October 30, 1996

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Gentlemen:

Attached is the final model evaluation report for Northshore Mining Company. This report supersedes the October 2, 1996 report. As you are aware, the model evaluation studies at Northshore have gone through several stages. The NO_x evaluation won in the first round of modeling (report of February 2, 1995), but SO_2 required modification (report of July 17, 1995); this resulted in a different model for each pollutant. This report presents an analysis to provide a single, combined model for evaluating both SO_2 and NO_x. Common features were incorporated into one model and then tested to see if it was capable of winning for both pollutants. Modeling at all stages was conducted following approved modifications to the original protocol. The ISCST2 model (Version 93109) was used for both the reference and candidate models; the difference was in the use of terrain and building downwash.

The model evaluation was conducted using on-site data collected from monitoring stations located at the modeled "hot spots". In addition, meteorological monitors were located to measure both the onshore and prevailing wind situations. Three on-site meteorological data sets were available to assess the local wind conditions and to use in the model evaluations.

This analysis presents an alternative approach which shows a win for both NO_x and SO_2 resulting in a single model capable of evaluating air quality impacts. We are therefore requesting that you approve this new combined candidate model for regulatory use at the Northshore Facility.

Sincerely Yours,

W. GALE BIGGS ASSOCIATES

Gale

W. Gale Biggs, Ph.D.

Enc.
cc: Dennis Becker MPCA
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COMBINED MODEL EVALUATION STUDY
FOR THE
NORTHSHORE TACONITE FACILITY
LOCATED AT
SILVER BAY, MINNESOTA

Prepared for:

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October 1996

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CHAPTER 1 EXECUTIVE SUMMARY

1.1 OVERVIEW

This air quality model evaluation was conducted by Northshore Mining Company (Northshore) to determine whether an alternative dispersion model would perform better than the ISCST2 model run in regulatory mode. The primary objective of this air quality model evaluation was to select the most appropriate dispersion model(s) to be used for regulatory assessment of Sulfur Dioxide (SO_2) and Nitrogen Oxides (NO_x) emission impacts from the Northshore facility in Silver Bay, MN.

The Northshore facility, shown in Figure 1-1, emits both SO_2 and NO_x. The SO_2 comes primarily from two electric generating plants using coal as fuel in the winter; during the summer natural gas is generally used, and consequently the SO_2 emissions become small. NO_x is emitted from these generating plants (regardless of the fuel used) as well as from the gas-fired pelletizing furnaces. The SO_2 and NO_x emissions at the Northshore facility were quantified from both existing Continuous Emission Monitoring (CEM) data and process/activity data.

The time period from September 1, 1992 through August 31, 1993 was selected as the data period for the NO_x and SO_2 modeling database and offers a special opportunity for the evaluation: during this period the power plants operated on coal, making available extensive SO_2 emissions for the evaluation. In addition to this data, an additional six months were made available for the SO_2 evaluation; these months were April/May 1992 and September through December 1993.

A continuous record of ambient pollutant concentration and meteorological data were available in the vicinity of the Northshore Plant. SO_2 and NO_x ambient concentrations were measured at four locations near the Plant. Meteorological data were collected at a 60 meter tower (at both the 10 and 60 m levels) near the main plant stacks and at a 10 meter tower located on Radio Tower Hill. These data, coupled with the SO_2 and NO_x emissions data, formed the total database for this model evaluation.

In preparing for this model evaluation, a preliminary modeling analysis was conducted. This analysis, which was discussed in the protocol, established three important facts:

- MONITOR SITES. The present ambient monitoring sites are located close to the areas of modeled SO_2 and NO_x concentration maxima ("hot-spots") for both reference and candidate models. This indicates that the ambient monitoring data adequately characterize the peak modeled concentrations.

- CONCENTRATIONS AND TIME INTERVALS. The ISCST2 model, when used in the regulatory mode, with on-site emissions and meteorological data, predicts SO_2 and NO_x concentrations that exceed ambient air quality standards. The exceedance for short-term time intervals is more pronounced than for annual average intervals, indicating short-term time intervals to be the controlling factor.

- ISCST2 OVERPREDICTION. The ISCST2 model predicts SO_2 and NO_x concentrations far greater than those measured by the ambient monitors. This indicates that the ISCST2 model overpredicts actual ambient concentrations attributable to facility emission impacts.

