752.89	4302.22	30.	1.5	321.	259.	518.25
38	1446800512	752.90	4302.22	30.	1.2	123.	259.	243.01
39	1446800513	752.86	4302.24	30.	1.8	633.	454.	967.07
40	1446800514	753.22	4302.17	54.	2.2	772.	259.	1678.81
41	1446800515	753.18	4302.18	57.	1.4	228.	648.	257.85
42	1446800516	753.00	4302.17	28.	1.5	259.	315.	356.08
43	1446800517	752.81	4302.13	16.	1.5	985.	404.	1262.20
44	1446800518	752.79	4302.13	16.	1.5	985.	404.	1262.20
45	1446800519	752.78	4302.13	24.	2.1	1511.	246.	2400.01
46	1446800520	752.98	4302.16	59.	1.2	2552.	315.	2303.30
47	1446800521	752.85	4302.25	3.	.0	0.	13.	156.18
48	1446800551	753.08	4302.17	54.	2.6	1713.	287.	3167.34
49	1446800552	753.08	4302.16	54.	2.3	613.	287.	1173.79
50	1446800553	753.08	4302.15	54.	1.4	388.	193.	747.44

RAPS 1976 POINT SOURCES

POINT SOURCE	RAPS ID	X (KM)	Y (KM)	HT. (M)	DIAM. (M)	FLOW (M3/MIN)	TEMP. (DEG C)	SO2 (MT/YR)
51	1446800725	750.54	4308.03	53.	1.8	1172.	176.	.15
52	1446800726	750.56	4308.03	53.	1.5	1758.	167.	.15
53	1446800803	746.95	4287.28	60.	2.9	180.	271.	63.41
54	1446800901	749.50	4286.30	76.	2.7	1416.	259.	1.81
55	1446800902	749.50	4286.30	76.	2.7	1416.	259.	2.72
56	1446800903	749.50	4286.30	79.	3.0	1416.	259.	3.63
57	1446800913	748.40	4286.50	53.	1.1	67.	13.	2345.98
58	1446800914	748.40	4286.50	30.	7.3	3692.	815.	929.86
59	1446800919	748.40	4286.50	68.	4.1	129705.	287.	247.66
60	1446800920	748.40	4286.50	60.	4.6	55507.	259.	106.14
61	1446800921	749.80	4286.30	32.	2.1	1308.	259.	820.10
62	1446800922	749.80	4286.30	46.	2.1	5664.	259.	435.45
63	1446800923	749.80	4286.30	46.	2.1	5664.	259.	435.45
64	1446801101	747.20	4286.80	42.	.8	529.	43.	229.61
65	1446801102	747.20	4286.80	13.	.8	424.	43.	229.61
66	1446801103	747.20	4286.80	10.	.8	413.	55.	.01
67	1446801105	747.20	4286.80	10.	.8	413.	55.	.02
68	1446801201	747.68	4287.75	14.	1.1	283.	315.	9.88
69	1446801202	747.69	4287.74	14.	1.1	283.	371.	8.94
70	1446801203	747.70	4287.73	14.	1.2	283.	315.	37.04
71	1446801204	747.71	4287.72	14.	1.1	283.	315.	11.36
72	1446801301	746.45	4307.90	53.	3.0	5434.	215.	199.64
73	1446801304	746.10	4307.29	38.	1.5	879.	343.	.29
74	1446801401	754.31	4302.87	45.	2.0	1465.	398.	18.40
75	1446801402	754.31	4302.90	56.	2.4	2304.	371.	30.43
76	1446801403	754.31	4302.95	45.	1.4	432.	329.	7.36
77	1446801404	754.42	4302.81	95.	4.3	9150.	343.	123.83
78	1446801405	754.92	4302.84	45.	2.3	1575.	426.	5.66
79	1446801406	755.12	4302.58	22.	1.5	366.	343.	1.70
80	1446801407	755.30	4302.63	45.	1.8	1008.	359.	7.08
81	1446801413	755.00	4302.40	45.	1.6	2397.	565.	8.91
82	1446801414	754.99	4302.30	45.	1.8	1301.	482.	5.52
83	1446801415	754.99	4302.37	48.	1.2	490.	509.	3.96
84	1446801417	754.99	4302.36	45.	2.4	2272.	426.	17.97
85	1446801418	754.99	4302.34	45.	2.4	1785.	398.	17.40
86	1446801419	754.99	4302.32	45.	1.8	897.	398.	9.20
87	1446801421	754.88	4302.40	106.	4.6	11704.	398.	60.00
88	1446801422	754.65	4302.30	45.	1.9	729.	371.	7.64
89	1446801424	754.73	4302.30	54.	1.9	1302.	332.	10.47
90	1446801430	754.69	4302.88	45.	1.5	967.	523.	6.22
91	1446801431	754.69	4302.86	45.	1.5	967.	523.	4.95
92	1446801433	754.82	4302.73	60.	2.9	4935.	287.	107.27
93	1446801434	754.85	4302.73	60.	2.9	4935.	290.	116.90
94	1446801439	754.44	4302.73	45.	1.8	432.	204.	4.67
95	1446801441	754.47	4302.75	21.	2.2	1279.	426.	15.00
96	1446801446	754.82	4302.72	63.	3.0	1734.	204.	18.11
97	1446801448	754.82	4302.69	63.	3.0	1734.	204.	13.86
98	1446801450	754.86	4302.72	63.	3.0	2267.	204.	24.48
99	1446801451	754.86	4302.69	63.	3.0	2267.	204.	21.94
100	1446801452	754.85	4302.55	40.	2.1	3267.	204.	22.64

RAPS 1976 POINT SOURCES

POINT SOURCE	RAPS ID	X (KM)	Y (KM)	HT. (M)	DIAM. (M)	FLOW (M3/MIN)	TEMP. (DEG C)	SO2 (MT/YR)
101	1446801453	754.88	4302.55	40.	2.1	3267.	204.	25.19
102	1446801457	754.30	4302.60	4.	.0	0.	13.	1122.51
103	1446801478	754.85	4302.31	58.	2.1	3267.	204.	9.48
104	1446801479	754.91	4302.55	45.	3.0	3267.	204.	14.86
105	1446801601	747.60	4307.52	22.	1.4	1327.	282.	32.68
106	1446801602	747.60	4307.50	25.	1.9	109.	315.	130.79
107	1446801702	746.12	4286.79	17.	1.5	280.	237.	35.21
108	1446801703	746.10	4286.79	17.	1.5	280.	237.	35.21
109	1446802002	747.90	4307.10	76.	4.0	1352.	359.	220.53
110	1446802003	747.90	4307.12	58.	1.4	1674.	165.	3066.20
111	1446802004	747.87	4307.13	58.	3.4	10189.	176.	7884.75
112	1446802101	744.11	4308.25	25.	1.0	444.	190.	.52
113	1446802102	744.10	4308.20	9.	.8	250.	190.	.54
114	1446802203	788.17	4293.15	24.	1.5	2200.	315.	365.77
115	1446802702	746.45	4285.45	22.	1.5	283.	232.	.01
116	1446803101	747.50	4283.84	10.	.5	283.	315.	20.06
117	1446803201	753.04	4302.90	45.	1.8	1841.	343.	2286.11
118	1446803301	789.15	4293.06	30.	1.4	283.	224.	40.00
119	1446803601	748.90	4286.00	8.	.7	145.	248.	2.98
120	1446803602	748.91	4286.00	8.	.7	137.	249.	.95
121	1446803701	748.35	4289.80	9.	.9	396.	65.	.03
122	1464600101	775.67	4232.54	184.	5.9	48710.	148.	70778.70
123	1464600102	775.67	4232.54	184.	5.9	48993.	148.	89203.35
124	1464600103	775.67	4232.54	184.	5.9	52850.	131.	70933.39
125	1464600401	777.60	4200.67	47.	3.0	1132.	273.	649.54
126	1464600501	777.86	4200.91	3.	.0	0.	65.	.52
127	1469000101	761.78	4267.53	68.	2.4	889.	240.	11.30
128	1469000201	747.81	4280.80	76.	3.7	283.	171.	23.58
129	1469000605	746.66	4275.60	42.	1.4	1378.	269.	21.46
130	1469000606	746.68	4275.60	42.	1.4	1378.	269.	21.65
131	1469000607	746.70	4275.60	42.	1.4	1378.	269.	350.18
132	1469000608	746.72	4275.60	42.	1.6	1410.	222.	655.18
133	1469000609	746.74	4275.60	42.	1.6	1352.	230.	498.20
134	1469000610	746.68	4275.65	42.	3.0	3456.	214.	1003.15
135	1469000622	746.35	4275.87	45.	1.5	1369.	70.	2490.85
136	1469000701	773.65	4269.93	19.	2.4	283.	259.	51.21
137	1469000702	773.67	4269.94	19.	2.4	283.	259.	51.21
138	1469000703	773.69	4269.95	19.	2.4	283.	259.	51.21
139	1469000704	773.70	4269.97	18.	2.4	283.	259.	51.21
140	1469001301	779.27	4264.21	19.	1.0	623.	308.	208.07
141	1469001302	779.25	4264.19	27.	1.5	897.	265.	455.36
142	1469001403	745.08	4276.29	99.	5.8	6744.	182.	15.81
143	1469001405	745.06	4276.25	99.	5.8	11563.	193.	154.44
144	1469001406	745.10	4276.24	99.	5.8	10599.	193.	171.15
145	1469001801	762.86	4266.56	20.	1.0	61.	109.	15.69
146	1469001901	748.70	4280.40	49.	2.6	567.	232.	1.08
147	1469001902	748.70	4280.40	49.	2.6	567.	232.	1.08
148	1469002101	762.53	4266.55	21.	.7	283.	13.	25.82
149	1469002401	773.09	4246.71	25.	.8	125.	232.	37.81
150	1469002501	746.14	4275.07	18.	.5	54.	221.	.01

RAPS 1976 POINT SOURCES

POINT SOURCE	RAPS ID	X (KM)	Y (KM)	HT. (M)	DIAM. (M)	FLOW (M3/MIN)	TEMP. (DEG C)	SO2 (MT/YR)
151	1469002502	746.14	4275.07	18.	.5	54.	221.	.01
152	1469002503	746.14	4275.07	18.	.5	54.	221.	.01
153	1469002601	748.42	4277.27	15.	.9	424.	204.	2.68
154	1469002701	748.70	4277.00	60.	2.1	1307.	259.	.48
155	1469002711	748.86	4276.90	27.	.8	123.	348.	.08
156	1469002801	751.94	4272.79	16.	1.2	283.	193.	17.52
157	1469003401	753.00	4281.30	7.	.9	287.	148.	.03
158	1469003402	753.00	4281.30	3.	.1	533.	93.	492.13
159	1469003801	746.43	4276.24	45.	1.5	1150.	84.	1022.92
160	1469003901	746.66	4276.12	34.	.9	1132.	982.	695.81
161	1469003902	746.55	4276.07	45.	.9	1416.	982.	69.85
162	1469003903	746.55	4276.06	19.	.2	56.	29.	101.60
163	1479200101	810.50	4259.00	3.	.1	28.	148.	.52
164	2616800301	688.37	4270.23	213.	6.2	45312.	140.	65259.69
165	2616800302	688.40	4270.20	213.	6.2	45312.	140.	66710.34
166	2616800303	688.45	4270.10	213.	8.8	90624.	140.	130475.38
167	2622800101	729.20	4233.60	24.	1.1	577.	176.	.14
168	2622800202	733.80	4229.25	76.	4.9	17558.	218.	12954.60
169	2622800301	729.57	4237.77	106.	6.1	28320.	82.	29450.85
170	2622800608	734.60	4227.70	15.	1.1	283.	121.	122.45
171	2622801501	739.43	4223.70	213.	6.2	45312.	140.	54483.59
172	2641600101	734.85	4310.67	182.	5.7	28603.	162.	57494.68
173	2641600102	734.85	4310.72	182.	5.7	28603.	162.	38861.23
174	2642800301	742.80	4275.52	68.	2.6	2562.	182.	124.14
175	2642800302	742.77	4275.48	68.	2.6	2455.	179.	114.20
176	2642800303	742.82	4275.56	68.	3.0	2598.	182.	231.29
177	2642800304	742.86	4275.51	22.	1.8	3780.	196.	.30
178	2642800305	742.84	4275.53	30.	1.7	1786.	148.	.13
179	2642800601	738.28	4284.80	68.	4.0	2265.	93.	1864.75
180	2642801201	738.75	4268.73	60.	2.9	1467.	293.	291.65
181	2642801202	738.63	4268.60	60.	3.0	1727.	219.	291.65
182	2642801203	738.65	4268.68	76.	3.0	1504.	82.	105.97
183	2642801701	744.25	4282.90	53.	.9	1132.	179.	1.58
184	2642801704	744.26	4282.88	36.	1.0	849.	121.	36.97
185	2642801705	744.27	4282.87	24.	1.0	849.	121.	2.04
186	2642802302	743.98	4276.56	45.	1.5	511.	162.	.10
187	2642802303	743.99	4276.55	45.	1.5	504.	162.	.10
188	2642802304	744.00	4276.54	45.	1.5	573.	162.	1.62
189	2642802305	744.01	4276.53	45.	1.5	623.	162.	1.93
190	2642802306	744.10	4276.35	45.	2.3	1538.	162.	1566.98
191	2642802401	743.88	4284.15	76.	3.3	4100.	218.	51.52
192	2642802402	743.91	4284.15	76.	3.3	4100.	218.	51.52
193	2642802501	741.83	4273.51	76.	3.3	4100.	218.	51.52
194	2642802502	741.84	4273.50	76.	3.3	4100.	218.	51.52
195	2642803801	745.20	4280.01	54.	7.0	16992.	176.	3433.13
196	2642804001	738.32	4279.65	54.	2.4	679.	218.	466.98
197	2642805601	740.85	4280.56	13.	.9	368.	148.	3.91
198	2642805702	743.70	4284.35	30.	1.8	283.	148.	.06
199	2642805801	744.81	4282.71	21.	1.5	830.	315.	235.83
200	2642805802	744.81	4282.70	21.	1.5	930.	315.	499.29

RAPS 1976 POINT SOURCES

POINT SOURCE	RAPS ID	X (KM)	Y (KM)	HT. (M)	DIAM. (M)	FLOW (M3/MIN)	TEMP. (DEG C)	SO2 (MT/YR)
201	2642805803	744.82	4282.69	21.	1.5	830.	315.	76.08
202	2643000101	733.08	4267.72	82.	5.5	6796.	204.	3612.38
203	2643000208	720.85	4269.46	38.	1.7	354.	248.	.07
204	2643000209	720.87	4269.46	38.	1.7	354.	248.	.07
205	2643000301	731.79	4287.14	15.	1.5	1189.	193.	13.77
206	2643000401	736.31	4290.31	45.	2.3	206.	315.	6.00
207	2643000701	728.50	4293.50	15.	.1	84.	232.	.08
208	2643000704	729.19	4293.03	22.	.1	461.	232.	.04
209	2643000705	729.19	4293.04	22.	.1	461.	232.	.04
210	2643000706	729.19	4293.06	22.	.1	461.	232.	.04
211	2643000707	729.19	4293.06	22.	.1	426.	232.	.04
212	2643000708	730.96	4292.55	22.	.1	310.	232.	.02
213	2643000709	730.96	4292.56	22.	.1	310.	232.	.02
214	2643000710	730.96	4292.57	22.	.1	146.	232.	.01
215	2643000711	730.96	4292.58	22.	.1	146.	232.	.01
216	2643000712	730.64	4292.88	22.	.1	160.	232.	.01
217	2643000713	730.64	4292.89	22.	.1	160.	232.	.01
218	2643000714	730.64	4292.90	22.	.1	491.	232.	.03
219	2643000801	741.85	4290.83	71.	4.6	11328.	259.	840.78
220	2643000901	738.59	4268.08	20.	1.1	934.	243.	697.35
221	2643000902	738.59	4268.07	20.	1.4	1416.	243.	886.77
222	2643000903	738.61	4268.08	21.	1.8	1132.	209.	.24
223	2643000904	738.61	4268.09	21.	1.8	1132.	209.	.24
224	2643000905	738.61	4268.10	21.	1.8	1897.	182.	416.83
225	2643000906	738.61	4268.08	25.	1.7	1614.	204.	1844.63
226	2643000913	738.41	4268.14	37.	1.8	1982.	76.	.08
227	2643000916	738.46	4268.05	44.	1.5	736.	76.	992.73
228	2643000917	738.52	4268.02	60.	1.8	1642.	82.	828.53
229	2643000918	738.60	4268.09	20.	2.1	934.	243.	380.53
230	2643001001	732.62	4253.57	76.	3.2	11653.	140.	15962.21
231	2643001002	732.67	4253.57	76.	3.2	11653.	140.	17047.21
232	2643001003	732.72	4253.57	106.	4.3	25488.	162.	26645.45
233	2643001004	732.77	4253.57	106.	4.7	28320.	162.	36787.74
234	2643001401	737.16	4264.12	60.	2.5	283.	193.	.08
235	2643001601	734.43	4281.15	54.	2.4	679.	218.	288.01

RAPS 1976 AREA SOURCES

AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)	AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)
1	75	685.	4275.	10.	4.52	51	240	715.	4298.	2.	9.53
2	76	685.	4285.	10.	6.84	52	241	715.	4300.	5.	8.86
3	88	690.	4295.	5.	8.15	53	242	715.	4305.	10.	34.79
4	94	694.	4300.	4.	.68	54	245	716.	4295.	1.	7.03
5	95	694.	4304.	6.	8.51	55	246	716.	4296.	1.	3.12
6	103	695.	4265.	5.	3.68	56	247	716.	4297.	1.	1.61
7	104	695.	4270.	5.	5.28	57	251	717.	4270.	2.	5.89
8	105	695.	4275.	5.	4.00	58	252	717.	4272.	2.	1.80
9	106	695.	4280.	5.	2.87	59	253	717.	4274.	2.	18.31
10	107	695.	4285.	5.	3.87	60	254	717.	4276.	2.	47.24
11	108	695.	4290.	5.	3.45	61	255	717.	4278.	2.	5.62
12	109	695.	4295.	2.	.29	62	256	717.	4295.	1.	5.98
13	110	695.	4297.	3.	6.37	63	257	717.	4296.	1.	4.44
14	117	697.	4295.	2.	.29	64	258	717.	4297.	1.	3.05
15	118	698.	4297.	2.	6.04	65	259	717.	4298.	1.	4.23
16	119	698.	4299.	1.	.53	66	260	717.	4299.	1.	2.85
17	120	698.	4300.	2.	.47	67	277	718.	4295.	1.	5.20
18	121	698.	4302.	2.	1.14	68	278	718.	4296.	1.	6.84
19	122	699.	4295.	1.	2.04	69	279	718.	4297.	1.	5.18
20	123	699.	4296.	1.	.28	70	280	718.	4298.	2.	5.49
21	124	699.	4299.	1.	.18	71	281	719.	4270.	2.	20.93
22	131	700.	4260.	5.	26.65	72	282	719.	4272.	2.	3.72
23	132	700.	4265.	5.	63.79	73	283	719.	4274.	2.	23.60
24	133	700.	4270.	5.	5.89	74	284	719.	4276.	2.	9.39
25	134	700.	4275.	5.	7.64	75	285	719.	4278.	2.	8.90
26	135	700.	4280.	5.	7.21	76	286	719.	4295.	1.	6.27
27	136	700.	4285.	5.	6.21	77	287	719.	4296.	1.	4.32
28	137	700.	4290.	5.	1.33	78	288	719.	4297.	1.	4.83
29	140	700.	4300.	5.	2.13	79	308	720.	4295.	5.	81.02
30	141	700.	4305.	5.	16.60	80	309	720.	4300.	5.	7.30
31	156	705.	4265.	5.	19.35	81	310	721.	4270.	2.	12.71
32	159	705.	4275.	5.	3.35	82	311	721.	4272.	2.	16.18
33	160	705.	4280.	5.	16.97	83	312	721.	4274.	2.	15.86
34	163	705.	4290.	5.	5.64	84	313	721.	4276.	2.	11.40
35	166	705.	4300.	5.	3.56	85	314	721.	4278.	2.	24.69
36	189	710.	4265.	5.	23.66	86	327	723.	4270.	1.	5.02
37	190	710.	4270.	5.	32.05	87	328	723.	4271.	1.	5.82
38	191	710.	4275.	5.	38.11	88	329	723.	4272.	1.	5.24
39	192	710.	4280.	5.	122.66	89	330	723.	4273.	1.	1.29
40	195	710.	4290.	5.	10.63	90	331	723.	4274.	1.	1.72
41	196	710.	4295.	5.	15.02	91	332	723.	4275.	1.	5.29
42	197	710.	4300.	5.	11.19	92	333	723.	4276.	1.	3.95
43	226	715.	4270.	2.	3.08	93	334	723.	4277.	1.	.76
44	227	715.	4272.	2.	11.10	94	335	723.	4278.	1.	.73
45	228	715.	4274.	2.	10.20	95	336	723.	4279.	1.	4.12
46	229	715.	4276.	2.	9.02	96	337	724.	4270.	1.	3.40
47	230	715.	4278.	2.	10.12	97	338	724.	4271.	1.	2.00
48	237	715.	4295.	1.	5.01	98	339	724.	4272.	1.	8.84
49	238	715.	4296.	1.	3.00	99	340	724.	4273.	1.	2.20
50	239	715.	4297.	1.	1.20	100	341	724.	4274.	1.	1.49

RAPS 1976 AREA SOURCES

AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)	AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)
101	342	724.	4275.	1.	5.15	151	419	726.	4288.	1.	1.27
102	343	724.	4276.	1.	3.87	152	420	726.	4289.	1.	1.32
103	344	724.	4277.	1.	.77	153	421	726.	4290.	1.	10.33
104	345	724.	4278.	1.	.56	154	422	726.	4291.	1.	10.33
105	346	724.	4279.	1.	4.69	155	423	726.	4292.	1.	3.59
106	356	725.	4270.	1.	8.01	156	430	727.	4270.	1.	2.80
107	367	725.	4271.	1.	4.83	157	431	727.	4271.	1.	3.49
108	368	725.	4272.	1.	2.72	158	432	727.	4272.	1.	8.28
109	369	725.	4273.	1.	3.34	159	433	727.	4273.	1.	1.15
110	370	725.	4274.	1.	1.72	160	434	727.	4274.	1.	1.22
111	371	725.	4275.	1.	3.43	161	435	727.	4275.	1.	3.13
112	372	725.	4276.	1.	1.58	162	436	727.	4276.	1.	.71
113	373	725.	4277.	1.	1.40	163	437	727.	4277.	1.	.20
114	374	725.	4278.	1.	1.49	164	438	727.	4278.	1.	2.43
115	375	725.	4279.	1.	6.61	165	439	727.	4279.	1.	3.71
116	376	725.	4280.	1.	10.72	166	440	727.	4280.	1.	.47
117	377	725.	4281.	1.	2.72	167	441	727.	4281.	1.	.79
118	378	725.	4282.	1.	2.10	168	442	727.	4282.	1.	1.79
119	379	725.	4283.	1.	9.20	169	443	727.	4283.	1.	4.56
120	380	725.	4284.	1.	2.77	170	444	727.	4284.	1.	1.91
121	381	725.	4285.	1.	4.31	171	445	727.	4285.	1.	3.43
122	382	725.	4286.	1.	5.74	172	446	727.	4286.	1.	3.48
123	383	725.	4287.	1.	4.42	173	447	727.	4287.	1.	3.06
124	384	725.	4288.	1.	3.47	174	448	727.	4288.	1.	2.15
125	385	725.	4289.	1.	3.67	175	449	727.	4289.	1.	5.53
126	386	725.	4290.	1.	4.11	176	450	727.	4290.	1.	1.97
127	387	725.	4291.	1.	4.90	177	451	727.	4291.	1.	6.03
128	388	725.	4292.	1.	.98	178	452	727.	4292.	1.	3.77
129	389	725.	4293.	2.	11.92	179	453	727.	4293.	1.	1.28
130	392	725.	4300.	5.	7.00	180	454	727.	4294.	1.	1.35
131	393	725.	4305.	5.	7.37	181	472	728.	4270.	2.	8.50
132	394	725.	4310.	5.	14.93	182	473	728.	4272.	1.	5.77
133	401	726.	4270.	1.	4.73	183	474	728.	4273.	1.	4.05
134	402	726.	4271.	1.	4.44	184	475	728.	4274.	1.	3.36
135	403	726.	4272.	1.	3.37	185	476	728.	4275.	1.	3.01
136	404	726.	4273.	1.	10.86	186	477	728.	4276.	1.	3.12
137	405	726.	4274.	1.	.51	187	478	728.	4277.	1.	.20
138	406	726.	4275.	1.	1.99	188	479	728.	4278.	1.	4.37
139	407	726.	4276.	1.	.49	189	480	728.	4279.	1.	.76
140	408	726.	4277.	1.	.32	190	481	728.	4280.	1.	.62
141	409	726.	4278.	1.	.35	191	482	728.	4281.	1.	1.01
142	410	726.	4279.	1.	6.22	192	483	728.	4282.	1.	.61
143	411	726.	4280.	1.	.79	193	484	728.	4283.	1.	3.64
144	412	726.	4281.	1.	1.52	194	485	728.	4284.	1.	1.39
145	413	726.	4282.	1.	1.83	195	486	728.	4285.	1.	2.39
146	414	726.	4283.	1.	3.30	196	487	728.	4286.	1.	2.20
147	415	726.	4284.	1.	2.66	197	488	728.	4287.	1.	1.61
148	416	726.	4285.	1.	4.60	198	489	728.	4288.	1.	1.86
149	417	726.	4286.	1.	5.29	199	490	728.	4289.	1.	2.38
150	418	726.	4287.	1.	1.13	200	491	728.	4290.	1.	1.63

RAPS 1976 AREA SOURCES

AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)	AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)
201	492	728.	4291.	1.	5.39	251	563	730.	4294.	1.	4.20
202	493	728.	4292.	1.	.35	252	564	730.	4295.	1.	3.99
203	494	728.	4293.	1.	4.71	253	565	730.	4296.	1.	3.36
204	495	728.	4294.	1.	2.28	254	566	730.	4297.	1.	1.26
205	504	729.	4272.	1.	3.43	255	567	730.	4298.	2.	3.50
206	505	729.	4273.	1.	6.63	256	568	730.	4300.	5.	13.29
207	506	729.	4274.	1.	6.89	257	569	730.	4305.	5.	10.14
208	507	729.	4275.	1.	6.33	258	571	731.	4272.	1.	2.32
209	508	729.	4276.	1.	3.97	259	572	731.	4273.	1.	3.19
210	509	729.	4277.	1.	1.73	260	573	731.	4274.	1.	5.69
211	510	729.	4278.	1.	5.49	261	574	731.	4275.	1.	2.55
212	511	729.	4279.	1.	1.88	262	575	731.	4276.	1.	5.49
213	512	729.	4280.	1.	1.10	263	576	731.	4277.	1.	.83
214	513	729.	4281.	1.	1.53	264	577	731.	4278.	1.	8.17
215	514	729.	4282.	1.	4.81	265	578	731.	4279.	1.	9.15
216	515	729.	4283.	1.	5.46	266	579	731.	4280.	1.	10.65
217	516	729.	4284.	1.	2.49	267	580	731.	4281.	1.	4.92
218	517	729.	4285.	1.	5.50	268	581	731.	4282.	1.	1.42
219	518	729.	4286.	1.	5.31	269	582	731.	4283.	1.	1.94
220	519	729.	4287.	1.	6.58	270	583	731.	4284.	1.	2.32
221	520	729.	4288.	1.	5.97	271	584	731.	4285.	1.	2.68
222	521	729.	4289.	1.	2.71	272	585	731.	4286.	1.	2.16
223	522	729.	4290.	1.	7.05	273	586	731.	4287.	1.	11.56
224	523	729.	4291.	1.	.70	274	587	731.	4288.	1.	2.59
225	524	729.	4292.	1.	.38	275	588	731.	4289.	1.	2.94
226	525	729.	4293.	1.	13.41	276	589	731.	4290.	1.	8.27
227	526	729.	4294.	1.	5.45	277	590	731.	4291.	1.	4.17
228	540	730.	4270.	2.	8.91	278	591	731.	4292.	1.	4.35
229	541	730.	4272.	1.	3.31	279	592	731.	4293.	1.	1.46
230	542	730.	4273.	1.	7.17	280	593	731.	4294.	1.	2.92
231	543	730.	4274.	1.	4.04	281	594	731.	4295.	1.	5.77
232	544	730.	4275.	1.	8.11	282	595	731.	4296.	1.	2.35
233	545	730.	4276.	1.	7.82	283	596	731.	4297.	1.	3.33
234	546	730.	4277.	1.	1.82	284	597	732.	4270.	1.	3.50
235	547	730.	4278.	1.	5.88	285	598	732.	4271.	1.	1.31
236	548	730.	4279.	1.	2.28	286	599	732.	4272.	1.	2.24
237	549	730.	4280.	1.	4.12	287	600	732.	4273.	1.	1.08
238	550	730.	4281.	1.	4.70	288	601	732.	4274.	1.	3.48
239	551	730.	4282.	1.	1.29	289	602	732.	4275.	1.	8.21
240	552	730.	4283.	1.	2.58	290	603	732.	4276.	1.	7.50
241	553	730.	4284.	1.	2.70	291	604	732.	4277.	1.	4.59
242	554	730.	4285.	1.	3.30	292	605	732.	4278.	1.	8.37
243	555	730.	4286.	1.	3.86	293	606	732.	4279.	1.	3.08
244	556	730.	4287.	1.	7.27	294	607	732.	4280.	1.	4.09
245	557	730.	4288.	1.	3.49	295	608	732.	4281.	1.	4.38
246	558	730.	4289.	1.	4.39	296	609	732.	4282.	1.	4.12
247	559	730.	4290.	1.	7.32	297	610	732.	4283.	1.	4.04
248	560	730.	4291.	1.	2.09	298	611	732.	4284.	1.	3.99
249	561	730.	4292.	1.	11.13	299	612	732.	4285.	1.	1.66
250	562	730.	4293.	1.	3.59	300	613	732.	4286.	1.	3.59

RAPS 1976 AREA SOURCES

AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)	AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)
301	614	732.	4287.	1.	11.03	351	672	734.	4277.	1.	9.15
302	615	732.	4288.	1.	3.19	352	673	734.	4278.	1.	9.65
303	616	732.	4289.	1.	7.02	353	674	734.	4279.	1.	8.63
304	617	732.	4290.	1.	5.77	354	675	734.	4280.	1.	3.20
305	618	732.	4291.	1.	5.82	355	676	734.	4281.	1.	8.76
306	619	732.	4292.	1.	3.24	356	677	734.	4282.	1.	4.97
307	620	732.	4293.	1.	.22	357	678	734.	4283.	1.	4.29
308	621	732.	4294.	1.	5.95	358	679	734.	4284.	1.	3.95
309	622	732.	4295.	1.	1.67	359	680	734.	4285.	1.	1.69
310	623	732.	4296.	1.	1.94	360	681	734.	4286.	1.	.73
311	624	732.	4297.	1.	3.20	361	682	734.	4287.	1.	1.83
312	625	732.	4298.	1.	.87	362	683	734.	4288.	1.	3.93
313	626	732.	4299.	1.	1.85	363	684	734.	4289.	1.	4.72
314	635	733.	4270.	1.	4.85	364	685	734.	4290.	1.	2.38
315	636	733.	4271.	1.	3.83	365	686	734.	4291.	1.	3.88
316	637	733.	4272.	1.	2.22	366	687	734.	4292.	1.	2.77
317	638	733.	4273.	1.	2.36	367	688	734.	4293.	1.	1.96
318	639	733.	4274.	1.	4.41	368	689	734.	4294.	1.	4.96
319	640	733.	4275.	1.	26.70	369	690	734.	4295.	1.	.56
320	641	733.	4276.	1.	16.08	370	691	734.	4296.	1.	.57
321	642	733.	4277.	1.	4.80	371	692	734.	4297.	1.	1.19
322	643	733.	4278.	1.	11.47	372	693	734.	4298.	1.	3.50
323	644	733.	4279.	1.	1.53	373	694	734.	4299.	1.	1.42
324	645	733.	4280.	1.	3.51	374	697	735.	4240.	10.	57.57
325	646	733.	4281.	1.	9.75	375	698	735.	4250.	5.	14.19
326	647	733.	4282.	1.	4.90	376	699	735.	4255.	5.	30.21
327	648	733.	4283.	1.	1.83	377	702	735.	4265.	1.	1.51
328	649	733.	4284.	1.	2.98	378	703	735.	4266.	1.	1.74
329	650	733.	4285.	1.	2.37	379	704	735.	4267.	1.	2.44
330	651	733.	4286.	1.	1.07	380	705	735.	4268.	1.	.99
331	652	733.	4287.	1.	2.12	381	706	735.	4269.	1.	5.36
332	653	733.	4288.	1.	1.64	382	707	735.	4270.	1.	.86
333	654	733.	4289.	1.	5.15	383	708	735.	4271.	1.	4.81
334	655	733.	4290.	1.	1.16	384	709	735.	4272.	1.	5.19
335	656	733.	4291.	1.	.59	385	710	735.	4273.	1.	18.43
336	657	733.	4292.	1.	4.40	386	711	735.	4274.	1.	42.39
337	658	733.	4293.	1.	3.45	387	712	735.	4275.	1.	9.34
338	659	733.	4294.	1.	7.11	388	713	735.	4276.	1.	4.68
339	660	733.	4295.	1.	1.39	389	714	735.	4277.	1.	22.58
340	661	733.	4296.	1.	.54	390	715	735.	4278.	1.	27.82
341	662	733.	4297.	1.	2.01	391	716	735.	4279.	1.	75.05
342	663	733.	4298.	1.	1.92	392	717	735.	4280.	1.	153.28
343	664	733.	4299.	1.	1.01	393	718	735.	4281.	1.	68.24
344	665	734.	4270.	1.	1.79	394	719	735.	4282.	1.	39.07
345	666	734.	4271.	1.	.33	395	720	735.	4283.	1.	9.48
346	667	734.	4272.	1.	.96	396	721	735.	4284.	1.	10.84
347	668	734.	4273.	1.	4.99	397	722	735.	4285.	1.	4.71
348	669	734.	4274.	1.	5.05	398	723	735.	4286.	1.	5.22
349	670	734.	4275.	1.	8.23	399	724	735.	4287.	1.	3.10
350	671	734.	4276.	1.	27.00	400	725	735.	4288.	1.	15.33

RAPS 1976 AREA SOURCES

AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)	AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)
401	726	735.	4289.	1.	.99	451	776	737.	4265.	1.	.93
402	727	735.	4290.	1.	1.25	452	777	737.	4266.	1.	1.80
403	728	735.	4291.	1.	.92	453	778	737.	4267.	1.	1.99
404	729	735.	4292.	1.	2.02	454	779	737.	4268.	1.	1.55
405	730	735.	4293.	1.	.73	455	780	737.	4269.	1.	1.89
406	731	735.	4294.	1.	5.18	456	781	737.	4270.	1.	5.52
407	732	735.	4295.	1.	.41	457	782	737.	4271.	1.	1.97
408	733	735.	4296.	1.	1.11	458	783	737.	4272.	1.	1.58
409	734	735.	4297.	1.	2.71	459	784	737.	4273.	1.	7.52
410	735	735.	4298.	1.	.42	460	785	737.	4274.	1.	7.32
411	736	735.	4299.	1.	2.14	461	786	737.	4275.	1.	23.23
412	737	735.	4300.	5.	16.35	462	787	737.	4276.	1.	35.07
413	738	735.	4305.	5.	9.85	463	788	737.	4277.	1.	10.90
414	739	735.	4310.	5.	48.46	464	789	737.	4278.	1.	14.90
415	740	735.	4315.	5.	14.87	465	790	737.	4279.	1.	64.32
416	741	736.	4265.	1.	1.69	466	791	737.	4280.	1.	67.00
417	742	736.	4266.	1.	2.79	467	792	737.	4281.	1.	66.64
418	743	736.	4267.	1.	2.83	468	793	737.	4282.	1.	34.90
419	744	736.	4268.	1.	11.80	469	794	737.	4283.	1.	72.99
420	745	736.	4269.	1.	4.02	470	795	737.	4284.	1.	43.49
421	746	736.	4270.	1.	3.57	471	796	737.	4285.	1.	35.79
422	747	736.	4271.	1.	3.91	472	797	737.	4286.	1.	5.14
423	748	736.	4272.	1.	3.96	473	798	737.	4287.	1.	6.06
424	749	736.	4273.	1.	3.52	474	799	737.	4288.	1.	1.52
425	750	736.	4274.	1.	15.45	475	800	737.	4289.	1.	2.43
426	751	736.	4275.	1.	36.28	476	801	737.	4290.	1.	2.65
427	752	736.	4276.	1.	5.69	477	802	737.	4291.	1.	1.61
428	753	736.	4277.	1.	9.08	478	803	737.	4292.	1.	2.35
429	754	736.	4278.	1.	7.90	479	804	737.	4293.	1.	.60
430	755	736.	4279.	1.	34.40	480	805	737.	4294.	1.	6.18
431	756	736.	4280.	1.	66.85	481	806	737.	4295.	1.	2.12
432	757	736.	4281.	1.	143.87	482	807	737.	4296.	1.	6.12
433	758	736.	4282.	1.	60.53	483	808	737.	4297.	1.	1.43
434	759	736.	4283.	1.	145.96	484	809	737.	4298.	1.	.45
435	760	736.	4284.	1.	18.91	485	810	737.	4299.	1.	.28
436	761	736.	4285.	1.	9.96	486	813	738.	4265.	2.	6.05
437	762	736.	4286.	1.	3.49	487	814	738.	4267.	1.	4.30
438	763	736.	4287.	1.	8.16	488	815	738.	4268.	1.	13.14
439	764	736.	4288.	1.	3.76	489	816	738.	4269.	1.	12.74
440	765	736.	4289.	1.	3.76	490	817	738.	4270.	1.	10.75
441	766	736.	4290.	1.	13.03	491	818	738.	4271.	1.	12.62
442	767	736.	4291.	1.	2.86	492	819	738.	4272.	1.	11.34
443	768	736.	4292.	1.	3.43	493	820	738.	4273.	1.	36.69
444	769	736.	4293.	1.	1.69	494	821	738.	4274.	1.	8.03
445	770	736.	4294.	1.	5.90	495	822	738.	4275.	1.	12.83
446	771	736.	4295.	1.	3.40	496	823	738.	4276.	1.	22.28
447	772	736.	4296.	1.	1.34	497	824	738.	4277.	1.	15.31
448	773	736.	4297.	1.	1.01	498	825	738.	4278.	1.	126.37
449	774	736.	4298.	1.	.46	499	826	738.	4279.	1.	36.52
450	775	736.	4299.	1.	.98	500	827	738.	4280.	1.	87.54