1.2 INITIAL ANALYSIS

Suspecting that the cause of the ISCST2 model's overprediction might be attributed to that model's downwash algorithm and treatment of terrain, the ISCST2 model was run without the building downwash and without elevated terrain. It was found that the ISCST2 model run in this "non-regulatory" mode predicted peak concentrations much closer to the measured peak concentrations. Based on this result, the ISCST2 model run without terrain and without downwash was used as the "candidate" model for predicting pollutant concentrations near the Northshore plant. This model was used for both evaluations, SO_2 and NO_x.

It was recognized that two site specific models may result from this evaluation, one for each pollutant. In fact, this at first turned out to be the case. Preliminary Cox evaluations showed that NO_x won with the candidate model but SO_2 did not. As a result, a modified candidate model was proposed for SO_2 which added building downwash back into the model but still did not consider elevated terrain[1]; this modified candidate model showed a win for SO_2. A request was made to submit this new model for SO_2 and the new evaluation was accepted by the MPCA and EPA. The win for NO_x and the request to modify the SO_2 candidate model appear in the "Interim Report" dated February 2, 1995. Letters approving this modification appear in Appendix A.

1.3 FINAL ANALYSIS

A new question was then raised. Would it be possible to further refine the candidate model to more accurately predict concentrations? Perhaps even bring together the two candidate

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[1]The meteorological dataset was also modified by using an alternative method for calculating stability. This new dataset was run for NO_x to verify that its winning status was unaffected. The results showed some small variations from earlier runs as reflected in Tables 5-1 and 5-2.

models into one model for both NO_x and SO_2? A culpability study was performed, breaking out individual source's contribution to each receptor location. The results suggested that the disparity in results between the regulatory and candidate models was not merely a terrain/downwash problem but actually a short-stack/tall-stack concern within the downwash routines. Thus another candidate model was suggested (to be tested on both pollutants) wherein downwash was implemented only for those sources subject to Huber-Snyder downwash and was not used for sources subject to the Schulman-Scire algorithm. The result of this analysis was that limited downwash was added to the NO_x candidate model and downwash was cut back within the SO_2 candidate model. The terrain features of the model were still not implemented.

This latest Cox evaluation showed two things: 1) this one model wins for both NO_x and SO_2 and 2) its correlates better to monitored values than the previously approved candidate models do for their respective pollutants. The purpose of this report is to describe this evaluation and to request the approval of this new single candidate model for both NO_x and SO_2.

1.4 HISTORY

In August 1988 Cyprus Minerals purchased the assets of the Reserve Mining Company's milling operations located at Silver Bay, Minnesota and was issued an air quality operating permit at that time. In conjunction with the issuance of the facility's operating permit, the Minnesota Pollution Control Agency (MPCA) conducted air dispersion modeling. The modeling predicted exceedances of the ambient air quality standards.

As a result of this 1989 modeling, Cyprus initiated in 1990 a PSD level monitoring program to measure the facility's SO_2 and NO_x air quality impacts. The locations of the monitors were determined based on the modeling performed as part of the initial permitting

activities. Several years of monitoring data established that the Northshore operations were well within applicable state and Federal ambient air quality standards.

In July 1991, a modeling protocol to assess current and future impacts of plant operations was developed and submitted for the agency's review. The protocol was designed to meet two goals: 1) quantification of the air quality impacts of the Northshore facility at full production levels and 2) selection of the most appropriate model for predicting and assessing facility impacts. Since the model evaluation has as an objective to meet future PSD permitting requirements, all SO_2 and NO_x standards (State and Federal) were addressed.

In early November 1991, a joint meeting was held with the MPCA and EPA to discuss the modeling approach and protocol, to verify data requirements and to assure proper placement of all monitoring sites. As a result of this meeting the need for additional data recovery (stack temperatures) was identified and added to the program on December 4, 1991. The EPA also recommended, based on a review of prior modeling information, that one monitoring site be relocated. This was completed and the station was placed on-line at the new location on December 1, 1991.

In September 1994, Cyprus Minerals sold the assets of the Cyprus Northshore facility to Cleveland Cliffs; the facility's name is now Northshore Mining Company, a subsidiary of Cleveland Cliffs.