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AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)	AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)
501	828	738.	4281.	1.	99.15	551	881	740.	4255.	2.	2.07
502	829	738.	4282.	1.	138.58	552	882	740.	4257.	1.	.87
503	830	738.	4283.	1.	134.69	553	883	740.	4258.	2.	4.64
504	831	738.	4284.	1.	36.80	554	886	740.	4265.	3.	87.98
505	832	738.	4285.	1.	13.85	555	887	740.	4268.	3.	59.59
506	833	738.	4286.	1.	6.28	556	888	740.	4271.	1.	28.75
507	834	738.	4287.	1.	4.68	557	889	740.	4272.	1.	9.55
508	835	738.	4288.	1.	3.95	558	890	740.	4273.	1.	15.80
509	836	738.	4289.	1.	1.58	559	891	740.	4274.	1.	64.87
510	837	738.	4290.	1.	1.27	560	892	740.	4275.	1.	17.00
511	838	738.	4291.	1.	3.21	561	893	740.	4276.	1.	61.96
512	839	738.	4292.	1.	3.57	562	894	740.	4277.	1.	30.17
513	840	738.	4293.	1.	1.87	563	895	740.	4278.	1.	135.83
514	841	738.	4294.	1.	4.45	564	896	740.	4279.	1.	102.67
515	842	738.	4295.	1.	2.59	565	897	740.	4280.	1.	297.04
516	843	738.	4296.	1.	.42	566	898	740.	4281.	1.	66.61
517	844	738.	4297.	1.	.84	567	899	740.	4282.	1.	53.51
518	845	738.	4298.	2.	1.92	568	900	740.	4283.	1.	68.65
519	846	739.	4267.	1.	.18	569	901	740.	4284.	1.	37.52
520	847	739.	4268.	1.	3.74	570	902	740.	4285.	1.	12.11
521	848	739.	4269.	1.	6.08	571	903	740.	4286.	1.	4.57
522	849	739.	4270.	1.	69.01	572	904	740.	4287.	1.	5.11
523	850	739.	4271.	1.	70.21	573	905	740.	4288.	1.	4.98
524	851	739.	4272.	1.	26.50	574	906	740.	4289.	1.	3.85
525	852	739.	4273.	1.	22.10	575	907	740.	4290.	1.	.81
526	853	739.	4274.	1.	40.95	576	908	740.	4291.	1.	.39
527	854	739.	4275.	1.	54.33	577	909	740.	4292.	1.	2.19
528	855	739.	4276.	1.	44.80	578	910	740.	4293.	1.	1.45
529	856	739.	4277.	1.	35.60	579	911	740.	4294.	1.	3.12
530	857	739.	4278.	1.	22.08	580	914	740.	4300.	5.	14.24
531	858	739.	4279.	1.	25.63	581	915	740.	4305.	3.	24.13
532	859	739.	4280.	1.	111.37	582	916	740.	4308.	2.	7.59
533	860	739.	4281.	1.	135.79	583	917	740.	4310.	2.	4.59
534	861	739.	4282.	1.	154.88	584	918	740.	4312.	2.	5.84
535	862	739.	4283.	1.	50.99	585	922	741.	4257.	1.	3.49
536	863	739.	4284.	1.	33.55	586	923	741.	4271.	1.	1.25
537	864	739.	4285.	1.	14.86	587	924	741.	4272.	1.	4.47
538	865	739.	4286.	1.	9.13	588	925	741.	4273.	1.	40.09
539	866	739.	4287.	1.	5.57	589	926	741.	4274.	1.	29.30
540	867	739.	4288.	1.	4.65	590	927	741.	4275.	1.	20.36
541	868	739.	4289.	1.	3.18	591	928	741.	4276.	1.	18.09
542	869	739.	4290.	1.	3.90	592	929	741.	4277.	1.	41.53
543	870	739.	4291.	1.	2.48	593	930	741.	4278.	1.	126.47
544	871	739.	4292.	1.	3.60	594	931	741.	4279.	1.	6.88
545	872	739.	4293.	1.	2.48	595	932	741.	4280.	1.	127.52
546	873	739.	4294.	1.	7.05	596	933	741.	4281.	1.	117.72
547	874	739.	4295.	1.	1.43	597	934	741.	4282.	1.	73.39
548	875	739.	4296.	1.	.68	598	935	741.	4283.	1.	53.99
549	876	739.	4297.	1.	.68	599	936	741.	4284.	1.	21.55
550	880	740.	4250.	5.	9.86	600	937	741.	4285.	1.	12.37

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601	938	741.	4286.	1.	28.46	651	995	743.	4267.	2.	52.78
602	939	741.	4287.	1.	4.21	652	996	743.	4269.	2.	12.82
603	940	741.	4288.	1.	12.92	653	997	743.	4271.	2.	20.40
604	941	741.	4289.	1.	23.60	654	996	743.	4273.	2.	18.28
605	942	741.	4290.	1.	11.77	655	999	743.	4275.	1.	13.59
606	943	741.	4291.	1.	2.15	656	1000	743.	4276.	1.	3.14
607	944	741.	4292.	1.	3.54	657	1001	743.	4277.	1.	28.93
608	945	741.	4293.	1.	2.67	658	1002	743.	4278.	1.	60.47
609	946	741.	4294.	1.	4.01	659	1003	743.	4279.	1.	406.74
610	948	742.	4255.	1.	.57	660	1004	743.	4280.	1.	270.81
611	949	742.	4256.	1.	.20	661	1005	743.	4281.	1.	76.35
612	950	742.	4257.	1.	.20	662	1006	743.	4282.	1.	23.46
613	951	742.	4258.	1.	.43	663	1007	743.	4283.	1.	9.89
614	952	742.	4259.	1.	4.69	664	1006	743.	4284.	1.	59.24
615	953	742.	4271.	1.	.91	665	1009	743.	4285.	1.	15.58
616	954	742.	4272.	1.	.59	666	1010	743.	4286.	2.	.76
617	955	742.	4273.	1.	9.93	667	1011	743.	4288.	2.	.35
618	956	742.	4274.	1.	16.43	668	1012	743.	4290.	1.	.16
619	957	742.	4275.	1.	45.66	669	1013	743.	4291.	1.	9.89
620	958	742.	4276.	1.	65.12	670	1014	743.	4292.	1.	2.20
621	959	742.	4277.	1.	72.66	671	1015	743.	4293.	1.	.62
622	960	742.	4278.	1.	43.84	672	1016	743.	4294.	1.	2.60
623	961	742.	4279.	1.	51.53	673	1017	743.	4305.	1.	1.98
624	962	742.	4280.	1.	184.95	674	1018	743.	4306.	1.	3.54
625	963	742.	4281.	1.	203.74	675	1019	743.	4307.	1.	5.21
626	964	742.	4282.	1.	59.64	676	1020	743.	4308.	1.	16.85
627	965	742.	4283.	1.	8.65	677	1021	743.	4309.	1.	21.31
628	966	742.	4284.	1.	30.35	678	1022	743.	4310.	1.	27.15
629	967	742.	4285.	1.	17.06	679	1023	743.	4311.	1.	23.50
630	968	742.	4286.	1.	7.16	680	1024	743.	4312.	1.	10.71
631	969	742.	4287.	1.	1.26	681	1025	743.	4313.	1.	10.38
632	970	742.	4288.	1.	.81	682	1027	744.	4257.	1.	4.08
633	971	742.	4289.	1.	.79	683	1028	744.	4258.	1.	1.37
634	972	742.	4290.	1.	11.33	684	1029	744.	4259.	1.	.40
635	973	742.	4291.	1.	3.22	685	1030	744.	4275.	1.	5.73
636	974	742.	4292.	1.	2.18	686	1031	744.	4276.	1.	24.10
637	975	742.	4293.	1.	.59	687	1032	744.	4277.	1.	38.08
638	976	742.	4294.	1.	3.05	688	1033	744.	4278.	1.	114.74
639	977	742.	4308.	1.	5.92	689	1034	744.	4279.	1.	103.26
640	978	742.	4309.	1.	2.54	690	1035	744.	4280.	1.	237.83
641	979	742.	4310.	1.	9.03	691	1036	744.	4281.	1.	93.90
642	980	742.	4311.	1.	15.41	692	1037	744.	4282.	1.	29.51
643	981	742.	4312.	1.	9.25	693	1038	744.	4283.	1.	13.08
644	982	742.	4313.	1.	9.31	694	1039	744.	4284.	1.	7.06
645	983	742.	4314.	1.	3.18	695	1040	744.	4285.	1.	6.67
646	990	743.	4255.	2.	10.89	696	1041	744.	4290.	1.	.15
647	991	743.	4257.	1.	3.89	697	1042	744.	4291.	1.	.17
648	992	743.	4258.	1.	1.05	698	1043	744.	4292.	1.	.70
649	993	743.	4259.	1.	.83	699	1044	744.	4293.	1.	2.52
650	994	743.	4265.	2.	37.93	700	1045	744.	4294.	1.	2.79

RAPS 1976 AREA SOURCES

AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)	AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)
701	1046	744.	4305.	1.	1.98	751	1103	746.	4283.	1.	11.17
702	1047	744.	4306.	1.	.55	752	1104	746.	4284.	1.	27.00
703	1048	744.	4307.	1.	5.04	753	1105	746.	4285.	1.	18.32
704	1049	744.	4308.	1.	16.71	754	1106	746.	4286.	1.	6.35
705	1050	744.	4309.	1.	23.90	755	1107	746.	4287.	1.	6.39
706	1051	744.	4310.	1.	24.36	756	1108	746.	4305.	1.	1.12
707	1052	744.	4311.	1.	23.01	757	1109	746.	4306.	1.	5.84
708	1053	744.	4312.	1.	9.41	758	1110	746.	4307.	1.	11.68
709	1054	744.	4313.	1.	9.31	759	1111	746.	4308.	1.	55.29
710	1058	745.	4245.	2.	3.87	760	1112	746.	4309.	1.	24.43
711	1059	745.	4247.	3.	5.50	761	1113	746.	4310.	1.	20.75
712	1060	745.	4250.	5.	15.82	762	1114	746.	4311.	1.	21.63
713	1061	745.	4255.	5.	30.23	763	1115	746.	4314.	1.	.28
714	1062	745.	4260.	5.	20.22	764	1117	747.	4246.	1.	.20
715	1063	745.	4265.	5.	31.21	765	1118	747.	4275.	1.	71.23
716	1066	745.	4275.	1.	4.35	766	1119	747.	4276.	1.	59.03
717	1067	745.	4276.	1.	1.91	767	1120	747.	4277.	1.	37.27
718	1068	745.	4277.	1.	12.05	768	1121	747.	4278.	1.	139.23
719	1069	745.	4278.	1.	26.11	769	1122	747.	4279.	1.	48.75
720	1070	745.	4279.	1.	28.11	770	1123	747.	4280.	3.	120.53
721	1071	745.	4280.	1.	39.03	771	1124	747.	4283.	1.	18.83
722	1072	745.	4281.	1.	25.33	772	1125	747.	4284.	1.	69.92
723	1073	745.	4282.	1.	22.44	773	1126	747.	4285.	1.	40.45
724	1074	745.	4283.	1.	21.62	774	1127	747.	4286.	1.	17.14
725	1075	745.	4284.	1.	7.55	775	1128	747.	4287.	1.	19.82
726	1076	745.	4285.	1.	4.56	776	1129	747.	4288.	1.	13.40
727	1077	745.	4286.	1.	5.26	777	1130	747.	4289.	1.	10.43
728	1078	745.	4287.	1.	1.75	778	1131	747.	4290.	1.	1.59
729	1079	745.	4288.	2.	8.86	779	1132	747.	4291.	1.	2.14
730	1080	745.	4290.	2.	1.81	780	1133	747.	4305.	1.	5.27
731	1081	745.	4292.	3.	16.34	781	1134	747.	4306.	1.	5.46
732	1082	745.	4295.	5.	9.21	782	1135	747.	4307.	1.	15.55
733	1085	745.	4305.	1.	.35	783	1136	747.	4308.	1.	36.91
734	1086	745.	4306.	1.	3.70	784	1137	747.	4309.	1.	29.79
735	1087	745.	4307.	1.	11.61	785	1138	747.	4310.	1.	20.09
736	1088	745.	4308.	1.	73.12	786	1139	747.	4311.	1.	24.12
737	1089	745.	4309.	1.	30.63	787	1140	747.	4312.	3.	6.63
738	1090	745.	4310.	1.	30.15	788	1146	748.	4246.	1.	4.49
739	1091	745.	4311.	1.	22.37	789	1147	748.	4247.	1.	2.75
740	1092	745.	4312.	2.	.49	790	1148	748.	4248.	1.	3.06
741	1093	745.	4314.	1.	.89	791	1149	748.	4249.	1.	3.01
742	1094	745.	4315.	5.	74.70	792	1150	748.	4275.	1.	83.05
743	1095	746.	4275.	1.	22.10	793	1151	748.	4276.	1.	85.58
744	1096	746.	4276.	1.	32.68	794	1152	748.	4277.	1.	87.81
745	1097	746.	4277.	1.	42.80	795	1153	748.	4278.	1.	198.59
746	1098	746.	4278.	1.	14.81	796	1154	748.	4279.	1.	40.43
747	1099	746.	4279.	1.	11.16	797	1155	748.	4283.	1.	8.44
748	1100	746.	4280.	1.	24.21	798	1156	748.	4284.	1.	21.56
749	1101	746.	4281.	1.	24.88	799	1157	748.	4285.	1.	12.90
750	1102	746.	4282.	1.	8.75	800	1158	748.	4286.	1.	14.05

RAPS 1976 AREA SOURCES

AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)	AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)
801	1159	748.	4287.	1.	29.13	851	1215	750.	4275.	1.	29.44
802	1160	748.	4288.	1.	12.70	852	1216	750.	4276.	1.	42.67
803	1161	748.	4289.	1.	13.48	853	1217	750.	4277.	1.	44.23
804	1162	748.	4290.	1.	2.74	854	1218	750.	4278.	1.	53.68
805	1163	748.	4291.	1.	.16	855	1219	750.	4279.	1.	31.14
806	1164	748.	4292.	1.	2.21	856	1220	750.	4280.	1.	15.16
807	1165	748.	4293.	1.	3.63	857	1221	750.	4281.	1.	3.25
808	1166	748.	4294.	1.	3.71	858	1222	750.	4282.	3.	26.80
809	1167	748.	4305.	1.	6.59	859	1223	750.	4285.	1.	2.11
810	1168	748.	4306.	1.	13.37	860	1224	750.	4286.	1.	7.85
811	1169	748.	4307.	1.	22.68	861	1225	750.	4287.	1.	17.42
812	1170	748.	4308.	1.	18.58	862	1226	750.	4288.	1.	28.63
813	1171	748.	4309.	1.	22.46	863	1227	750.	4289.	1.	24.02
814	1172	748.	4310.	1.	26.35	864	1228	750.	4290.	1.	9.59
815	1173	748.	4311.	1.	26.59	865	1229	750.	4291.	1.	4.31
816	1175	749.	4246.	1.	4.22	866	1230	750.	4292.	1.	2.59
817	1176	749.	4247.	1.	.90	867	1231	750.	4293.	1.	7.19
818	1177	749.	4248.	1.	2.34	868	1232	750.	4294.	1.	2.40
819	1178	749.	4249.	1.	2.34	869	1233	750.	4295.	5.	65.96
820	1179	749.	4275.	1.	65.99	870	1235	750.	4302.	1.	3.58
821	1180	749.	4276.	1.	60.79	871	1236	750.	4303.	1.	3.72
822	1181	749.	4277.	1.	67.23	872	1237	750.	4304.	1.	2.47
823	1182	749.	4278.	1.	60.47	873	1238	750.	4305.	1.	5.05
824	1183	749.	4279.	1.	30.22	874	1239	750.	4306.	1.	45.27
825	1184	749.	4283.	1.	1.69	875	1240	750.	4307.	1.	48.31
826	1185	749.	4284.	1.	14.22	876	1241	750.	4308.	1.	12.26
827	1186	749.	4285.	1.	14.34	877	1242	750.	4309.	1.	6.30
828	1187	749.	4286.	1.	30.75	878	1245	750.	4315.	5.	28.49
829	1188	749.	4287.	1.	24.30	879	1246	751.	4272.	1.	12.49
830	1189	749.	4288.	1.	23.40	880	1247	751.	4273.	1.	12.57
831	1190	749.	4289.	1.	12.09	881	1248	751.	4274.	1.	12.06
832	1191	749.	4290.	1.	4.34	882	1249	751.	4275.	1.	23.09
833	1192	749.	4291.	1.	1.05	883	1250	751.	4276.	1.	20.62
834	1193	749.	4292.	1.	2.23	884	1251	751.	4277.	1.	28.34
835	1194	749.	4293.	1.	1.63	885	1252	751.	4278.	1.	42.74
836	1195	749.	4294.	1.	4.42	886	1253	751.	4279.	1.	29.11
837	1196	749.	4305.	1.	9.57	887	1254	751.	4280.	1.	20.75
838	1197	749.	4306.	1.	33.96	888	1255	751.	4281.	1.	1.34
839	1198	749.	4307.	1.	10.97	889	1256	751.	4285.	1.	5.68
840	1199	749.	4308.	1.	13.84	890	1257	751.	4286.	1.	1.80
841	1200	749.	4309.	1.	9.18	891	1258	751.	4287.	1.	16.35
842	1201	749.	4310.	1.	2.61	892	1259	751.	4288.	1.	35.39
843	1202	749.	4311.	1.	7.10	893	1260	751.	4289.	1.	29.75
844	1206	750.	4245.	5.	16.20	894	1261	751.	4290.	1.	15.61
845	1207	750.	4250.	5.	34.90	895	1262	751.	4291.	1.	3.91
846	1208	750.	4255.	10.	53.28	896	1263	751.	4292.	1.	3.74
847	1211	750.	4270.	2.	39.13	897	1264	751.	4293.	1.	7.82
848	1212	750.	4272.	1.	62.41	898	1265	751.	4294.	1.	2.94
849	1213	750.	4273.	1.	41.02	899	1266	751.	4302.	1.	2.37
850	1214	750.	4274.	1.	13.49	900	1267	751.	4303.	1.	3.11

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AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)	AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)
901	1268	751.	4304.	1.	5.01	951	1322	753.	4287.	1.	1.69
902	1269	751.	4305.	1.	21.36	952	1323	753.	4288.	1.	2.00
903	1270	751.	4306.	1.	21.03	953	1324	753.	4289.	1.	2.23
904	1271	751.	4307.	1.	23.26	954	1325	753.	4290.	1.	1.84
905	1272	751.	4308.	1.	.19	955	1326	753.	4291.	1.	.69
906	1273	751.	4309.	1.	.19	956	1327	753.	4292.	1.	1.08
907	1274	752.	4270.	3.	77.85	957	1328	753.	4293.	1.	8.43
908	1275	752.	4273.	1.	24.62	958	1329	753.	4294.	1.	8.45
909	1276	752.	4274.	1.	23.37	959	1330	753.	4300.	1.	2.91
910	1277	752.	4275.	1.	7.41	960	1331	753.	4301.	1.	4.90
911	1278	752.	4276.	1.	36.35	961	1332	753.	4302.	1.	16.39
912	1279	752.	4277.	1.	28.42	962	1333	753.	4303.	1.	12.43
913	1280	752.	4278.	1.	30.30	963	1334	753.	4304.	1.	8.57
914	1281	752.	4279.	1.	25.41	964	1335	753.	4305.	1.	27.08
915	1282	752.	4280.	1.	24.82	965	1336	753.	4306.	1.	23.47
916	1283	752.	4281.	1.	14.21	966	1337	753.	4307.	1.	6.68
917	1284	752.	4285.	1.	1.08	967	1338	753.	4308.	1.	2.76
918	1285	752.	4286.	1.	1.08	968	1339	753.	4309.	1.	4.80
919	1286	752.	4287.	1.	1.14	969	1340	754.	4273.	1.	13.73
920	1287	752.	4288.	1.	8.69	970	1341	754.	4274.	1.	11.01
921	1288	752.	4289.	1.	6.83	971	1342	754.	4275.	1.	16.43
922	1289	752.	4290.	1.	7.43	972	1343	754.	4276.	1.	10.65
923	1290	752.	4291.	1.	.81	973	1344	754.	4277.	1.	11.52
924	1291	752.	4292.	1.	1.21	974	1345	754.	4278.	1.	12.74
925	1292	752.	4293.	1.	9.71	975	1346	754.	4279.	1.	12.87
926	1293	752.	4294.	1.	3.16	976	1347	754.	4280.	1.	10.13
927	1294	752.	4300.	1.	4.02	977	1348	754.	4281.	1.	9.02
928	1295	752.	4301.	1.	4.04	978	1349	754.	4282.	1.	7.84
929	1296	752.	4302.	1.	7.19	979	1350	754.	4283.	1.	9.01
930	1297	752.	4303.	1.	3.25	980	1351	754.	4284.	1.	1.51
931	1298	752.	4304.	1.	4.30	981	1352	754.	4285.	1.	1.08
932	1299	752.	4305.	1.	23.81	982	1353	754.	4286.	1.	1.08
933	1300	752.	4306.	1.	28.09	983	1354	754.	4287.	1.	2.82
934	1301	752.	4307.	1.	24.61	984	1355	754.	4288.	1.	2.85
935	1302	752.	4308.	1.	1.26	985	1356	754.	4289.	1.	2.73
936	1303	752.	4309.	1.	2.14	986	1357	754.	4290.	1.	7.90
937	1308	753.	4273.	1.	11.35	987	1358	754.	4291.	1.	1.25
938	1309	753.	4274.	1.	11.28	988	1359	754.	4292.	1.	1.69
939	1310	753.	4275.	1.	16.34	989	1360	754.	4293.	1.	8.93
940	1311	753.	4276.	1.	21.19	990	1361	754.	4294.	1.	7.73
941	1312	753.	4277.	1.	12.95	991	1362	754.	4300.	1.	3.87
942	1313	753.	4278.	1.	21.03	992	1363	754.	4301.	1.	4.15
943	1314	753.	4279.	1.	16.19	993	1364	754.	4302.	1.	6.80
944	1315	753.	4280.	1.	14.86	994	1365	754.	4303.	1.	5.95
945	1316	753.	4281.	1.	20.87	995	1366	754.	4304.	1.	11.47
946	1317	753.	4282.	1.	7.91	996	1367	754.	4305.	1.	9.43
947	1318	753.	4283.	1.	9.54	997	1368	754.	4306.	1.	11.64
948	1319	753.	4284.	1.	1.48	998	1369	754.	4307.	1.	11.58
949	1320	753.	4285.	1.	1.08	999	1370	754.	4308.	1.	12.22
950	1321	753.	4286.	1.	1.08	1000	1371	754.	4309.	1.	13.45

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1001	1376	755.	4245.	5.	6.97	1051	1428	756.	4312.	1.	3.77
1002	1377	755.	4250.	5.	76.96	1052	1429	756.	4313.	1.	.84
1003	1378	755.	4265.	4.	50.85	1053	1430	756.	4314.	1.	.23
1004	1379	755.	4269.	1.	.96	1054	1431	757.	4269.	1.	7.69
1005	1380	755.	4270.	1.	4.58	1055	1432	757.	4270.	1.	6.30
1006	1381	755.	4271.	1.	3.43	1056	1433	757.	4271.	1.	10.67
1007	1382	755.	4272.	1.	2.72	1057	1434	757.	4272.	1.	6.98
1008	1383	755.	4273.	1.	8.60	1058	1435	757.	4273.	1.	7.48
1009	1384	755.	4274.	1.	9.67	1059	1436	757.	4274.	1.	8.41
1010	1385	755.	4275.	1.	16.00	1060	1437	757.	4275.	1.	9.07
1011	1386	755.	4276.	1.	7.39	1061	1438	757.	4276.	1.	7.21
1012	1387	755.	4277.	1.	6.96	1062	1439	757.	4277.	1.	7.84
1013	1388	755.	4278.	2.	10.17	1063	1440	757.	4278.	1.	3.05
1014	1391	755.	4285.	5.	45.63	1064	1441	757.	4279.	1.	1.33
1015	1392	755.	4290.	5.	62.53	1065	1442	757.	4304.	3.	1.10
1016	1393	755.	4295.	5.	33.77	1066	1443	757.	4307.	1.	.26
1017	1394	755.	4300.	1.	3.52	1067	1444	757.	4308.	2.	33.54
1018	1395	755.	4301.	1.	3.54	1068	1445	757.	4310.	2.	37.38
1019	1396	755.	4302.	1.	7.14	1069	1446	757.	4312.	3.	12.67
1020	1397	755.	4303.	1.	6.18	1070	1449	758.	4269.	1.	24.84
1021	1398	755.	4304.	1.	9.60	1071	1450	758.	4270.	1.	14.82
1022	1399	755.	4305.	1.	6.48	1072	1451	758.	4271.	1.	11.94
1023	1400	755.	4306.	1.	8.30	1073	1452	758.	4272.	1.	4.23
1024	1401	755.	4307.	1.	8.43	1074	1453	758.	4273.	1.	4.13
1025	1402	755.	4308.	1.	8.61	1075	1454	758.	4274.	1.	2.81
1026	1403	755.	4309.	1.	12.39	1076	1455	758.	4275.	2.	37.18
1027	1404	755.	4310.	1.	19.22	1077	1456	758.	4277.	2.	20.31
1028	1405	755.	4311.	1.	13.77	1078	1457	758.	4279.	1.	7.28
1029	1406	755.	4312.	1.	3.77	1079	1458	758.	4307.	1.	.30
1030	1407	755.	4313.	1.	.84	1080	1459	759.	4265.	1.	1.67
1031	1408	755.	4314.	1.	.23	1081	1460	759.	4266.	1.	4.76
1032	1409	755.	4315.	5.	11.28	1082	1461	759.	4267.	1.	28.76
1033	1410	756.	4269.	1.	8.22	1083	1462	759.	4268.	1.	28.41
1034	1411	756.	4270.	1.	7.56	1084	1463	759.	4269.	1.	29.66
1035	1412	756.	4271.	1.	7.24	1085	1464	759.	4270.	1.	13.21
1036	1413	756.	4272.	1.	7.01	1086	1465	759.	4271.	1.	14.31
1037	1414	756.	4273.	1.	7.09	1087	1466	759.	4272.	1.	8.21
1038	1415	756.	4274.	1.	6.63	1088	1467	759.	4273.	1.	1.16
1039	1416	756.	4275.	1.	8.29	1089	1468	759.	4274.	1.	1.16
1040	1417	756.	4276.	1.	9.66	1090	1469	759.	4279.	1.	3.40
1041	1418	756.	4277.	1.	7.35	1091	1470	759.	4307.	1.	.25
1042	1419	756.	4300.	4.	47.67	1092	1471	759.	4308.	1.	1.78
1043	1420	756.	4304.	1.	.36	1093	1472	759.	4309.	1.	2.03
1044	1421	756.	4305.	1.	.97	1094	1473	759.	4310.	1.	1.78
1045	1422	756.	4306.	1.	.97	1095	1474	759.	4311.	1.	1.78
1046	1423	756.	4307.	1.	.97	1096	1482	760.	4250.	5.	55.41
1047	1424	756.	4308.	1.	.97	1097	1483	760.	4255.	5.	54.45
1048	1425	756.	4309.	1.	4.27	1098	1484	760.	4260.	5.	92.34
1049	1426	756.	4310.	1.	13.70	1099	1485	760.	4265.	1.	5.25
1050	1427	756.	4311.	1.	13.77	1100	1486	760.	4266.	1.	38.59

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AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)
1101	1487	760.	4267.	1.	19.07
1102	1488	760.	4268.	1.	25.46
1103	1489	760.	4269.	1.	25.62
1104	1494	760.	4280.	3.	38.25
1105	1495	760.	4283.	1.	8.91
1106	1496	760.	4284.	1.	.87
1107	1497	760.	4285.	1.	1.40
1108	1498	760.	4286.	1.	2.84
1109	1499	760.	4287.	3.	11.36
1110	1500	760.	4290.	5.	54.29
1111	1505	760.	4305.	5.	17.59
1112	1506	760.	4310.	5.	29.05
1113	1507	760.	4315.	5.	17.00
1114	1508	761.	4265.	1.	15.98
1115	1509	761.	4266.	1.	34.34
1116	1510	761.	4267.	1.	52.45
1117	1511	761.	4268.	1.	50.02
1118	1512	761.	4269.	1.	12.63
1119	1513	761.	4283.	1.	13.57
1120	1514	761.	4284.	1.	3.28
1121	1515	761.	4285.	1.	.26
1122	1516	761.	4286.	1.	6.93
1123	1517	762.	4265.	1.	37.35
1124	1518	762.	4266.	1.	53.92
1125	1519	762.	4267.	1.	27.64
1126	1520	762.	4268.	1.	25.86
1127	1521	762.	4269.	1.	10.30
1128	1522	762.	4283.	1.	25.73
1129	1523	762.	4284.	1.	13.92
1130	1524	762.	4285.	1.	7.37
1131	1525	762.	4286.	1.	6.31
1132	1539	763.	4265.	1.	73.12
1133	1540	763.	4266.	1.	98.47
1134	1541	763.	4267.	1.	19.07
1135	1542	763.	4268.	1.	17.45
1136	1543	763.	4269.	1.	8.26
1137	1544	763.	4280.	1.	6.59
1138	1545	763.	4281.	1.	6.59
1139	1546	763.	4282.	1.	11.94
1140	1547	763.	4283.	1.	42.89
1141	1548	763.	4284.	1.	13.92
1142	1549	763.	4285.	1.	12.11
1143	1550	763.	4286.	1.	8.41
1144	1551	763.	4287.	1.	1.35
1145	1552	763.	4288.	1.	1.95
1146	1553	763.	4289.	1.	1.01
1147	1559	764.	4265.	1.	35.01
1148	1560	764.	4266.	1.	60.62
1149	1561	764.	4267.	1.	43.02
1150	1562	764.	4268.	1.	8.25
1151	1563	764.	4269.	1.	2.97
1152	1564	764.	4280.	1.	5.98
1153	1565	764.	4281.	1.	5.98
1154	1566	764.	4282.	1.	22.06
1155	1567	764.	4283.	1.	33.83
1156	1568	764.	4284.	1.	21.13
1157	1569	764.	4285.	1.	7.80
1158	1570	764.	4286.	1.	24.33
1159	1571	764.	4287.	1.	6.64
1160	1572	764.	4288.	1.	7.94
1161	1573	764.	4289.	1.	7.41
1162	1584	765.	4250.	10.	137.15
1163	1585	765.	4260.	5.	28.02
1164	1586	765.	4265.	5.	197.78
1165	1590	765.	4280.	5.	96.71
1166	1591	765.	4285.	5.	76.84
1167	1592	765.	4290.	5.	44.79
1168	1595	765.	4305.	10.	118.54
1169	1596	765.	4315.	5.	20.54
1170	1619	770.	4260.	5.	32.66
1171	1620	770.	4265.	5.	43.83
1172	1621	770.	4270.	5.	195.13
1173	1622	770.	4275.	5.	9.77
1174	1623	770.	4280.	5.	7.14
1175	1624	770.	4285.	5.	33.77
1176	1625	770.	4290.	5.	47.79
1177	1626	770.	4295.	5.	40.96
1178	1627	770.	4300.	5.	34.09
1179	1628	770.	4315.	5.	14.69
1180	1637	775.	4260.	10.	113.57
1181	1638	775.	4270.	5.	45.46
1182	1639	775.	4275.	5.	58.52
1183	1640	775.	4280.	5.	9.90
1184	1641	775.	4285.	10.	70.81
1185	1642	775.	4295.	10.	77.01
1186	1643	775.	4305.	10.	73.22
1187	1644	775.	4315.	5.	30.55
1188	1667	780.	4270.	5.	46.04
1189	1668	780.	4275.	5.	32.90
1190	1669	780.	4280.	5.	12.41
1191	1670	780.	4315.	5.	33.92
1192	1701	785.	4269.	1.	2.20
1193	1702	785.	4270.	1.	1.09
1194	1703	785.	4271.	1.	14.16
1195	1704	785.	4272.	1.	14.16
1196	1705	785.	4273.	1.	1.03
1197	1706	785.	4274.	1.	1.03
1198	1707	785.	4275.	5.	58.59
1199	1708	785.	4280.	5.	12.33
1200	1709	785.	4285.	10.	232.40

RAPS 1976 AREA SOURCES

AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)	AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)
1201	1710	785.	4295.	10.	73.14	1251	2098	715.	4268.	2.	6.89
1202	1711	785.	4305.	5.	14.94	1252	2099	715.	4280.	1.	1.23
1203	1712	765.	4310.	5.	12.10	1253	2100	715.	4281.	2.	.40
1204	1717	786.	4271.	4.	13.57	1254	2101	715.	4283.	2.	2.60
1205	1742	790.	4275.	5.	3.56	1255	2102	715.	4285.	2.	1.27
1206	1743	790.	4280.	5.	23.89	1256	2103	715.	4287.	2.	.94
1207	2031	700.	4295.	1.	.41	1257	2104	715.	4289.	2.	.83
1208	2032	700.	4296.	1.	.45	1258	2105	715.	4291.	2.	.62
1209	2033	700.	4297.	1.	1.84	1259	2106	715.	4293.	2.	8.22
1210	2034	700.	4298.	2.	1.67	1260	2109	716.	4280.	1.	1.28
1211	2035	701.	4295.	3.	13.38	1261	2112	717.	4254.	2.	1.40
1212	2036	702.	4298.	2.	1.49	1262	2113	717.	4256.	2.	1.40
1213	2037	704.	4295.	3.	17.46	1263	2114	717.	4258.	2.	1.40
1214	2038	704.	4298.	2.	.33	1264	2115	717.	4260.	2.	2.00
1215	2041	705.	4259.	2.	.25	1265	2116	717.	4262.	2.	2.94
1216	2042	705.	4261.	2.	.44	1266	2117	717.	4264.	2.	1.32
1217	2043	705.	4263.	2.	24.06	1267	2118	717.	4266.	2.	1.50
1218	2044	705.	4270.	5.	23.87	1268	2119	717.	4268.	2.	13.38
1219	2045	705.	4285.	3.	1.48	1269	2120	717.	4280.	1.	.27
1220	2046	705.	4288.	2.	.45	1270	2121	717.	4281.	2.	2.04
1221	2047	706.	4298.	2.	.21	1271	2122	717.	4283.	2.	3.35
1222	2050	707.	4259.	2.	3.95	1272	2123	717.	4285.	2.	1.55
1223	2051	707.	4261.	2.	.53	1273	2124	717.	4287.	2.	1.41
1224	2052	707.	4263.	2.	10.15	1274	2125	717.	4289.	2.	1.01
1225	2053	707.	4288.	2.	1.00	1275	2126	717.	4291.	2.	10.32
1226	2054	707.	4295.	3.	13.60	1276	2127	717.	4293.	2.	13.94
1227	2055	708.	4285.	3.	2.11	1277	2130	718.	4280.	1.	.21
1228	2056	708.	4298.	2.	1.00	1278	2133	719.	4252.	2.	1.10
1229	2058	709.	4257.	2.	.66	1279	2134	719.	4254.	2.	2.64
1230	2059	709.	4259.	2.	.97	1280	2135	719.	4256.	2.	1.10
1231	2060	709.	4261.	2.	.96	1281	2136	719.	4258.	2.	.72
1232	2061	709.	4263.	2.	4.07	1282	2137	719.	4260.	2.	.72
1233	2062	709.	4288.	2.	1.00	1283	2138	719.	4262.	2.	2.99
1234	2066	711.	4257.	2.	1.47	1284	2139	719.	4264.	2.	2.38
1235	2067	711.	4259.	2.	1.44	1285	2140	719.	4266.	2.	4.57
1236	2068	711.	4261.	4.	6.56	1286	2141	719.	4268.	2.	17.07
1237	2069	711.	4285.	3.	1.19	1287	2142	719.	4280.	1.	.34
1238	2070	711.	4288.	2.	1.10	1288	2143	719.	4281.	2.	4.06
1239	2076	713.	4257.	2.	1.55	1289	2144	719.	4283.	2.	14.73
1240	2077	713.	4259.	2.	.82	1290	2145	719.	4285.	2.	.90
1241	2078	713.	4288.	2.	1.63	1291	2146	719.	4287.	2.	2.31
1242	2083	714.	4285.	1.	.53	1292	2147	719.	4289.	2.	19.61
1243	2084	714.	4286.	1.	.53	1293	2148	719.	4291.	2.	5.57
1244	2085	714.	4287.	1.	1.13	1294	2149	719.	4293.	2.	2.37
1245	2092	715.	4256.	2.	.56	1295	2150	720.	4280.	1.	.24
1246	2093	715.	4258.	2.	.80	1296	2153	721.	4250.	2.	1.10
1247	2094	715.	4260.	2.	1.20	1297	2154	721.	4252.	2.	1.10
1248	2095	715.	4262.	2.	.61	1298	2155	721.	4254.	2.	1.10
1249	2096	715.	4264.	2.	.46	1299	2156	721.	4256.	2.	3.21
1250	2097	715.	4266.	2.	3.45	1300	2157	721.	4258.	2.	1.88