1.5 POLLUTANT SOURCES

The major sources of sulfur dioxide from the facility are the two electric generating plants. The plants are relatively small; Unit 1 is capable of generating 50 megawatts and Unit 2 75 megawatts. The burning of coal, or fuel oil, in these boilers produces the major sulfur dioxide emissions from the facility; natural gas combustion produces negligible sulfur dioxide.

Historical and current emission monitoring at the facility has shown that the pelletizing furnaces contribute minor amounts of sulfur dioxide.

The power plants at the facility can burn several fuels all of which cause emissions of nitrogen oxides at variable rates depending on fuel type. The pelletizing furnaces utilize natural gas which also results in nitrogen oxides emissions.

1.6 PROGRAM OBJECTIVES

The primary objective of this air quality model evaluation was to select the most appropriate dispersion model to be used for regulatory assessment of the SO_2 and NO_x emissions from the Northshore facility.

In meeting this primary objective, the dispersion model selected will serve as a regulatory predictive model with which Northshore can examine the impact of future expansions or emission increases. The objectives of this program can be stated as follows:

1) development of a site specific model capable of predicting concentrations for assessment of state and federal standards.

2) development of a site specific model capable of conducting a PSD permitting review for future facility modifications.

The standards to be satisfied in this analysis cover all state and federal NO_2 and SO_2 standards. The winning model will be used for all PSD analyses including increment consumption and the sensitivity analyses for Federal Land Managers (although the FLM's retain the right to specify different modeling procedures for evaluating Air Quality Related Values). In addition, it will be used for all state sensitivity analyses such as acid rain and lake sensitivity studies. Table 1-1 lists the standards of concern.

TABLE 1-1
SO_2 and NO_2 AMBIENT AIR QUALITY STANDARDS

POLLUTANT	CATEGORY	AVERAGING TIME	STANDARD*
SULFUR DIOXIDE			
	PRIMARY	1-HR	1300
	SECONDARY	3-HR	915
	PRIMARY/SECONDARY	3-HR	1300
	PSD INCREMENT/CLASS I	3-HR	25
	PSD INCREMENT/CLASS II	3-HR	512
	EPISODIC/ALERT	24-HR	800
	PRIMARY/SECONDARY	24-HR	365
	PSD INCREMENT/CLASS I	24-HR	5
	PSD INCREMENT/CLASS II	24-HR	91
	PRIMARY	ANNUAL	80
	SECONDARY	ANNUAL	60
	PSD INCREMENT/CLASS I	ANNUAL	2
	PSD INCREMENT/CLASS II	ANNUAL	20
	FLM SENSITIVITY ANALYSES		
	STATE ACID RAIN AND LAKE SENSITIVITY ANALYSES		
NITROGEN DIOXIDE			
	EPISODIC/ALERT	1-HR	1130
	EPISODIC/ALERT	24-HR	282
	PRIMARY/SECONDARY	ANNUAL	100
	PSD INCREMENT/CLASS I	ANNUAL	2.5
	PSD INCREMENT/CLASS II	ANNUAL	25
	FLM SENSITIVITY ANALYSES		
	STATE ACID RAIN AND LAKE SENSITIVITY ANALYSES		
Health Related Values (including toxic emissions)**			
PM (PM_{10} and smaller)**			
	PRIMARY	24-HR	***
	PRIMARY	ANNUAL	***

* values expressed in micrograms per cubic meter

** The pollutants emitted from the power plant and the pelletizers will be modeled using the winning model, pollutants from all the other emission sources will be modeled using the regulatory approach. This would include all future and current pollutant standards.

*** All current and future standards will be included.

1.7 OTHER ISSUES

Note in Table 1-1 that the approved candidate model also will be applied to pelletizer and power plant emissions for establishing compliance with current and future air quality standards for both particulate matter and other health related values. The model evaluation used nitrogen oxide (NO_x) and sulfur dioxide (SO_2) to determine the transport and dispersion of the plumes emitted from the pelletizer and power plant stacks. Small particles, PM_{10} and smaller, disperse in the same way as gaseous emissions because their gravitational settling velocities are very low (<0.005 m/s) and ambient turbulence is sufficient to keep the particles suspended and well mixed in the emissions plume. The principle of equivalence for gaseous and particulate dispersion is the basis for the classical dispersion experiments used by Pasquill, Gifford and Turner to develop the Gaussian dispersion model and the dispersion rates used in the ISC model.