RAPS 1976 AREA SOURCES

AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)	AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)
1301	2158	721.	4260.	2.	.72	1351	2211	727.	4262.	2.	5.90
1302	2159	721.	4262.	2.	.72	1352	2212	727.	4264.	2.	9.48
1303	2160	721.	4264.	2.	6.23	1353	2213	727.	4266.	2.	11.68
1304	2161	721.	4266.	4.	26.88	1354	2214	727.	4268.	2.	5.93
1305	2162	721.	4280.	1.	.27	1355	2215	727.	4295.	2.	9.22
1306	2163	721.	4281.	2.	13.53	1356	2216	728.	4297.	1.	.98
1307	2164	721.	4283.	2.	15.71	1357	2217	728.	4298.	2.	1.09
1308	2165	721.	4285.	2.	15.01	1358	2218	729.	4248.	2.	7.04
1309	2166	721.	4287.	2.	15.42	1359	2219	729.	4250.	2.	4.25
1310	2167	721.	4289.	2.	11.50	1360	2220	729.	4252.	2.	2.66
1311	2168	721.	4291.	2.	16.48	1361	2221	729.	4254.	2.	4.51
1312	2169	721.	4293.	2.	12.82	1362	2222	729.	4255.	2.	1.42
1313	2170	722.	4280.	1.	5.45	1363	2223	729.	4258.	2.	7.78
1314	2172	723.	4250.	2.	.29	1364	2224	729.	4260.	2.	14.31
1315	2173	723.	4252.	2.	.28	1365	2225	729.	4262.	2.	10.15
1316	2174	723.	4254.	2.	.29	1366	2226	729.	4264.	2.	9.78
1317	2175	723.	4256.	2.	.28	1367	2227	729.	4266.	2.	11.48
1318	2176	723.	4258.	2.	1.84	1368	2228	729.	4268.	2.	5.46
1319	2177	723.	4260.	2.	2.67	1369	2229	729.	4295.	1.	14.63
1320	2178	723.	4262.	2.	1.79	1370	2230	729.	4296.	1.	.59
1321	2179	723.	4264.	2.	5.61	1371	2231	729.	4297.	1.	.44
1322	2180	723.	4280.	1.	.88	1372	2234	730.	4310.	5.	11.49
1323	2181	723.	4281.	2.	4.11	1373	2236	731.	4248.	2.	3.93
1324	2182	723.	4283.	2.	7.06	1374	2237	731.	4250.	4.	20.54
1325	2183	723.	4285.	2.	8.24	1375	2238	731.	4254.	2.	.87
1326	2184	723.	4287.	2.	8.44	1376	2239	731.	4256.	2.	3.08
1327	2185	723.	4289.	2.	7.90	1377	2240	731.	4258.	2.	3.40
1328	2186	723.	4291.	2.	15.96	1378	2241	731.	4260.	2.	7.21
1329	2187	723.	4293.	2.	9.19	1379	2242	731.	4262.	2.	6.39
1330	2189	724.	4280.	1.	1.04	1380	2243	731.	4264.	2.	26.39
1331	2190	725.	4248.	2.	.35	1381	2244	731.	4266.	2.	8.00
1332	2191	725.	4250.	2.	.69	1382	2245	731.	4268.	2.	33.74
1333	2192	725.	4252.	2.	.76	1383	2246	732.	4245.	3.	3.72
1334	2193	725.	4254.	2.	.69	1384	2247	733.	4248.	2.	1.35
1335	2194	725.	4256.	2.	.82	1385	2248	733.	4254.	2.	6.29
1336	2195	725.	4258.	2.	3.25	1386	2249	733.	4256.	2.	.79
1337	2196	725.	4260.	2.	4.42	1387	2250	733.	4258.	2.	12.35
1338	2197	725.	4262.	2.	1.58	1388	2251	733.	4260.	2.	6.07
1339	2198	725.	4264.	2.	3.48	1389	2252	733.	4262.	2.	.97
1340	2199	725.	4266.	2.	9.39	1390	2253	733.	4264.	2.	11.10
1341	2200	725.	4268.	2.	9.72	1391	2254	733.	4266.	2.	20.57
1342	2201	725.	4295.	2.	2.48	1392	2255	733.	4268.	2.	12.73
1343	2202	725.	4297.	3.	.91	1393	2256	735.	4260.	2.	13.49
1344	2204	727.	4248.	2.	6.57	1394	2257	735.	4262.	1.	1.09
1345	2205	727.	4250.	2.	5.49	1395	2258	735.	4263.	1.	3.34
1346	2206	727.	4252.	2.	7.19	1396	2259	735.	4264.	1.	2.37
1347	2207	727.	4254.	2.	6.67	1397	2260	736.	4262.	3.	14.58
1348	2208	727.	4256.	2.	7.50	1398	2261	737.	4260.	2.	5.91
1349	2209	727.	4258.	2.	5.16	1399	2262	739.	4260.	2.	4.47
1350	2210	727.	4260.	2.	4.95	1400	2263	739.	4262.	3.	13.89

RAPS 1976 AREA SOURCES

AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)	AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)
1401	2264	740.	4295.	2.	7.41	1451	2314	753.	4267.	1.	.93
1402	2265	740.	4297.	1.	2.03	1452	2315	753.	4310.	1.	8.61
1403	2266	740.	4298.	2.	4.73	1453	2316	753.	4311.	2.	11.80
1404	2267	740.	4314.	2.	5.73	1454	2317	753.	4313.	2.	8.19
1405	2268	740.	4316.	3.	8.85	1455	2318	754.	4267.	1.	2.36
1406	2269	740.	4319.	1.	1.45	1456	2319	754.	4268.	1.	2.36
1407	2270	741.	4260.	2.	14.13	1457	2320	754.	4269.	1.	2.36
1408	2271	741.	4297.	1.	1.54	1458	2321	754.	4310.	1.	8.35
1409	2272	741.	4319.	1.	1.24	1459	2322	755.	4280.	1.	1.87
1410	2273	742.	4262.	3.	9.31	1460	2323	755.	4281.	1.	2.67
1411	2274	742.	4295.	1.	1.20	1461	2324	755.	4282.	1.	7.68
1412	2275	742.	4296.	1.	1.20	1462	2325	755.	4283.	1.	2.64
1413	2276	742.	4297.	3.	4.39	1463	2326	755.	4284.	1.	1.08
1414	2277	742.	4315.	1.	1.27	1464	2327	756.	4280.	2.	7.97
1415	2278	742.	4319.	1.	1.27	1465	2328	756.	4282.	1.	8.18
1416	2279	743.	4260.	2.	2.82	1466	2329	756.	4283.	2.	8.35
1417	2280	743.	4295.	2.	.81	1467	2330	757.	4282.	1.	20.46
1418	2281	743.	4314.	2.	20.10	1468	2331	758.	4280.	2.	16.61
1419	2282	743.	4316.	2.	7.75	1469	2332	758.	4282.	1.	19.47
1420	2283	743.	4318.	2.	4.75	1470	2333	758.	4283.	2.	11.85
1421	2284	745.	4270.	2.	66.90	1471	2334	759.	4282.	1.	7.87
1422	2285	745.	4272.	1.	8.91	1472	2337	760.	4270.	2.	23.25
1423	2286	745.	4273.	2.	30.16	1473	2338	760.	4272.	2.	6.63
1424	2287	745.	4300.	2.	10.58	1474	2339	760.	4274.	2.	20.13
1425	2288	745.	4302.	3.	.85	1475	2340	760.	4276.	2.	8.60
1426	2289	746.	4272.	1.	9.24	1476	2341	760.	4278.	2.	12.11
1427	2290	747.	4270.	1.	12.55	1477	2342	760.	4295.	2.	2.86
1428	2291	747.	4271.	1.	3.63	1478	2343	760.	4297.	2.	2.50
1429	2292	747.	4272.	1.	2.28	1479	2344	760.	4299.	2.	4.30
1430	2293	747.	4273.	1.	3.64	1480	2345	760.	4301.	2.	4.98
1431	2294	747.	4274.	1.	21.49	1481	2346	760.	4303.	2.	1.72
1432	2295	747.	4300.	2.	1.81	1482	2349	762.	4270.	2.	21.67
1433	2296	748.	4270.	2.	22.89	1483	2350	762.	4272.	2.	17.80
1434	2297	748.	4272.	1.	2.28	1484	2351	762.	4274.	2.	33.49
1435	2298	748.	4273.	2.	251.71	1485	2352	762.	4276.	2.	8.30
1436	2299	748.	4302.	1.	.55	1486	2353	762.	4278.	2.	7.40
1437	2300	748.	4303.	2.	5.38	1487	2354	762.	4295.	2.	2.48
1438	2301	749.	4272.	1.	4.26	1488	2355	762.	4297.	2.	5.08
1439	2302	749.	4300.	2.	7.49	1489	2356	762.	4299.	1.	.96
1440	2303	749.	4302.	1.	.35	1490	2357	762.	4300.	1.	.98
1441	2304	750.	4265.	3.	12.49	1491	2358	762.	4301.	1.	1.69
1442	2305	750.	4268.	2.	4.53	1492	2359	762.	4302.	1.	.19
1443	2306	750.	4310.	2.	42.03	1493	2360	762.	4303.	2.	2.39
1444	2307	750.	4312.	3.	3.13	1494	2364	763.	4299.	1.	19.75
1445	2308	751.	4300.	1.	3.51	1495	2365	763.	4300.	1.	6.92
1446	2309	751.	4301.	1.	3.54	1496	2366	763.	4301.	1.	5.84
1447	2310	752.	4268.	2.	6.64	1497	2367	763.	4302.	1.	.87
1448	2311	752.	4310.	1.	7.17	1498	2369	764.	4270.	2.	20.25
1449	2312	752.	4311.	1.	1.17	1499	2370	764.	4272.	2.	2.89
1450	2313	753.	4265.	2.	5.72	1500	2371	764.	4274.	2.	29.59

RAPS 1976 AREA SOURCES

AREA SOURCE	RAPS GRID ID	X (KM)	Y (KM)	SIDE (KM)	SO2 (MT/YR)
1501	2372	764.	4276.	2.	14.89
1502	2373	764.	4278.	2.	14.32
1503	2374	764.	4295.	2.	3.56
1504	2375	764.	4297.	1.	1.35
1505	2376	764.	4298.	1.	1.68
1506	2377	764.	4299.	1.	19.26
1507	2378	764.	4300.	1.	7.15
1508	2379	764.	4301.	1.	12.91
1509	2380	764.	4302.	1.	6.00
1510	2381	764.	4303.	2.	8.77
1511	2382	765.	4297.	1.	6.43
1512	2383	765.	4298.	1.	6.43
1513	2384	765.	4299.	1.	23.08
1514	2385	765.	4300.	1.	18.00
1515	2386	765.	4301.	1.	12.77
1516	2387	765.	4302.	1.	11.69
1517	2388	766.	4270.	4.	35.92
1518	2389	766.	4274.	2.	24.28
1519	2390	766.	4276.	2.	20.90
1520	2391	766.	4278.	2.	20.75
1521	2392	766.	4295.	2.	.65
1522	2393	766.	4297.	2.	1.88
1523	2394	766.	4299.	1.	17.28
1524	2395	766.	4300.	1.	11.30
1525	2396	766.	4301.	2.	55.54
1526	2397	766.	4303.	2.	17.76
1527	2398	767.	4299.	1.	30.96
1528	2399	767.	4300.	1.	25.10
1529	2400	768.	4274.	2.	46.75
1530	2401	768.	4276.	2.	20.79
1531	2402	768.	4278.	2.	20.79
1532	2403	768.	4295.	2.	14.99
1533	2404	768.	4297.	2.	14.69
1534	2405	768.	4299.	2.	2.26
1535	2406	768.	4301.	2.	1.65
1536	2407	768.	4303.	2.	6.16

APPENDIX B

ANNUAL AVERAGE METEOROLOGICAL JOINT FREQUENCY FUNCTION FROM THE 1976 RAPS/RAMS DATA BASE

The meteorological joint frequency function contained in the following pages is in the Standard National Climatic Center format for a 6 stability category day/night STAR deck (1=A, 2=B, 3=C, 4=D-day, 5=D-night, and 6=E-F). Sixteen 22.5° wind direction sectors are included, beginning with the northernmost wind direction sector and proceeding clockwise (i.e., N, NNE, NE, ...). The six wind speed classes, designated as U1 through U6, represent wind speeds in the range of 0-3, 4-6, 7-10, 11-16, 17-21, and greater than 21 knots. Central wind speeds for each class did vary by model, however.

SECTOR	U1	U2	U3	U4	U5	U6
			THE JOINT FREQUENCY FUNCTION FOR STABILITY CLASS 1			
1	.114000-003	.114000-003	.000000	.000000	.000000	.000000
2	.114000-003	.455000-003	.000000	.000000	.000000	.000000
3	.455000-003	.342000-003	.000000	.000000	.000000	.000000
4	.342000-003	.342000-003	.000000	.000000	.000000	.000000
5	.228000-003	.455000-003	.000000	.000000	.000000	.000000
6	.342000-003	.569000-003	.000000	.000000	.000000	.000000
7	.569000-003	.342000-003	.000000	.000000	.000000	.000000
8	.114000-003	.455000-003	.000000	.000000	.000000	.000000
9	.569000-003	.342000-003	.000000	.000000	.000000	.000000
10	.455000-003	.342000-003	.114000-003	.000000	.000000	.000000
11	.569000-003	.569000-003	.000000	.000000	.000000	.000000
12	.114000-003	.114000-003	.000000	.000000	.000000	.000000
13	.228000-003	.569000-003	.000000	.000000	.000000	.000000
14	.228000-003	.114000-003	.000000	.000000	.000000	.000000
15	.455000-003	.455000-003	.000000	.000000	.000000	.000000
16	.114000-003	.000000	.000000	.000000	.000000	.000000
			THE JOINT FREQUENCY FUNCTION FOR STABILITY CLASS 2			
1	.113800-002	.216300-002	.159400-002	.000000	.000000	.000000
2	.683000-003	.182100-002	.113800-002	.000000	.000000	.000000
3	.683000-003	.125200-002	.102500-002	.000000	.000000	.000000
4	.148000-002	.102500-002	.125200-002	.000000	.000000	.000000
5	.159400-002	.239100-002	.000000	.000000	.000000	.000000
6	.261800-002	.193500-002	.102500-002	.000000	.000000	.000000
7	.148000-002	.250500-002	.102500-002	.000000	.000000	.000000
8	.102500-002	.182100-002	.125200-002	.000000	.000000	.000000
9	.159400-002	.284600-002	.148000-002	.000000	.000000	.000000
10	.683000-003	.364300-002	.159400-002	.000000	.000000	.000000
11	.216300-002	.261800-002	.193500-002	.000000	.000000	.000000
12	.683000-003	.182100-002	.227700-002	.000000	.000000	.000000
13	.102500-002	.227700-002	.102500-002	.000000	.000000	.000000
14	.159400-002	.125200-002	.342000-003	.000000	.000000	.000000
15	.797000-003	.193500-002	.148000-002	.000000	.000000	.000000
16	.159400-002	.182100-002	.683000-003	.000000	.000000	.000000

SECTOR	U1	U2	U3	U4	U5	U6
			THE JOINT FREQUENCY FUNCTION FOR STABILITY CLASS 3			
1	.113800-002	.409800-002	.512300-002	.000000	.000000	.000000
2	.455000-003	.170800-002	.500900-002	.683000-003	.000000	.000000
3	.683000-003	.911000-003	.204900-002	.228000-003	.000000	.000000
4	.113800-002	.170800-002	.102500-002	.000000	.000000	.000000
5	.170800-002	.170800-002	.170800-002	.000000	.000000	.000000
6	.159400-002	.216300-002	.216300-002	.000000	.000000	.000000
7	.136600-002	.239100-002	.444000-002	.228000-003	.000000	.000000
8	.455000-003	.341500-002	.296000-002	.569000-003	.000000	.000000
9	.125200-002	.455400-002	.592000-002	.125200-002	.000000	.000000
10	.159400-002	.432600-002	.557800-002	.148000-002	.114000-003	.000000
11	.911000-003	.182100-002	.614800-002	.342000-003	.000000	.000000
12	.125200-002	.227700-002	.318800-002	.455000-003	.000000	.000000
13	.569000-003	.409800-002	.375700-002	.569000-003	.000000	.000000
14	.911000-003	.204900-002	.808300-002	.911000-003	.000000	.000000
15	.113800-002	.227700-002	.478100-002	.342000-003	.000000	.000000
16	.102500-002	.148000-002	.500900-002	.228000-003	.000000	.000000
			THE JOINT FREQUENCY FUNCTION FOR STABILITY CLASS 4			
1	.683000-003	.250500-002	.364300-002	.113800-002	.000000	.000000
2	.455000-003	.250500-002	.489500-002	.911000-003	.114000-003	.000000
3	.569000-003	.227700-002	.466800-002	.113800-002	.000000	.000000
4	.683000-003	.307400-002	.307400-002	.000000	.000000	.000000
5	.797000-003	.136600-002	.239100-002	.000000	.000000	.000000
6	.797000-003	.216300-002	.398500-002	.228000-003	.000000	.000000
7	.455000-003	.239100-002	.375700-002	.284600-002	.228000-003	.000000
8	.193500-002	.296000-002	.603400-002	.523700-002	.000000	.000000
9	.159400-002	.261800-002	.637500-002	.149130-001	.296000-002	.000000
10	.911000-003	.227700-002	.637500-002	.990400-002	.239100-002	.000000
11	.455000-003	.136600-002	.296000-002	.352900-002	.455000-003	.000000
12	.911000-003	.159400-002	.421200-002	.387100-002	.797000-003	.569000-003
13	.228000-003	.125200-002	.307400-002	.432600-002	.342000-003	.455000-003
14	.569000-003	.170800-002	.387100-002	.103600-001	.136600-002	.000000
15	.455000-003	.193500-002	.603400-002	.922100-002	.284600-002	.000000
16	.113800-002	.159400-002	.683100-002	.444000-002	.114000-003	.000000

THE JOINT FREQUENCY FUNCTION FOR STABILITY CLASS 5

SECTOR	U1	U2	U3	U4	U5	U6
1	.113800-002	.193500-002	.523700-002	.102500-002	.000000	.000000
2	.797000-003	.216300-002	.569200-002	.911000-003	.000000	.000000
3	.125200-002	.284600-002	.603400-002	.159400-002	.000000	.000000
4	.683000-003	.227700-002	.148000-002	.000000	.000000	.000000
5	.136600-002	.216300-002	.569000-003	.000000	.000000	.000000
6	.113800-002	.296000-002	.148000-002	.000000	.000000	.000000
7	.148000-002	.398500-002	.375700-002	.102500-002	.000000	.000000
8	.113800-002	.421200-002	.110430-001	.796900-002	.114000-003	.000000
9	.125200-002	.455400-002	.979100-002	.135470-001	.170800-002	.000000
10	.193500-002	.227700-002	.626100-002	.603400-002	.114000-003	.000000
11	.569000-003	.250500-002	.318800-002	.136600-002	.114000-003	.000000
12	.683000-003	.227700-002	.318800-002	.182100-002	.000000	.000000
13	.683000-003	.170800-002	.444000-002	.318800-002	.342000-003	.000000
14	.113800-002	.911000-003	.580600-002	.774100-002	.148000-002	.000000
15	.911000-003	.204900-002	.751400-002	.899400-002	.159400-002	.000000
16	.216300-002	.398500-002	.683100-002	.580600-002	.797000-003	.000000

THE JOINT FREQUENCY FUNCTION FOR STABILITY CLASS 6

SECTOR	U1	U2	U3	U4	U5	U6
1	.512300-002	.967700-002	.478100-002	.342000-003	.000000	.000000
2	.478100-002	.728600-002	.182100-002	.000000	.000000	.000000
3	.523700-002	.110430-001	.444000-002	.114000-003	.000000	.000000
4	.557800-002	.762800-002	.136600-002	.000000	.000000	.000000
5	.603400-002	.899400-002	.569000-003	.000000	.000000	.000000
6	.876600-002	.819700-002	.911000-003	.000000	.000000	.000000
7	.512300-002	.127590-001	.182100-002	.000000	.000000	.000000
8	.705800-002	.187840-001	.751400-002	.455000-003	.000000	.000000
9	.118400-001	.211750-001	.150270-001	.911000-003	.000000	.000000
10	.660300-002	.160520-001	.124090-001	.569000-003	.000000	.000000
11	.705800-002	.130920-001	.455400-002	.000000	.000000	.000000
12	.398500-002	.104740-001	.557800-002	.000000	.000000	.000000
13	.409800-002	.124090-001	.535100-002	.114000-003	.000000	.000000
14	.352900-002	.853800-002	.637500-002	.683000-003	.000000	.000000
15	.352900-002	.956300-002	.103600-001	.113800-002	.000000	.000000
16	.455400-002	.774100-002	.592000-002	.455000-003	.000000	.000000

APPENDIX C

HIGHEST AND SECOND-HIGHEST SO_2 CONCENTRATIONS OBSERVED AND PREDICTED (RAM AND TEM-8A) IN 1976 FOR THE RAPS/RAMS STATIONS

TABLE C-1

HIGHEST 1 HOUR OBSERVED AND PREDICTED CONCENTRATIONS FOR RAPS/RAMS 1976

Station	Observed		RAM		TEM-8A	
	($\mu g/m^3$)	Mo-Day, Hr	($\mu g/m^3$)	Mo-Day, Hr	($\mu g/m^3$)	Mo-Day, Hr
1 (101)[a]	1543	01-23, 22	1224	01-18, 08	7328	10-28, 05
2 (103)	1645	11-06, 14	798	11-16, 20	3397	10-28, 05
3 (104)	2487	12-06, 14	1606	05-13, 19	3492	10-28, 05
4 (105)	944	06-17, 08	1614	01-18, 04	3065	10-28, 05
5 (106)	1268	12-06, 09	751	09-22, 07	1868	03-23, 06
6 (108)	2483	10-07, 06	899	08-20, 03	2435	10-28, 05
7 (113)	1516	04-13, 11	773	01-04, 19	1516	03-23, 02
8 (114)	1062	01-23, 15	2003	08-23, 05	3868	08-23, 05
9 (115)	595	01-18, 12	2935	01-27, 05	3694	05-14, 03
10 (116)	1079	01-11, 22	718	05-14, 03	3445	05-14, 03
11 (120)	1048	04-11, 09	683	02-07, 07	1975	08-23, 05
12 (121)	485	12-14, 03	951	10-28, 05	1889	11-15, 02
13 (122)	1900	02-20, 12	718	03-23, 07	2329	03-23, 07

[a]RAPS/RAMS monitoring ID codes in parentheses.