Since the model evaluation under-predicted for both pollutants in the study, any use of the winning model for particulates or health related values would also include an under-prediction factor. As shown in Table 5-6 (page 57) sulfur dioxide has the largest under-prediction factor of 1.2 for the 24-hr average. This factor, along with an additional 10% regulatory safety factor, will be used in assessing modeled values using the winning model for the power plant and pelletizers.

In the analysis of the under-prediction factors for PM and the other health related values (including toxic substances) which have different averaging times than shown in Table 5-6, the following scheme is presented. For those averaging periods of less than 3-hr, the 1-hr factor of 1.8 will be used; between 3-hr but less than 24-hr, the 3-hr factor of 1.7 will be used; and for averaging times of 24-hr or greater, but less than the annual, the 24-hr factor of 1.2 will be used. Annual values will be used as calculated in the model. This scheme will only be used on those concentrations contributed by the power plant and the pelletizers.

For the modeling of pollutants that only involve the power plant and the pelletizer, the winning candidate model shall be used. To model pollutants which involve emission sources in addition to the power plant and pelletizers, a two tiered approach is presented:

1. The initial modeling effort will use the regulatory model. If the resulting modeled concentrations are within standards, no further modeling will be conducted.

2. If any receptor locations show exceedances of the standards, then two additional model runs will be conducted. These runs will be for only those receptors and averaging periods showing exceedances and include only the eligible sources (i.e., the power plant and pelletizer emission sources). The first model run will use the regulatory approach, while the second will use the winning candidate model; culpability analyses will be conducted for each. For each eligible source, the difference[2] between the regulatory and winning model concentrations will be subtracted from the tier one receptor concentrations. The resultant value will then be compared to the standard for compliance.

1.8 SUMMARY OF RESULTS

The model analysis was conducted as specified in the protocol[3,4]. The ISCST2 model[5] was used as specified in the protocol

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[2] The concentrations calculated by the winning candidate model will be corrected with the appropriate under-prediction factor and the 10% regulatory factor prior to subtraction from the regulatory model concentration.

[3] Modeling Protocol Air Quality Model Evaluation for Cyprus Northshore Mining Company. January 30, 1993.

for both the reference and candidate evaluations; both NO_x and SO_2 were included in the analyses.

A twelve month database was initially selected from available eighteen months of data. The database extended from September 1992 through August 1993. Ambient air quality and meteorological data were continuous for this period. The twelve months selected had the most complete record of air quality, meteorology and emissions data available. The first fifteen days of September 1992 did not have emissions since the Northshore facility was down and did not resume production until the sixteenth. This database provided the input to the model evaluation presented below. When the modified candidate model was proposed for SO_2, an additional six months of data were added to the evaluation. The final candidate model described in this report used the original twelve months of data for NO_x and the eighteen months of data for SO_2.

The evaluation showed a clear win for the new combined candidate model. Even though it underpredicted (with the exception of the 24-hour NO_x analysis), it still had a solid win over the reference model which showed dramatic over-predictions. The underprediction adjustments as stated in the protocol were implemented to provide a model acceptable for regulatory use.

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[4] Office of Air Quality Planning and Standards, Protocol for Determining the Best Performing Model, EPA-454/R-92-025, U.S. EPA, Research Triangle Park, NC. December 1992.

[5] The ISCST2 model was used for the candidate model runs. The Bowman Environmental Engineering version of BEEST-X was used for the regulatory model runs. The BEEST-X model is an EPA approved model incorporating both ISCST2 and COMPLEX I to satisfy the regulatory requirements for intermediate terrain analyses.

CHAPTER 2 MONITORED DATA

2.1 DESCRIPTION OF THE FIELD PROGRAM

Northshore has operated an air quality monitoring program at the plant in accordance with EPA's "Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD)" (EPA, 1987). The monitoring program consists of three main field activities: 1) stack emissions data collection, 2) air quality data collection, and 3) meteorological data collection. Figure 2-1 shows the location of the ambient monitoring stations. The meteorological data have been (and continue to be) collected at two towers: a 10 m tower located on Radio Tower hill at Station CNM6 and a 60 m tower at CNM9.

2.2 EMISSIONS MONITORING

Several continuous stack monitoring probes are part of the monitoring program. Table 2-1 lists the monitors and their locations. The results of the monitoring program were used along with other information to determine Northshore's air quality impact on the surrounding terrain. The following is a summary of the ambient air quality and meteorological measurement programs and their findings.

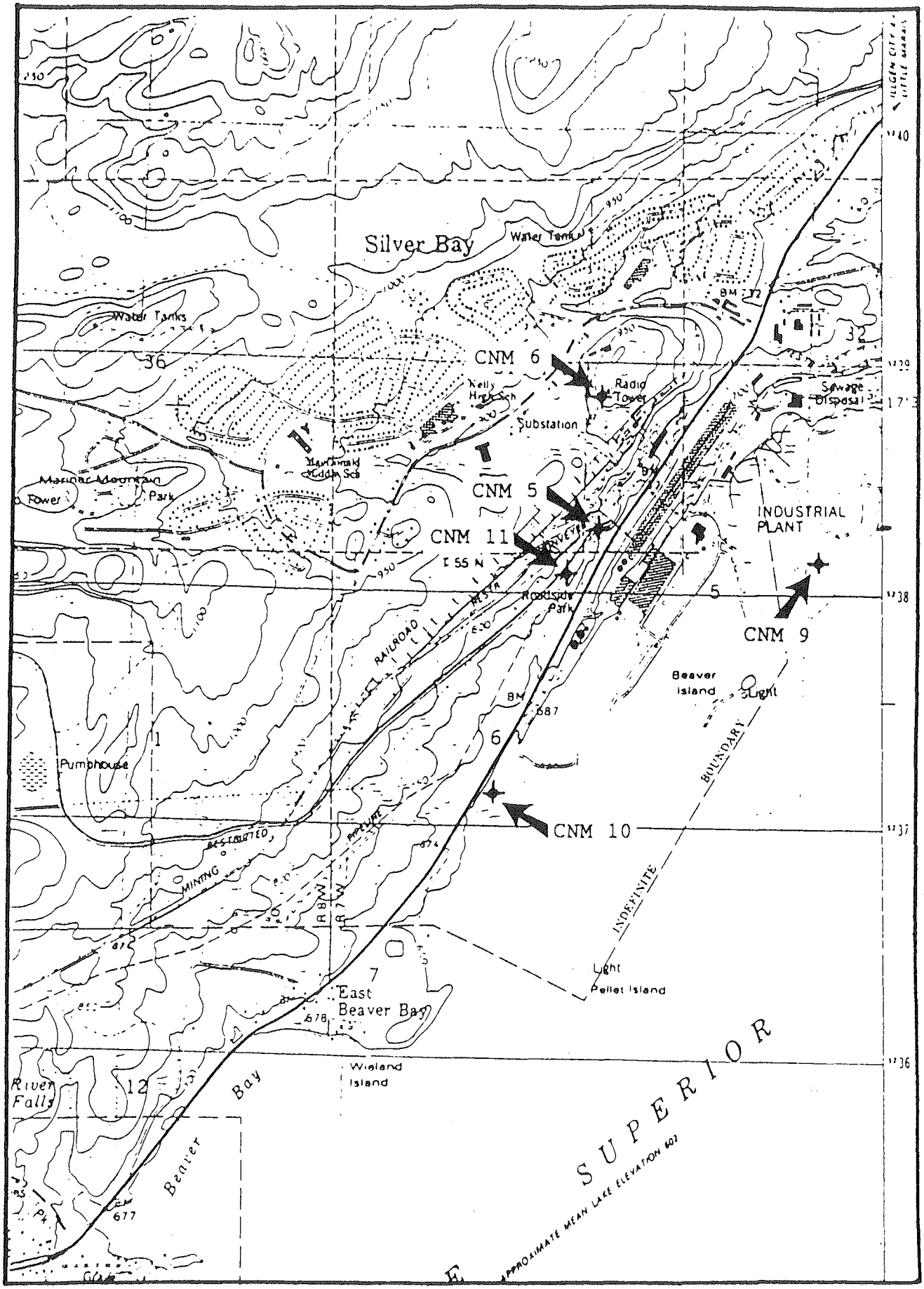


FIGURE 2-1 LOCATION OF MONITORING SITES

TABLE 2-1

CEM's AND THEIR LOCATION

POLLUTANT	MANUFACTURER/MODEL	LOCATION
NO_x/SO_2	Lear Siegler/SM8100	No. 11 Pelletizer Waste Gas Stack
O_2	Dynatron/401	No. 11 Pelletizer Waste Gas Stack
NO_x/SO_2	Lear Siegler/SM8100	No. 12 Pelletizer Waste Gas Stack
O_2	Dynatron/401	No. 12 Pelletizer Waste Gas Stack
NO_x/SO_2	Lear Siegler/SM8100	No. 2 Boiler Stack
O_2	Dynatron/401	No. 2 Boiler Stack

2.3 AMBIENT AIR QUALITY MONITORING