TABLE C-2

SECOND HIGHEST 1 HOUR OBSERVED AND PREDICTED CONCENTRATIONS FOR RAPS/RAMS 1976

Station	Observed		RAM		TEM-8A	
	($\mu g/m^3$)	Mo-Day, Hr	($\mu g/m^3$)	Mo-Day, Hr	($\mu g/m^3$)	Mo-Day, Hr
1 (101)[a]	1524	01-23, 23	1193	01-10, 02	5889	10-28, 03
2 (103)	1613	11-06, 15	770	10-28, 05	2118	08-25, 04
3 (104)	2301	11-25, 03	1427	10-01, 06	2503	02-23, 03
4 (105)	582	12-15, 18	1303	11-14, 23	2504	11-15, 06
5 (106)	1260	12-06, 13	703	11-14, 06	1796	04-05, 10
6 (108)	464	12-11, 22	827	02-02, 21	2289	04-29, 03
7 (113)	901	04-13, 12	740	01-18, 08	1472	01-04, 19
8 (114)	1021	01-22, 16	1567	01-17, 24	1977	04-29, 22
9 (115)	536	01-16, 21	2099	08-24, 03	3473	04-29, 02
10 (116)	713	01-11, 21	671	07-17, 03	2040	07-17, 03
11 (120)	856	06-11, 10	608	12-15, 17	1753	08-25, 01
12 (121)	415	12-08, 21	777	05-11, 19	1851	03-23, 03
13 (122)	771	06-17, 09	669	06-10, 03	2087	08-23, 10

[a]RAPS/RAMS monitoring ID codes in parentheses.

TABLE C-3

HIGHEST 3 HOUR OBSERVED AND PREDICTED CONCENTRATIONS FOR RAPS/RAMS 1976

Station	Observed		RAM		TEM-8A	
	($\mu g/m^3$)	Mo-Day, Hr	($\mu g/m^3$)	Mo-Day, Hr	($\mu g/m^3$)	Mo-Day, Hr
1 (101)[a]	1416	01-23, 21	1064	01-10, 03	5078	10-28, 06
2 (103)	1513	11-06, 15	573	02-07, 06	1722	11-15, 06
3 (104)	1728	12-11, 18	1139	01-15, 03	1872	10-28, 06
4 (105)	534	12-11, 21	904	01-18, 06	2134	11-15, 06
5 (106)	816	12-05, 06	666	11-14, 06	1290	04-29, 06
6 (108)	390	12-11, 24	471	02-03, 06	1435	08-08, 03
7 (113)	407	12-22, 03	394	11-16, 21	814	05-10, 06
8 (114)	718	01-22, 18	747	08-03, 03	1555	08-03, 03
9 (115)	379	12-11, 24	965	03-06, 06	1857	01-26, 06
10 (116)	446	12-25, 12	462	07-17, 03	1581	07-17, 03
11 (120)	636	06-11, 12	271	01-02, 18	990	02-09, 03
12 (121)	350	12-14, 03	417	05-14, 21	1320	05-26, 03
13 (122)	509	02-03, 12	441	06-10, 03	970	06-17, 03

[a]RAPS/RAMS monitoring ID codes in parentheses.

TABLE C-4

SECOND HIGHEST 3 HOUR OBSERVED AND PREDICTED CONCENTRATIONS FOR RAPS/RAMS 1976

Station	Observed		RAM		TEM-8A	
	($\mu g/m^3$)	Mo-Day, Hr	($\mu g/m^3$)	Mo-Day, Hr	($\mu g/m^3$)	Mo-Day, Hr
1 (101)[a]	1295	01-22, 24	809	01-10, 06	4108	10-28, 03
2 (103)	959	11-09, 12	549	11-16, 21	1334	10-28, 06
3 (104)	1609	11-25, 06	1127	10-01, 06	1737	11-15, 06
4 (105)	388	06-14, 12	650	11-15, 21	1537	11-15, 09
5 (106)	757	12-18, 15	492	02-02, 21	1259	03-18, 03
6 (108)	378	12-11, 21	468	10-28, 09	1234	11-15, 06
7 (113)	359	12-10, 09	389	01-24, 21	731	04-09, 06
8 (114)	433	02-05, 09	729	09-02, 03	1443	08-23, 06
9 (115)	339	12-11, 21	942	01-26, 21	1698	01-26, 03
10 (116)	415	02-05, 09	330	10-13, 21	1234	05-14, 03
11 (120)	429	04-11, 09	230	02-07, 09	781	08-25, 03
12 (121)	302	05-08, 18	408	11-15, 06	1005	09-18, 03
13 (122)	426	12-13, 18	328	03-25, 06	849	08-25, 03

[a] RAPS/RAMS monitoring ID codes in parentheses.

TABLE C-5

HIGHEST 24 HOUR OBSERVED AND PREDICTED CONCENTRATIONS
FOR RAPS/RAMS 1976

Station	Observed		RAM		TEM-8A	
	($\mu g/m^3$)	Mo-Day, Hr	($\mu g/m^3$)	Mo-Day, Hr	($\mu g/m^3$)	Mo-Day, Hr
1 (101)[a]	254	02-29	482	12-31	2069	11-15
2 (103)	460	11-06	270	11-16	469	11-16
3 (104)	1233	12-15	366	10-01	711	11-16
4 (105)	267	12-11	321	11-15	728	11-15
5 (106)	478	12-06	232	02-02	573	11-15
6 (108)	179	12-11	208	12-14	380	02-27
7 (113)	198	10-09	190	11-16	323	08-15
8 (114)	195	01-23	271	04-29	443	08-23
9 (115)	141	12-11	376	02-06	1080	01-26
10 (116)	326	02-05	139	01-26	456	01-26
11 (120)	129	01-18	104	11-17	340	02-09
12 (121)	150	02-09	138	06-03	355	08-17
13 (122)	185	02-03	127	01-05	293	10-11

[a]RAPS/RAMS monitoring ID codes in parentheses.

TABLE C-6

SECOND HIGHEST 24 HOUR OBSERVED AND PREDICTED CONCENTRATIONS FOR RAPS/RAMS 1976

Station	Observed ($\mu g/m^3$)	Observed Mo-Day, Hr	RAM ($\mu g/m^3$)	RAM Mo-Day, Hr	TEM-8A ($\mu g/m^3$)	TEM-8A Mo-Day, Hr
1 (101)[a]	190	12-11	424	01-09	1852	11-14
2 (103)	393	11-09	227	02-07	462	11-15
3 (104)	1170	12-11	332	11-16	706	11-15
4 (105)	151	12-13	269	06-06	514	04-29
5 (106)	474	12-05	197	11-14	520	10-28
6 (108)	152	11-16	197	02-03	348	11-16
7 (113)	158	12-14	162	01-09	294	04-19
8 (114)	191	02-05	206	08-03	427	08-03
9 (115)	141	01-16	349	01-26	780	02-06
10 (116)	150	12-11	137	01-16	392	01-16
11 (120)	129	01-05	80	12-09	267	08-25
12 (121)	143	12-08	108	08-17	326	08-19
13 (122)	178	06-17	104	03-25	245	01-05

[a]RAPS/RAMS monitoring ID codes.

APPENDIX D

HOURLY METEOROLOGICAL AND OBSERVED CONCENTRATION DATA FOR SELECTED DAYS WITH HIGH MODELED CONCENTRATIONS

The tables in this appendix provide sets of daily hour-by-hour meteorological and air quality data (negative values indicate missing data) used in the urban model evaluations. The sample data are provided to support case study analyses of days when high concentrations were observed in the RAPS network or predicted by the short-term air quality models (TEM-8A and RAM). The days selected, and the basis for the selection are given in Table D-1.

TABLE D-1

SELECTED DAYS OF DATA AND SELECTION CRITERIA

Date	Criterion	Hour Ending	Receptor
01/15/76	RAM-H3	3	3
01/26/76	RAM-2H24	24	9
01/26/76	TEM-2H24	24	9
01/27/76	RAM-H1	5	9
08/23/76	RAM-2H1	5	8
08/23/76	TEM-2H1	5	8
10/28/76	TEM-H1	5	1
10/28/76	TEM-H3	6	1
11/15/76	TEM-H24	24	1
11/16/76	*	*	*
12/06/76	OBS-H1	14	3
12/11/76	OBS-H3	18	3
12/15/76	OBS-H24	24	3
12/31/76	RAM-H24	24	1

* Several high or second high values were observed and predicted for 1-, 3- and 24-hour averaging periods on 11/16/76.

RAM - RAM model predicted concentration
TEM - TEM-8A model predicted concentration
OBS - observed concentration

H1, H3, H24 = Highest 1-, 3-, and 24-hour average concentration for the year.
2H1, 2H3, 2H24 = Second highest 1-, 3-, and 24-hour average concentration for the year

HOURLY METEOROLOGY
COMPOSITE FROM 25 ST. LOUIS RAPS/RAMS STATIONS
76/ 1/15

HOUR ENDING	WIND DIR DEG	WIND SPD M/S	TEMP DEG K	MIX HEIGHT METERS	STAB CLASS
1	213.	2.89	270.37	159.00	6
2	203.	2.72	269.82	159.00	6
3	198.	2.52	269.82	159.00	6
4	190.	2.53	269.82	159.00	6
5	191.	2.93	269.26	159.00	6
6	186.	3.14	269.82	159.00	6
7	176.	3.32	270.37	159.00	5
8	175.	4.36	272.04	249.94	4
9	179.	4.52	273.71	400.12	4
10	177.	5.22	275.37	550.29	4
11	182.	5.70	278.15	700.47	4
12	181.	6.68	279.82	850.65	4
13	186.	6.83	280.37	1000.82	4
14	193.	7.40	280.93	1151.00	4
15	203.	6.61	280.93	1151.00	4
16	207.	5.76	280.93	1151.00	4
17	232.	8.48	280.37	1150.49	4
18	228.	8.22	279.82	1137.85	4
19	222.	6.32	279.82	1125.21	4
20	223.	5.43	279.82	1112.56	4
21	230.	5.15	279.82	1099.92	4
22	230.	4.58	279.26	1087.28	4
23	233.	3.98	279.26	1074.64	4
24	257.	4.15	279.26	1061.99	4

HOURLY METEOROLOGY
COMPOSITE FROM 25 ST. LOUIS RAPS/RAMS STATIONS
76/ 1/26

HOUR ENDING	WIND DIR DEG	WIND SPD M/S	TEMP DEG K	MIX HEIGHT METERS	STAB CLASS
1	321.	3.59	272.04	810.27	4
2	322.	3.70	272.04	805.71	4
3	321.	3.33	271.46	801.15	4
4	317.	3.83	270.93	796.59	4
5	318.	4.37	270.37	792.03	4
6	319.	4.74	269.82	787.47	4
7	313.	3.88	269.26	782.91	4
8	316.	3.74	268.71	778.35	4
9	313.	3.83	268.71	773.80	4
10	311.	4.21	268.71	769.24	4
11	312.	3.38	269.26	764.68	4
12	313.	3.23	270.37	760.12	3
13	305.	3.23	270.93	755.56	4
14	304.	5.01	270.93	751.00	4
15	305.	5.52	270.93	751.00	4
16	303.	5.12	270.37	751.00	4
17	305.	5.05	268.71	751.00	4
18	308.	4.39	268.15	678.49	5
19	311.	4.52	267.04	591.91	5
20	317.	4.53	266.48	505.33	5
21	321.	4.34	265.93	418.75	5
22	330.	4.11	265.37	332.16	6
23	346.	3.18	264.82	245.58	6
24	350.	2.89	264.26	159.00	6

HOURLY METEOROLOGY
COMPOSITE FROM 25 ST. LOUIS RAPS/RAMS STATIONS
76/ 1/27

HOUR ENDING	WIND DIR DEG	WIND SPD M/S	TEMP DEG K	MIX HEIGHT METERS	STAB CLASS
1	350.	2.40	263.70	159.00	7
2	348.	1.62	263.15	159.00	7
3	333.	1.69	263.15	159.00	7
4	328.	1.50	262.59	159.00	7
5	314.	1.48	262.59	159.00	6
6	309.	1.92	262.04	159.00	6
7	301.	1.92	262.59	159.00	6
8	295.	2.06	263.70	244.33	5
9	304.	1.83	265.37	363.94	4
10	323.	1.95	266.48	483.55	3
11	318.	1.93	267.59	603.16	2
12	302.	1.48	268.71	722.78	2
13	293.	1.68	269.82	842.39	2
14	296.	1.38	270.37	962.00	2
15	289.	.79	270.93	962.00	2
16	203.	1.21	270.93	962.00	3
17	170.	1.19	269.82	962.00	3
18	106.	1.38	269.26	952.37	4
19	120.	1.81	268.71	747.87	5
20	116.	2.36	268.71	630.10	6
21	132.	2.96	268.71	512.32	5
22	149.	3.52	268.71	394.55	5
23	152.	4.14	268.71	276.77	5
24	158.	4.44	268.71	159.00	5

HOURLY METEOROLOGY
COMPOSITE FROM 25 ST. LOUIS RAPS/RAMS STATIONS
76/ 8/23

HOUR ENDING	WIND DIR DEG	WIND SPD M/S	TEMP DEG K	MIX HEIGHT METERS	STAB CLASS
1	157.	1.04	293.71	135.00	7
2	140.	1.33	293.15	135.00	7
3	146.	1.34	292.60	135.00	7
4	34.	.91	292.04	135.00	7
5	62.	.75	291.48	135.00	7
6	82.	.76	292.04	266.78	6
7	59.	1.04	294.82	504.06	5
8	56.	1.12	297.04	741.33	4
9	58.	1.19	299.82	978.61	3
10	88.	1.78	301.49	1215.89	2
11	112.	2.34	302.60	1453.17	2
12	106.	3.03	303.15	1690.44	2
13	93.	3.56	302.60	1927.72	3
14	90.	4.07	302.04	2165.00	3
15	76.	4.18	302.60	2165.00	4
16	74.	4.31	302.04	2165.00	3
17	75.	3.96	301.49	2165.00	3
18	75.	3.19	300.37	2165.00	4
19	75.	2.82	299.26	2047.15	5
20	78.	2.57	298.15	1664.72	5
21	86.	1.94	297.60	1282.29	5
22	83.	1.94	297.04	899.86	6
23	83.	1.50	296.49	517.43	6
24	52.	1.53	295.37	135.00	6

HOURLY METEOROLOGY
COMPOSITE FROM 25 ST. LOUIS RAPS/RAMS STATIONS
76/10/28

HOUR ENDING	WIND DIR DEG	WIND SPD M/S	TEMP DEG K	MIX HEIGHT METERS	STAB CLASS
1	40.	.80	273.15	116.00	7
2	46.	.70	272.59	116.00	7
3	270.	.58	272.59	116.00	7
4	340.	.67	272.04	116.00	7
5	16.	.51	271.46	116.00	7
6	135.	.71	271.48	116.00	7
7	178.	1.01	272.59	179.73	6
8	184.	1.11	275.37	301.34	5
9	187.	1.71	277.04	422.95	4
10	198.	2.86	278.71	544.56	3
11	194.	2.47	279.82	666.17	2
12	183.	1.28	280.37	787.78	2
13	187.	1.98	281.48	909.39	2
14	196.	2.20	282.04	1031.00	3
15	209.	2.46	282.04	1031.00	3
16	202.	2.39	281.48	1031.00	4
17	191.	2.17	279.82	1031.00	4
18	174.	1.82	278.71	902.93	5
19	161.	2.03	277.04	770.44	5
20	168.	2.40	277.04	637.95	6
21	173.	2.42	276.48	505.46	6
22	177.	2.50	275.93	372.98	6
23	180.	2.92	275.93	240.49	6
24	188.	3.33	275.37	108.00	6

HOURLY METEOROLOGY
COMPOSITE FROM 25 ST. LOUIS RAPS/RAMS STATIONS
76/11/15

HOUR ENDING	WIND DIR DEG	WIND SPD M/S	TEMP DEG K	MIX HEIGHT METERS	STAB CLASS
1	115.	.65	273.15	96.00	6
2	87.	.58	273.15	96.00	6
3	34.	.86	273.15	96.00	6
4	16.	1.32	272.59	96.00	7
5	19.	1.41	272.04	96.00	7
6	16.	1.08	271.48	96.00	7
7	22.	.85	271.48	117.31	5
8	20.	.76	273.71	236.41	5
9	68.	.74	275.93	355.51	4
10	91.	1.16	277.59	474.61	3
11	77.	1.26	278.71	593.70	2
12	62.	1.01	279.26	712.80	2
13	39.	.89	279.82	831.90	2
14	115.	.59	280.37	951.00	2
15	167.	.63	280.37	951.00	2
16	83.	.67	279.82	951.00	3
17	90.	.82	278.15	954.56	4
18	76.	1.22	277.04	802.59	5
19	104.	1.36	275.93	684.82	6
20	108.	1.48	274.82	567.06	7
21	114.	1.45	274.26	449.29	7
22	148.	1.76	274.26	331.53	7
23	163.	1.68	273.71	213.76	7
24	165.	1.36	273.15	96.00	7