SO_2 was measured with a fluorescent SO_2 analyzer and NO_x was measured with a chemiluminescent nitrogen oxides analyzer. The NO_x, SO_2, and meteorological monitoring stations were located at the following sites:

1) SO_2, NO_x, and PM_{10} monitors located on the Mile Post 7 Pipeline road southwest of the Northshore main gate. The site is identified as CNM5 in Figure 2-1.

2) SO_2, NO_x monitors, and a 10 meter meteorological station located on Radio Tower Hill. The site is identified as CNM6 in Figure 2-1.

3) 10 meter and 60 meter meteorological station located at the pump house for the storm water collection pond. The site is identified as CNM9 in Figure 2-1.

4) NO_x, SO_2, and PM_{10} monitors located at the scenic overlook area just Southwest of the main power plant. The site is identified as CNM10 in Figure 2-1. Two PM_{10} monitors were co-located here, designated as CNM10 and CNM10A.

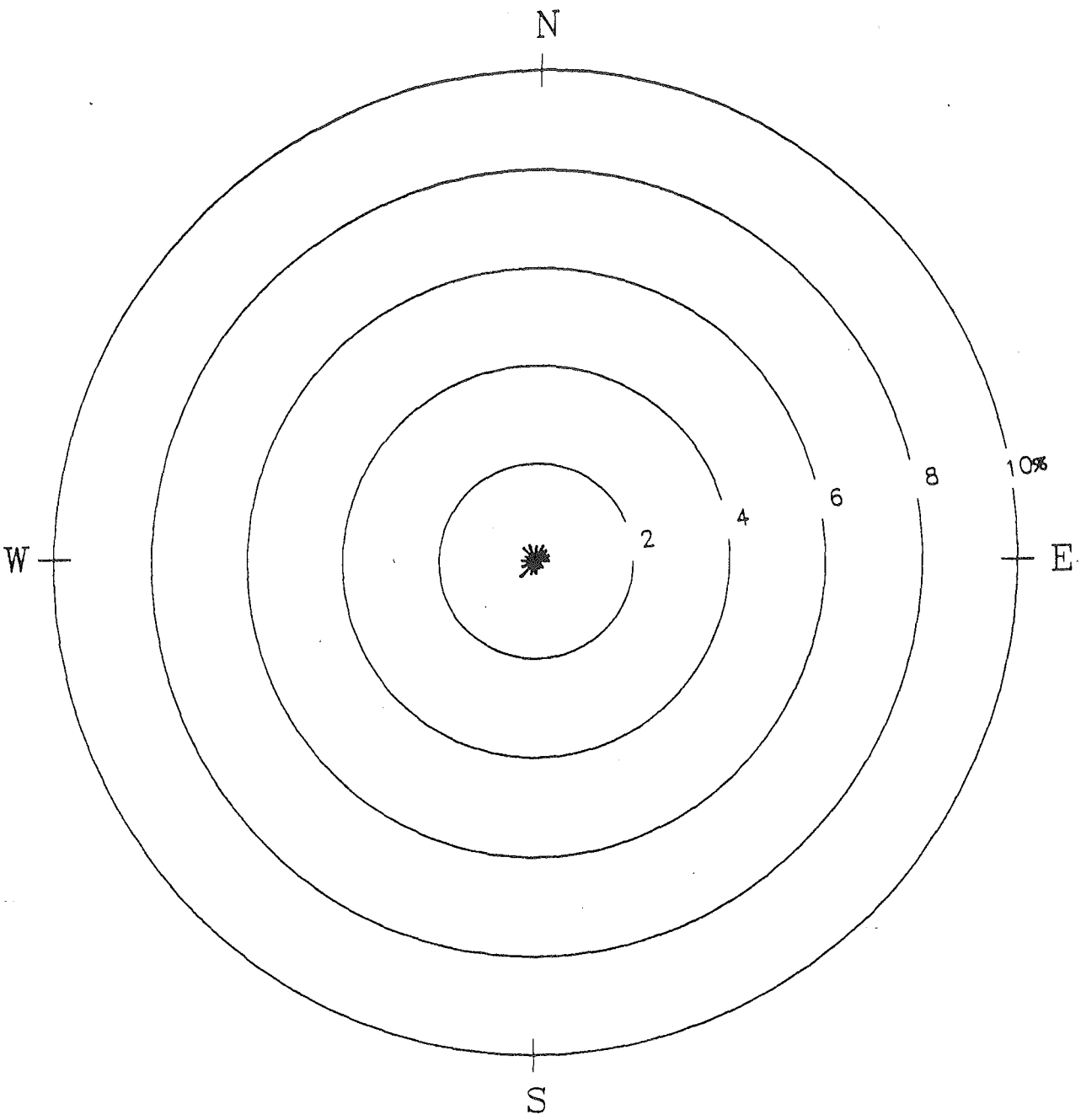
5) NO_x, SO_2, and PM_{10} monitors located 230 m SW of CNM5. The site is designated as CNM11 in Figure 2-1.

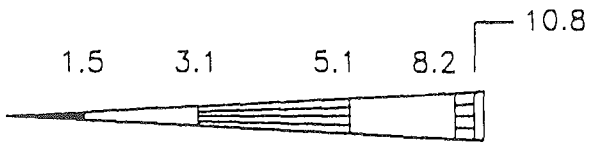
2.4 METEOROLOGY

The meteorological data were collected at two towers: 1) a 60 m tower located east of the power plant (CNM9) with measurements at both the 10- and 60-m levels, and 2) a 10 m tower located on Radio Tower Hill (Figure 2-1). The protocol specified the 60 m tower data for primary use (except for σ_θ which was obtained from the 10 m level) with backup coming from the other two data sets.

Wind roses were generated using the initial twelve months of meteorological data. These were broken into 2 groups: 1) by six stability classes and 2) by winds greater than and less than 4 mps. Figure 2-2 shows the A stability wind rose for the Northshore site. With the exception of the D stability wind rose, the scale of the plots were kept at 10% for consistency. Figure 2-2 identifies the primary directions as from the northwest/north-northwest and southwest for this stability class. Figures 2-3 through 2-7 show the stability classes B through F. These figures show that the D and E stability classes are the dominant classes, which is the expected result. The D stability class dominates with the highest percentage of occurance. The D, E and F stabilities (Figures 2-5, 2-6 and 2-7) show the shoreline flow pattern. The more unstable flows (Figures 2-2, 2-3 and 2-4) are mostly off the land onto the lake. None of the figures show a predominance of flows off the lake onto the land and the D and E stabilities show the largest amount of onshore flows.

In addition, the wind roses for wind speeds both above and below 4 mps were generated; these are shown in Figures 2-8 and 2-9. (NOTE THE SCALES ARE DIFFERENT FOR THE TWO GRAPHS.) The lower wind speeds have more onshore wind flows than the higher wind speeds and are more evenly distributed. This indicates a weaker synoptic pattern for the onshore flows and, as shown in the stability wind roses, a higher percentage of neutral and stable flows.