HOURLY METEOROLOGY
COMPOSITE FROM 25 ST. LOUIS RAPS/RAMS STATIONS
76/11/16

HOUR ENDING	WIND DIR DEG	WIND SPD M/S	TEMP DEG K	MIX HEIGHT METERS	STAB CLASS
1	174.	1.36	272.59	96.00	7
2	169.	1.08	272.04	96.00	7
3	150.	1.13	272.04	96.00	7
4	170.	1.44	271.48	96.00	7
5	190.	1.62	270.93	96.00	6
6	204.	1.92	270.93	96.00	7
7	209.	1.75	271.48	121.57	6
8	221.	1.19	273.71	281.63	5
9	218.	.98	276.48	441.69	4
10	232.	1.48	278.71	601.76	3
11	190.	2.10	280.37	761.82	3
12	202.	2.83	282.04	921.88	3
13	206.	2.86	282.60	1081.94	3
14	204.	2.63	283.15	1242.00	3
15	214.	2.30	283.15	1242.00	2
16	227.	1.36	282.60	1242.00	3
17	188.	1.25	280.93	1235.71	4
18	185.	1.55	279.26	1048.49	5
19	165.	1.53	278.15	896.41	6
20	188.	1.04	277.59	744.33	7
21	187.	1.11	276.48	592.25	7
22	188.	1.73	275.93	440.16	6
23	182.	2.24	275.37	288.08	6
24	234.	2.13	274.82	136.00	6

HOURLY METEOROLOGY
COMPOSITE FROM 25 ST. LOUIS RAPS/RAMS STATIONS
76/12/ 6

HOUR ENDING	WIND DIR DEG	WIND SPD M/S	TEMP DEG K	MIX HEIGHT METERS	STAB CLASS
1	133.	2.42	273.71	132.00	5
2	130.	2.38	273.71	132.00	5
3	124.	2.16	273.71	132.00	5
4	135.	2.01	274.26	132.00	6
5	144.	1.41	274.26	132.00	5
6	142.	1.29	273.71	712.39	4
7	164.	1.57	274.26	704.63	4
8	168.	2.36	274.82	696.97	4
9	179.	2.05	275.37	689.31	4
10	187.	1.70	275.93	681.65	4
11	184.	2.07	276.48	673.99	4
12	192.	1.77	277.04	666.32	4
13	213.	1.68	277.04	658.66	4
14	326.	1.69	275.93	651.00	4
15	348.	4.75	274.26	651.00	4
16	352.	5.21	273.71	651.00	4
17	353.	5.31	273.15	647.98	4
18	348.	5.40	272.04	640.50	4
19	350.	6.24	271.48	633.03	4
20	348.	6.12	270.93	625.55	4
21	340.	5.84	269.26	618.08	4
22	334.	6.18	268.15	610.60	4
23	334.	6.58	266.48	603.13	4
24	332.	6.83	265.37	595.65	4

HOURLY METEOROLOGY
COMPOSITE FROM 25 ST. LOUIS RAPS/RAMS STATIONS
76/12/11

HOUR ENDING	WIND DIR DEG	WIND SPD M/S	TEMP DEG K	MIX HEIGHT METERS	STAB CLASS
1	11.	4.04	266.48	622.45	4
2	13.	3.68	265.93	188.00	5
3	13.	3.24	265.93	188.00	5
4	6.	2.99	265.93	188.00	5
5	10.	2.59	265.93	188.00	5
6	10.	2.99	265.93	188.00	5
7	8.	3.17	265.93	188.00	5
8	19.	2.77	265.93	256.90	4
9	27.	2.48	266.48	349.91	4
10	26.	2.32	266.48	442.93	3
11	40.	1.56	267.04	535.95	4
12	36.	.94	268.15	628.97	3
13	21.	.66	269.26	721.98	3
14	296.	.72	269.82	815.00	3
15	250.	.91	269.82	815.00	4
16	180.	1.81	270.37	815.00	4
17	190.	1.63	270.37	815.00	4
18	192.	1.80	270.93	815.00	4
19	199.	1.16	270.93	815.00	4
20	194.	1.10	271.48	815.00	4
21	177.	1.27	271.48	815.00	4
22	191.	1.34	271.48	815.00	4
23	200.	2.32	272.04	815.00	4
24	211.	2.41	272.04	815.00	4

HOURLY METEOROLOGY
COMPOSITE FROM 25 ST. LOUIS RAPS/RAMS STATIONS
76/12/15

HOUR ENDING	WIND DIR DEG	WIND SPD M/S	TEMP DEG K	MIX HEIGHT METERS	STAB CLASS
1	214.	2.90	274.82	124.00	6
2	217.	3.02	274.26	124.00	6
3	224.	2.60	274.26	124.00	6
4	237.	2.54	273.71	124.00	5
5	260.	2.44	273.71	124.00	6
6	262.	2.48	273.15	124.00	6
7	265.	2.35	273.15	124.00	5
8	244.	2.37	275.37	189.93	5
9	243.	2.02	277.04	285.10	4
10	244.	2.26	278.71	380.28	3
11	261.	2.24	280.37	475.46	3
12	262.	2.13	282.04	570.64	3
13	270.	2.70	283.71	665.82	3
14	269.	2.78	284.26	761.00	3
15	269.	2.72	284.26	761.00	4
16	271.	2.50	282.60	761.00	4
17	245.	2.09	280.93	730.09	5
18	237.	2.18	279.26	650.94	6
19	219.	2.47	278.71	571.78	6
20	230.	2.80	278.71	492.63	6
21	237.	3.06	278.15	413.47	5
22	248.	3.57	278.71	334.31	5
23	282.	4.91	278.15	255.16	5
24	303.	5.34	277.04	176.00	5

HOURLY METEOROLOGY
COMPOSITE FROM 25 ST. LOUIS RAPS/RAMS STATIONS
76/12/31

HOUR ENDING	WIND DIR DEG	WIND SPD M/S	TEMP DEG K	MIX HEIGHT METERS	STAB CLASS
1	316.	5.20	254.26	245.00	5
2	316.	4.40	254.26	245.00	5
3	317.	4.30	253.70	245.00	5
4	312.	3.84	254.26	245.00	5
5	303.	3.66	254.82	245.00	5
6	298.	3.60	254.26	245.00	5
7	299.	3.47	254.26	245.00	5
8	299.	3.55	254.26	271.78	4
9	302.	3.96	254.26	317.82	4
10	306.	3.92	255.37	363.86	3
11	284.	2.84	256.48	409.89	3
12	281.	3.09	258.15	455.93	3
13	284.	3.22	259.26	501.96	3
14	300.	3.23	260.37	548.00	3
15	300.	3.20	260.93	548.00	3
16	303.	3.24	260.37	548.00	4
17	304.	3.18	259.26	534.62	5
18	297.	2.88	258.70	482.25	6
19	298.	3.06	258.70	429.87	6
20	299.	3.17	258.15	377.50	6
21	295.	2.71	257.59	325.12	6
22	292.	2.84	257.59	272.75	6
23	304.	3.15	257.59	220.37	5
24	305.	3.60	257.59	168.00	5

SELECTED MODEL EVALUATION INPUT DATA FOR RAPS DATA BASE
HOURLY MEASURED SO2 CONCENTRATIONS (UG/M**3) BY STATION
76/ 1/15

HOUR ENDING	101 (1)	103 (2)	104 (3)	105 (4)	106 (5)	108 (6)	113 (7)	114 (8)	115 (9)	116 (10)	120 (11)	121 (12)	122 (13)
1	37.	20.	202.	32.	18.	56.	-1.	23.	40.	47.	7.	7.	7.
2	35.	21.	123.	27.	34.	94.	-1.	50.	62.	29.	7.	7.	7.
3	84.	8.	106.	24.	40.	66.	-1.	44.	30.	33.	7.	11.	7.
4	187.	11.	121.	24.	120.	115.	-1.	107.	11.	25.	9.	25.	7.
5	253.	24.	89.	23.	85.	147.	31.	55.	7.	44.	16.	15.	7.
6	259.	27.	82.	27.	101.	195.	-1.	73.	19.	99.	8.	16.	7.
7	241.	95.	92.	54.	159.	240.	-1.	142.	181.	70.	14.	11.	20.
8	306.	96.	98.	30.	85.	194.	-1.	159.	82.	-1.	7.	14.	118.
9	41.	51.	135.	12.	63.	72.	-1.	202.	7.	-1.	7.	109.	249.
10	48.	107.	96.	20.	93.	70.	-1.	62.	7.	22.	7.	75.	269.
11	73.	28.	55.	17.	80.	68.	-1.	62.	7.	8.	7.	8.	122.
12	7.	33.	45.	7.	85.	30.	-1.	35.	7.	7.	7.	96.	131.
13	33.	46.	40.	8.	151.	37.	-1.	69.	7.	7.	7.	12.	60.
14	68.	56.	182.	7.	200.	64.	-1.	66.	7.	7.	7.	7.	68.
15	186.	7.	215.	43.	153.	132.	-1.	86.	7.	7.	7.	7.	16.
16	84.	56.	279.	202.	13.	179.	-1.	7.	20.	7.	7.	7.	8.
17	8.	52.	185.	106.	14.	7.	-1.	7.	12.	11.	11.	19.	7.
18	8.	-1.	129.	163.	19.	7.	-1.	7.	7.	7.	7.	75.	7.
19	17.	-1.	178.	145.	14.	7.	-1.	7.	7.	7.	7.	106.	7.
20	7.	-1.	193.	242.	18.	7.	-1.	7.	7.	30.	7.	9.	7.
21	9.	-1.	78.	74.	18.	8.	-1.	14.	7.	70.	86.	104.	7.
22	10.	-1.	69.	58.	14.	7.	119.	116.	18.	75.	277.	9.	7.
23	-1.	-1.	79.	113.	20.	-1.	-1.	-1.	-1.	-1.	8.	-1.	-1.
24	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.

SELECTED MODEL EVALUATION INPUT DATA FOR RAPS DATA BASE
HOURLY MEASURED SO2 CONCENTRATIONS (UG/M**3) BY STATION
76/ 1/26

HOUR ENDING	101 (1)	103 (2)	104 (3)	105 (4)	106 (5)	108 (6)	113 (7)	114 (8)	115 (9)	116 (10)	120 (11)	121 (12)	122 (13)
1	27.	7.	45.	12.	7.	37.	7.	32.	160.	38.	7.	7.	7.
2	26.	7.	96.	7.	7.	13.	7.	36.	204.	63.	7.	7.	7.
3	23.	7.	76.	7.	7.	17.	7.	21.	239.	85.	7.	7.	7.
4	15.	7.	48.	7.	7.	10.	7.	8.	46.	43.	7.	7.	7.
5	18.	7.	34.	7.	7.	10.	7.	10.	80.	22.	7.	7.	7.
6	21.	7.	50.	7.	7.	7.	7.	7.	66.	43.	7.	7.	7.
7	17.	7.	61.	19.	7.	7.	7.	7.	85.	46.	7.	7.	7.
8	12.	7.	35.	45.	8.	7.	7.	29.	38.	34.	7.	7.	7.
9	-1.	7.	59.	43.	7.	7.	7.	7.	54.	31.	7.	7.	7.
10	-1.	7.	22.	32.	7.	7.	7.	96.	41.	43.	7.	7.	7.
11	-1.	7.	13.	36.	7.	103.	7.	-1.	80.	-1.	7.	7.	7.
12	-1.	7.	11.	44.	7.	105.	7.	26.	159.	-1.	7.	7.	7.
13	-1.	7.	18.	28.	7.	15.	7.	16.	83.	83.	7.	7.	7.
14	57.	7.	23.	34.	7.	38.	7.	15.	24.	112.	7.	7.	7.
15	41.	7.	8.	8.	7.	10.	9.	7.	45.	110.	7.	8.	7.
16	33.	7.	8.	7.	8.	7.	8.	7.	95.	159.	7.	-1.	7.
17	-1.	-1.	7.	8.	7.	7.	9.	7.	121.	147.	7.	7.	7.
18	-1.	7.	8.	8.	7.	7.	7.	7.	240.	60.	7.	7.	7.
19	40.	7.	13.	12.	7.	7.	7.	7.	288.	129.	7.	8.	7.
20	43.	7.	65.	7.	7.	7.	7.	7.	161.	140.	7.	7.	7.
21	43.	7.	38.	7.	7.	7.	7.	7.	152.	139.	7.	8.	7.
22	39.	7.	90.	10.	7.	162.	7.	61.	72.	20.	7.	7.	10.
23	-1.	7.	17.	14.	7.	84.	-1.	-1.	12.	8.	7.	7.	-1.
24	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	7.	-1.	-1.	-1.	-1.

SELECTED MODEL EVALUATION INPUT DATA FOR RAPS DATA BASE
HOURLY MEASURED SO2 CONCENTRATIONS (UG/M**3) BY STATION
76/ 1/27

HOUR ENDING	101 (1)	103 (2)	104 (3)	105 (4)	106 (5)	108 (6)	113 (7)	114 (8)	115 (9)	116 (10)	120 (11)	121 (12)	122 (13)
1	22.	7.	14.	99.	56.	8.	7.	7.	7.	9.	7.	10.	10.
2	14.	7.	42.	23.	162.	7.	7.	7.	7.	24.	7.	7.	7.
3	22.	7.	63.	28.	127.	7.	7.	7.	-1.	57.	7.	7.	7.
4	29.	17.	71.	44.	12.	8.	7.	7.	7.	60.	7.	7.	7.
5	17.	12.	100.	14.	12.	7.	7.	7.	7.	35.	7.	7.	7.
6	38.	7.	94.	20.	13.	7.	8.	7.	-1.	9.	7.	7.	7.
7	49.	10.	146.	79.	10.	7.	17.	7.	8.	7.	7.	7.	7.
8	53.	9.	112.	84.	23.	7.	21.	7.	-1.	7.	7.	7.	7.
9	-1.	27.	153.	81.	25.	7.	16.	7.	-1.	76.	7.	7.	7.
10	-1.	31.	85.	56.	15.	7.	7.	7.	-1.	205.	7.	7.	9.
11	-1.	19.	114.	46.	7.	168.	8.	25.	-1.	290.	7.	7.	10.
12	-1.	9.	106.	39.	13.	10.	7.	7.	-1.	188.	7.	7.	7.
13	-1.	35.	98.	30.	7.	8.	7.	7.	-1.	152.	7.	7.	7.
14	12.	51.	25.	14.	7.	7.	7.	7.	-1.	128.	7.	7.	7.
15	-1.	40.	46.	23.	7.	8.	7.	7.	-1.	36.	7.	7.	7.
16	80.	46.	68.	28.	7.	7.	7.	7.	27.	7.	7.	7.	7.
17	55.	39.	26.	38.	7.	7.	7.	7.	9.	7.	7.	7.	7.
18	50.	13.	52.	58.	15.	7.	8.	7.	7.	7.	7.	7.	7.
19	51.	28.	83.	11.	10.	7.	7.	7.	10.	17.	7.	7.	7.
20	106.	44.	77.	21.	66.	7.	10.	7.	90.	41.	66.	7.	7.
21	81.	32.	67.	30.	66.	8.	30.	7.	74.	67.	186.	7.	7.
22	171.	39.	55.	31.	60.	11.	122.	32.	64.	61.	123.	-1.	11.
23	-1.	115.	98.	-1.	-1.	41.	127.	89.	-1.	-1.	75.	153.	-1.
24	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.

SELECTED MODEL EVALUATION INPUT DATA FOR RAPS DATA BASE
HOURLY MEASURED SO2 CONCENTRATIONS (UG/M**3) BY STATION
76/ 8/23

HOUR ENDING	101 (1)	103 (2)	104 (3)	105 (4)	106 (5)	108 (6)	113 (7)	114 (8)	115 (9)	116 (10)	120 (11)	121 (12)	122 (13)
1	11.	-1.	7.	7.	27.	-1.	-1.	7.	7.	7.	7.	42.	24.
2	7.	-1.	7.	7.	25.	-1.	-1.	7.	7.	7.	7.	37.	10.
3	7.	-1.	7.	7.	20.	-1.	-1.	7.	7.	7.	7.	10.	15.
4	28.	-1.	7.	7.	17.	7.	-1.	7.	7.	7.	7.	7.	25.
5	39.	-1.	7.	7.	12.	7.	-1.	7.	7.	7.	7.	7.	-1.
6	10.	-1.	7.	7.	18.	7.	-1.	7.	7.	7.	7.	7.	16.
7	19.	-1.	7.	7.	16.	7.	-1.	7.	7.	7.	7.	7.	-1.
8	24.	-1.	21.	9.	49.	-1.	-1.	6.	6.	6.	6.	34.	15.
9	30.	-1.	42.	178.	92.	10.	-1.	-1.	6.	6.	6.	39.	21.
10	13.	-1.	40.	143.	101.	6.	-1.	-1.	6.	6.	6.	234.	14.
11	57.	19.	40.	143.	-1.	6.	73.	6.	-1.	6.	34.	141.	17.
12	76.	-1.	58.	64.	-1.	6.	-1.	-1.	6.	6.	54.	-1.	13.
13	12.	-1.	21.	69.	-1.	12.	-1.	-1.	6.	6.	-1.	-1.	24.
14	7.	-1.	7.	92.	71.	-1.	-1.	6.	6.	6.	-1.	-1.	15.
15	6.	-1.	6.	70.	36.	-1.	-1.	6.	6.	6.	-1.	-1.	18.
16	6.	-1.	6.	111.	29.	10.	-1.	6.	6.	6.	15.	45.	20.
17	6.	-1.	6.	103.	32.	6.	-1.	6.	6.	6.	13.	42.	15.
18	6.	-1.	6.	68.	32.	7.	-1.	6.	6.	6.	9.	36.	-1.
19	6.	-1.	6.	29.	36.	6.	-1.	6.	6.	6.	6.	34.	13.
20	6.	6.	6.	44.	42.	-1.	-1.	6.	6.	6.	6.	33.	-1.
21	18.	6.	6.	191.	32.	7.	-1.	6.	6.	6.	6.	-1.	12.
22	9.	6.	6.	152.	78.	-1.	-1.	6.	6.	6.	6.	-1.	-1.
23	11.	-1.	6.	202.	-1.	-1.	-1.	7.	-1.	-1.	-1.	-1.	22.
24	-1.	-1.	-1.	-1.	-1.	7.	-1.	-1.	-1.	-1.	-1.	-1.	-1.

SELECTED MODEL EVALUATION INPUT DATA FOR RAPS DATA BASE
HOURLY MEASURED SO2 CONCENTRATIONS (UG/M**3) BY STATION
76/10/28

HOUR ENDING	101 (1)	103 (2)	104 (3)	105 (4)	106 (5)	108 (6)	113 (7)	114 (8)	115 (9)	116 (10)	120 (11)	121 (12)	122 (13)
1	9.	-1.	9.	-1.	26.	8.	7.	8.	7.	7.	-1.	10.	7.
2	11.	7.	18.	9.	22.	9.	7.	7.	7.	7.	-1.	8.	7.
3	19.	7.	32.	20.	-1.	10.	7.	-1.	7.	7.	-1.	8.	7.
4	11.	7.	26.	72.	23.	8.	7.	-1.	7.	7.	-1.	7.	7.
5	11.	7.	40.	50.	11.	8.	7.	-1.	7.	7.	-1.	7.	7.
6	9.	7.	84.	6.	12.	7.	8.	-1.	7.	7.	-1.	7.	7.
7	10.	11.	86.	9.	22.	12.	17.	-1.	7.	7.	-1.	7.	7.
8	21.	26.	63.	8.	34.	9.	42.	-1.	7.	7.	-1.	7.	7.
9	17.	32.	37.	23.	229.	69.	37.	-1.	9.	7.	-1.	8.	7.
10	140.	62.	264.	52.	366.	121.	71.	-1.	10.	7.	-1.	48.	42.
11	81.	28.	92.	-1.	167.	62.	159.	-1.	36.	7.	-1.	112.	138.
12	48.	-1.	66.	45.	50.	70.	121.	-1.	88.	7.	-1.	81.	172.
13	55.	-1.	67.	48.	46.	82.	87.	-1.	94.	7.	-1.	44.	136.
14	59.	-1.	85.	55.	79.	94.	72.	-1.	88.	7.	-1.	90.	239.
15	74.	-1.	54.	81.	132.	70.	61.	-1.	76.	7.	-1.	86.	158.
16	126.	55.	61.	80.	146.	97.	110.	-1.	63.	7.	-1.	60.	60.
17	108.	62.	66.	70.	147.	132.	94.	-1.	49.	7.	-1.	80.	38.
18	147.	116.	159.	140.	178.	91.	92.	-1.	41.	31.	-1.	71.	60.
19	115.	129.	183.	102.	140.	127.	152.	-1.	45.	24.	-1.	68.	41.
20	73.	48.	105.	58.	94.	99.	173.	-1.	45.	7.	-1.	129.	22.
21	61.	23.	103.	30.	45.	50.	110.	-1.	31.	7.	-1.	171.	33.
22	41.	9.	80.	25.	-1.	54.	56.	-1.	-1.	7.	-1.	206.	22.
23	-1.	22.	45.	18.	21.	50.	-1.	-1.	-1.	7.	-1.	-1.	58.
24	-1.	10.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.

SELECTED MODEL EVALUATION INPUT DATA FOR RAPS DATA BASE
HOURLY MEASURED SO2 CONCENTRATIONS (UG/M**3) BY STATION
76/11/15

HOUR ENDING	101 (1)	103 (2)	104 (3)	105 (4)	106 (5)	108 (6)	113 (7)	114 (8)	115 (9)	116 (10)	120 (11)	121 (12)	122 (13)
1	63.	20.	314.	10.	52.	10.	33.	7.	-1.	7.	26.	30.	-1.
2	41.	26.	386.	-1.	-1.	13.	29.	7.	-1.	7.	30.	30.	7.
3	47.	12.	415.	10.	25.	7.	24.	8.	-1.	7.	28.	25.	7.
4	52.	8.	323.	14.	42.	7.	14.	12.	-1.	7.	44.	32.	7.
5	34.	17.	146.	25.	78.	12.	9.	9.	-1.	7.	18.	33.	7.
6	45.	22.	140.	31.	40.	10.	24.	17.	-1.	7.	14.	28.	7.
7	45.	23.	232.	28.	39.	15.	23.	26.	-1.	7.	7.	26.	7.
8	66.	30.	404.	28.	75.	16.	43.	23.	-1.	7.	7.	29.	7.
9	72.	67.	809.	31.	260.	60.	63.	136.	-1.	7.	24.	-1.	30.
10	155.	29.	454.	127.	226.	58.	127.	144.	-1.	7.	64.	-1.	69.
11	139.	71.	456.	105.	240.	48.	191.	122.	-1.	7.	122.	-1.	60.
12	119.	44.	376.	51.	203.	27.	296.	120.	-1.	7.	124.	-1.	51.
13	66.	24.	313.	47.	125.	21.	190.	140.	-1.	7.	117.	-1.	33.
14	116.	45.	237.	43.	116.	15.	205.	60.	-1.	7.	113.	-1.	34.
15	141.	42.	647.	32.	129.	21.	75.	19.	-1.	7.	-1.	-1.	31.
16	153.	67.	734.	32.	125.	32.	82.	11.	-1.	7.	88.	121.	27.
17	111.	51.	401.	36.	179.	45.	92.	37.	-1.	7.	89.	123.	28.
18	66.	48.	420.	33.	194.	79.	139.	22.	-1.	9.	90.	123.	21.
19	73.	46.	622.	32.	135.	62.	64.	44.	-1.	8.	68.	133.	13.
20	104.	48.	801.	23.	89.	45.	67.	35.	-1.	19.	56.	141.	7.
21	88.	26.	580.	47.	86.	36.	62.	38.	-1.	137.	69.	132.	8.
22	147.	32.	782.	20.	37.	36.	59.	48.	-1.	231.	86.	76.	8.
23	-1.	-1.	-1.	8.	-1.	63.	-1.	-1.	-1.	-1.	-1.	-1.	-1.
24	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.

SELECTED MODEL EVALUATION INPUT DATA FOR RAPS DATA BASE
HOURLY MEASURED SO2 CONCENTRATIONS (UG/M**3) BY STATION
76/11/16

HOUR ENDING	101 (1)	103 (2)	104 (3)	105 (4)	106 (5)	108 (6)	113 (7)	114 (8)	115 (9)	116 (10)	120 (11)	121 (12)	122 (13)
1	185.	52.	562.	7.	47.	37.	142.	95.	-1.	142.	-1.	91.	-1.
2	162.	69.	817.	8.	139.	24.	170.	87.	-1.	136.	33.	133.	-1.
3	107.	35.	800.	7.	231.	32.	114.	51.	-1.	119.	61.	174.	-1.
4	153.	79.	902.	8.	225.	49.	87.	80.	-1.	139.	125.	135.	-1.
5	289.	56.	658.	12.	278.	60.	74.	89.	-1.	124.	70.	139.	-1.
6	175.	71.	1221.	54.	230.	55.	232.	114.	-1.	95.	64.	121.	-1.
7	271.	141.	742.	48.	151.	85.	193.	158.	-1.	111.	67.	100.	-1.
8	176.	157.	810.	43.	110.	79.	130.	174.	-1.	109.	66.	86.	-1.
9	123.	306.	888.	-1.	111.	181.	-1.	104.	-1.	138.	61.	65.	-1.
10	154.	215.	1309.	-1.	112.	220.	108.	104.	-1.	304.	43.	54.	-1.
11	312.	384.	-1.	142.	333.	376.	-1.	256.	-1.	94.	73.	45.	-1.
12	230.	228.	1389.	110.	414.	263.	128.	224.	-1.	64.	81.	49.	-1.
13	319.	162.	-1.	95.	392.	233.	-1.	112.	-1.	-1.	-1.	-1.	-1.
14	158.	84.	739.	48.	393.	268.	54.	109.	-1.	34.	58.	-1.	-1.
15	185.	96.	760.	91.	309.	217.	49.	116.	-1.	27.	33.	-1.	-1.
16	195.	237.	1277.	112.	156.	169.	53.	35.	-1.	29.	41.	-1.	-1.
17	186.	222.	1194.	91.	107.	160.	38.	78.	-1.	19.	150.	-1.	-1.
18	178.	182.	1154.	81.	120.	198.	55.	97.	-1.	7.	144.	-1.	-1.
19	162.	127.	900.	68.	94.	178.	63.	41.	-1.	12.	97.	322.	-1.
20	107.	148.	1009.	-1.	148.	161.	72.	66.	-1.	78.	165.	208.	-1.
21	131.	182.	-1.	53.	153.	-1.	110.	86.	-1.	144.	169.	167.	-1.
22	84.	170.	-1.	41.	105.	-1.	164.	180.	-1.	148.	138.	226.	-1.
23	-1.	134.	-1.	25.	129.	-1.	-1.	-1.	-1.	-1.	115.	216.	-1.
24	-1.	107.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	60.	-1.	-1.

SELECTED MODEL EVALUATION INPUT DATA FOR RAPS DATA BASE
HOURLY MEASURED SO2 CONCENTRATIONS (UG/M**3) BY STATION
76/12/ 6

HOUR ENDING	101 (1)	103 (2)	104 (3)	105 (4)	106 (5)	108 (6)	113 (7)	114 (8)	115 (9)	116 (10)	120 (11)	121 (12)	122 (13)
1	238.	52.	-1.	84.	466.	35.	144.	26.	37.	7.	89.	93.	39.
2	185.	50.	-1.	78.	469.	26.	177.	12.	35.	7.	133.	110.	45.
3	205.	38.	-1.	73.	472.	18.	138.	8.	36.	7.	148.	75.	38.
4	198.	-1.	-1.	63.	443.	12.	113.	9.	29.	7.	196.	48.	37.
5	136.	45.	-1.	57.	394.	13.	109.	12.	-1.	7.	140.	57.	45.
6	126.	22.	-1.	52.	231.	12.	88.	10.	22.	7.	116.	89.	97.
7	140.	14.	-1.	38.	213.	41.	94.	111.	28.	7.	91.	96.	96.
8	163.	24.	-1.	23.	748.	110.	160.	140.	32.	7.	82.	118.	83.
9	142.	32.	-1.	41.	1268.	105.	335.	208.	9.	7.	52.	78.	88.
10	120.	88.	-1.	27.	1007.	192.	-1.	154.	7.	7.	28.	70.	78.
11	116.	-1.	-1.	59.	400.	191.	-1.	195.	7.	7.	13.	62.	46.
12	63.	58.	-1.	85.	-1.	122.	-1.	75.	7.	7.	7.	133.	29.
13	106.	40.	-1.	43.	1260.	176.	-1.	131.	7.	-1.	7.	65.	32.
14	144.	199.	2487.	243.	327.	124.	-1.	56.	29.	7.	9.	30.	34.
15	77.	74.	755.	79.	290.	31.	48.	23.	32.	49.	23.	56.	38.
16	-1.	33.	187.	108.	459.	31.	64.	32.	37.	7.	42.	48.	31.
17	56.	31.	152.	90.	412.	28.	45.	16.	-1.	7.	43.	38.	-1.
18	42.	26.	262.	69.	320.	14.	27.	7.	29.	7.	46.	-1.	15.
19	36.	19.	176.	49.	289.	10.	19.	7.	24.	7.	34.	27.	8.
20	23.	7.	331.	41.	254.	7.	-1.	7.	9.	7.	22.	26.	17.
21	35.	12.	121.	27.	174.	7.	-1.	7.	62.	7.	7.	7.	12.
22	7.	10.	118.	10.	74.	7.	-1.	7.	110.	11.	7.	7.	7.
23	7.	11.	273.	-1.	-1.	7.	-1.	-1.	45.	-1.	-1.	-1.	-1.
24	-1.	13.	-1.	-1.	-1.	8.	-1.	-1.	-1.	-1.	-1.	-1.	-1.

SELECTED MODEL EVALUATION INPUT DATA FOR RAPS DATA BASE
HOURLY MEASURED SO2 CONCENTRATIONS (UG/M**3) BY STATION
76/12/11

HOUR ENDING	101 (1)	103 (2)	104 (3)	105 (4)	106 (5)	108 (6)	113 (7)	114 (8)	115 (9)	116 (10)	120 (11)	121 (12)	122 (13)
1	32.	52.	360.	63.	63.	7.	7.	7.	7.	10.	7.	147.	7.
2	30.	81.	570.	73.	36.	12.	7.	7.	7.	7.	7.	125.	7.
3	50.	117.	702.	97.	59.	18.	7.	7.	11.	8.	-1.	156.	7.
4	59.	-1.	788.	143.	93.	31.	7.	15.	19.	28.	15.	177.	7.
5	78.	78.	541.	159.	102.	45.	7.	7.	15.	36.	34.	64.	7.
6	94.	124.	1114.	198.	121.	36.	11.	7.	17.	42.	50.	53.	-1.
7	87.	83.	776.	179.	121.	26.	8.	7.	10.	63.	29.	60.	9.
8	89.	108.	793.	160.	109.	38.	8.	27.	19.	47.	36.	61.	11.
9	123.	117.	473.	276.	90.	111.	47.	69.	51.	36.	61.	31.	27.
10	124.	116.	-1.	249.	134.	141.	109.	97.	58.	42.	39.	36.	44.
11	166.	106.	-1.	314.	151.	155.	159.	159.	51.	36.	55.	45.	49.
12	165.	86.	757.	247.	221.	76.	200.	218.	45.	36.	64.	56.	73.
13	194.	98.	1126.	300.	227.	83.	188.	203.	-1.	35.	76.	72.	82.
14	-1.	139.	1564.	314.	283.	159.	202.	202.	-1.	35.	67.	74.	118.
15	-1.	228.	1741.	330.	191.	285.	129.	141.	193.	60.	58.	64.	163.
16	360.	300.	1998.	325.	172.	279.	136.	198.	138.	157.	63.	86.	122.
17	300.	333.	1711.	286.	324.	324.	217.	245.	174.	217.	64.	73.	69.
18	301.	238.	1476.	359.	-1.	-1.	-1.	342.	-1.	361.	61.	-1.	69.
19	371.	456.	-1.	532.	-1.	401.	-1.	347.	291.	554.	59.	60.	69.
20	385.	498.	2099.	556.	-1.	309.	-1.	334.	337.	-1.	60.	58.	68.
21	415.	441.	-1.	513.	-1.	423.	-1.	311.	389.	500.	73.	64.	61.
22	350.	494.	-1.	347.	-1.	464.	-1.	305.	368.	406.	58.	85.	66.
23	258.	331.	1735.	227.	-1.	413.	-1.	378.	383.	437.	58.	80.	95.
24	153.	195.	1894.	153.	-1.	292.	-1.	262.	386.	305.	39.	60.	84.

SELECTED MODEL EVALUATION INPUT DATA FOR RAPS DATA BASE
HOURLY MEASURED SO2 CONCENTRATIONS (UG/M**3) BY STATION
76/12/15

HOUR ENDING	101 (1)	103 (2)	104 (3)	105 (4)	106 (5)	108 (6)	113 (7)	114 (8)	115 (9)	116 (10)	120 (11)	121 (12)	122 (13)
1	-1.	95.	1835.	62.	83.	93.	20.	38.	53.	-1.	25.	-1.	7.
2	-1.	53.	-1.	68.	56.	112.	27.	56.	78.	-1.	9.	-1.	7.
3	75.	60.	1807.	64.	130.	101.	50.	48.	82.	85.	20.	-1.	8.
4	52.	65.	1365.	53.	64.	112.	44.	58.	119.	80.	13.	-1.	12.
5	43.	51.	1551.	33.	40.	93.	13.	47.	87.	112.	7.	-1.	8.
6	32.	62.	1129.	42.	71.	87.	8.	7.	58.	113.	7.	-1.	7.
7	51.	65.	-1.	44.	45.	53.	7.	7.	61.	-1.	7.	-1.	7.
8	55.	125.	1725.	108.	46.	47.	7.	7.	64.	-1.	7.	-1.	7.
9	77.	90.	1302.	101.	34.	44.	8.	7.	78.	-1.	8.	-1.	7.
10	59.	79.	1376.	79.	58.	26.	7.	7.	80.	48.	-1.	-1.	8.
11	52.	72.	1163.	148.	34.	13.	9.	7.	28.	53.	7.	7.	8.
12	38.	65.	518.	28.	24.	82.	7.	7.	7.	9.	7.	-1.	7.
13	37.	34.	341.	30.	28.	73.	7.	7.	7.	7.	7.	-1.	7.
14	25.	19.	206.	26.	36.	119.	7.	7.	8.	7.	8.	-1.	7.
15	21.	29.	237.	46.	42.	82.	7.	7.	7.	7.	8.	-1.	7.
16	40.	31.	466.	122.	-1.	11.	-1.	7.	7.	7.	12.	-1.	7.
17	160.	71.	1367.	297.	-1.	7.	-1.	7.	7.	7.	16.	-1.	7.
18	349.	271.	2206.	582.	610.	9.	39.	7.	7.	7.	15.	-1.	7.
19	493.	419.	-1.	497.	588.	38.	89.	22.	7.	54.	34.	-1.	7.
20	124.	260.	1460.	100.	286.	110.	78.	41.	28.	120.	46.	-1.	7.
21	72.	76.	2135.	63.	78.	87.	48.	12.	109.	29.	25.	10.	-1.
22	70.	55.	-1.	54.	64.	68.	8.	7.	108.	60.	11.	7.	-1.
23	73.	120.	-1.	63.	-1.	24.	24.	7.	80.	-1.	-1.	7.	-1.
24	-1.	45.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.

SELECTED MODEL EVALUATION INPUT DATA FOR RAPS DATA BASE
HOURLY MEASURED SO2 CONCENTRATIONS (UG/M**3) BY STATION
76/12/31

HOUR ENDING	101 (1)	103 (2)	104 (3)	105 (4)	106 (5)	108 (6)	113 (7)	114 (8)	115 (9)	116 (10)	120 (11)	121 (12)	122 (13)
1	8.	8.	127.	8.	9.	8.	8.	8.	117.	8.	8.	8.	-1.
2	8.	8.	423.	8.	11.	8.	8.	8.	210.	48.	8.	8.	-1.
3	8.	8.	253.	8.	15.	17.	8.	45.	244.	72.	-1.	8.	-1.
4	8.	8.	146.	8.	17.	11.	8.	30.	166.	34.	8.	8.	-1.
5	33.	-1.	69.	14.	8.	-1.	8.	8.	88.	8.	8.	8.	-1.
6	22.	10.	72.	22.	8.	8.	14.	8.	19.	20.	-1.	8.	-1.
7	34.	10.	60.	30.	8.	8.	15.	8.	19.	18.	-1.	8.	-1.
8	13.	8.	113.	73.	8.	8.	8.	8.	8.	8.	-1.	8.	-1.
9	59.	8.	163.	55.	8.	8.	10.	8.	8.	8.	-1.	8.	-1.
10	22.	9.	631.	44.	20.	124.	8.	71.	29.	35.	8.	8.	-1.
11	32.	72.	683.	49.	23.	-1.	23.	120.	101.	187.	8.	8.	-1.
12	25.	73.	198.	17.	9.	7.	17.	7.	181.	212.	7.	7.	-1.
13	20.	82.	257.	9.	11.	7.	10.	7.	71.	35.	7.	7.	-1.
14	47.	40.	242.	25.	16.	6.	10.	7.	57.	8.	7.	7.	-1.
15	15.	20.	104.	25.	9.	8.	15.	7.	59.	19.	7.	7.	-1.
16	33.	11.	119.	24.	17.	8.	9.	7.	92.	37.	7.	7.	-1.
17	33.	8.	121.	22.	9.	8.	10.	7.	98.	79.	7.	7.	-1.
18	13.	11.	96.	23.	10.	8.	13.	7.	8.	30.	7.	7.	-1.
19	26.	20.	148.	21.	7.	8.	9.	7.	7.	7.	7.	7.	-1.
20	45.	18.	113.	15.	7.	7.	8.	7.	7.	7.	7.	7.	-1.
21	52.	24.	187.	42.	10.	7.	8.	7.	7.	7.	7.	7.	-1.
22	65.	23.	258.	22.	25.	9.	17.	8.	8.	8.	8.	8.	-1.
23	8.	-1.	150.	-1.	39.	8.	9.	8.	6.	-1.	6.	8.	8.
24	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.	-1.

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16. ABSTRACT

This report summarizes the results of a comprehensive evaluation of "urban" air quality simulation models using SO_2 and meteorological data collected as part of the St. Louis RAPS study. The report contains numerous tabulations of each model's performance in terms of statistical measures of performance recommended by the American Meteorological Society.

The purpose of the report is two-fold. First, it serves to document for the models considered, and similar models, their relative performance. Second, it provides the basis for a peer scientific review of the models. To stay within the spirit of this latter purpose, the report is limited to a factual presentation of information and performance statistics. No attempt is made to interpret the statistics or to provide direction to the reader, lest reviewers might be biased.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Mathematical modeling Meteorology Sulfur Dioxide Statistical Measures Performance Evaluation St. Louis RAPS Study	Air Quality Impact Assessment	

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