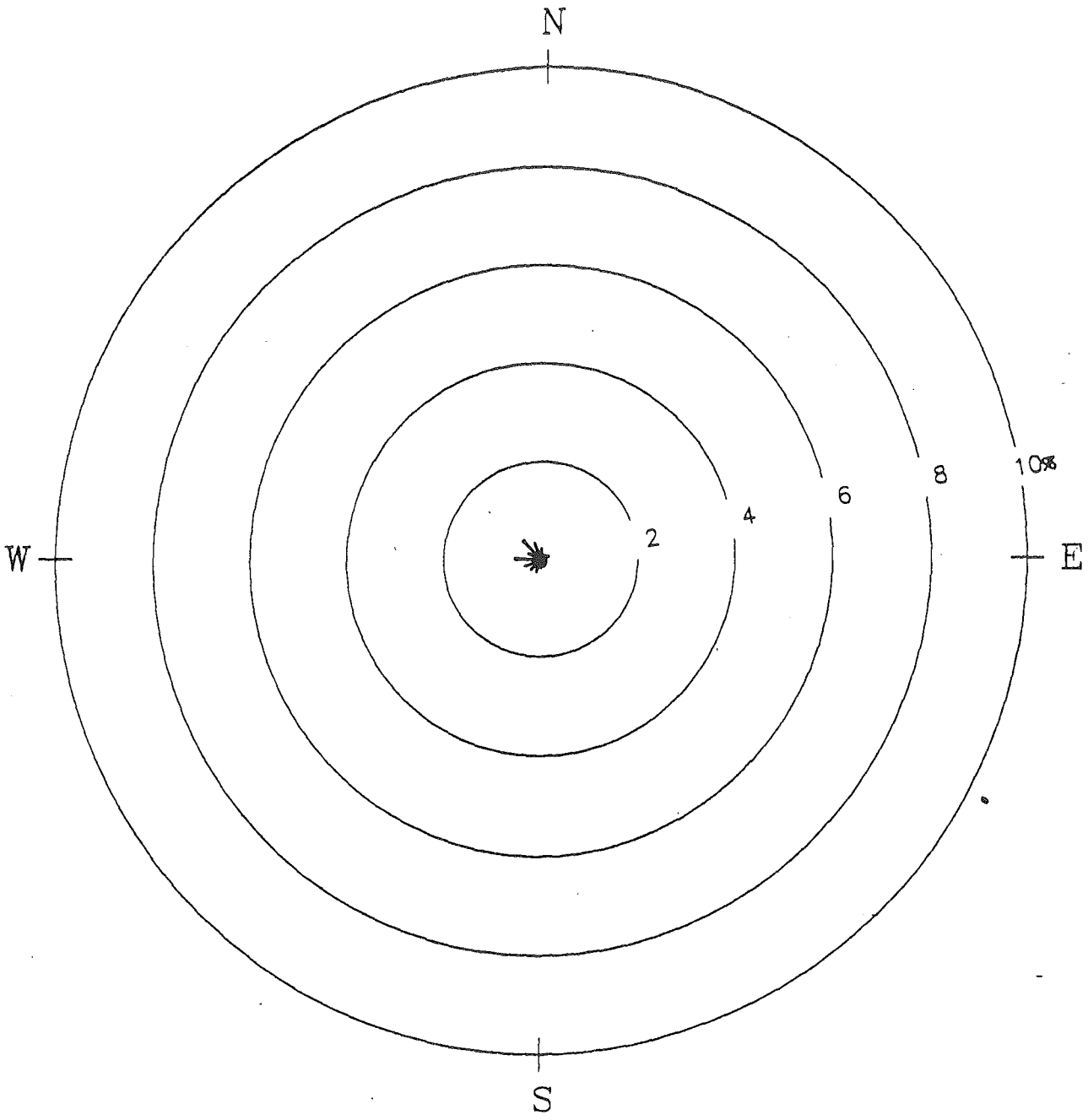


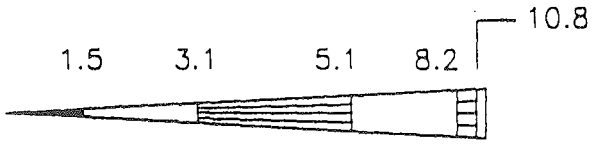


WIND SPEED CLASS BOUNDARIES
(METERS/SECOND)

NOTES:
DIAGRAM OF THE FREQUENCY OF OCCURRENCE FOR EACH WIND DIRECTION. WIND DIRECTION IS THE DIRECTION FROM WHICH THE WIND IS BLOWING. EXAMPLE – WIND IS BLOWING FROM THE NORTH .3 PERCENT OF THE TIME.

FIGURE 2-2
WINDROSE
STABILITY CLASS A
NORTHSHORE MINING
PERIOD: 1992-93

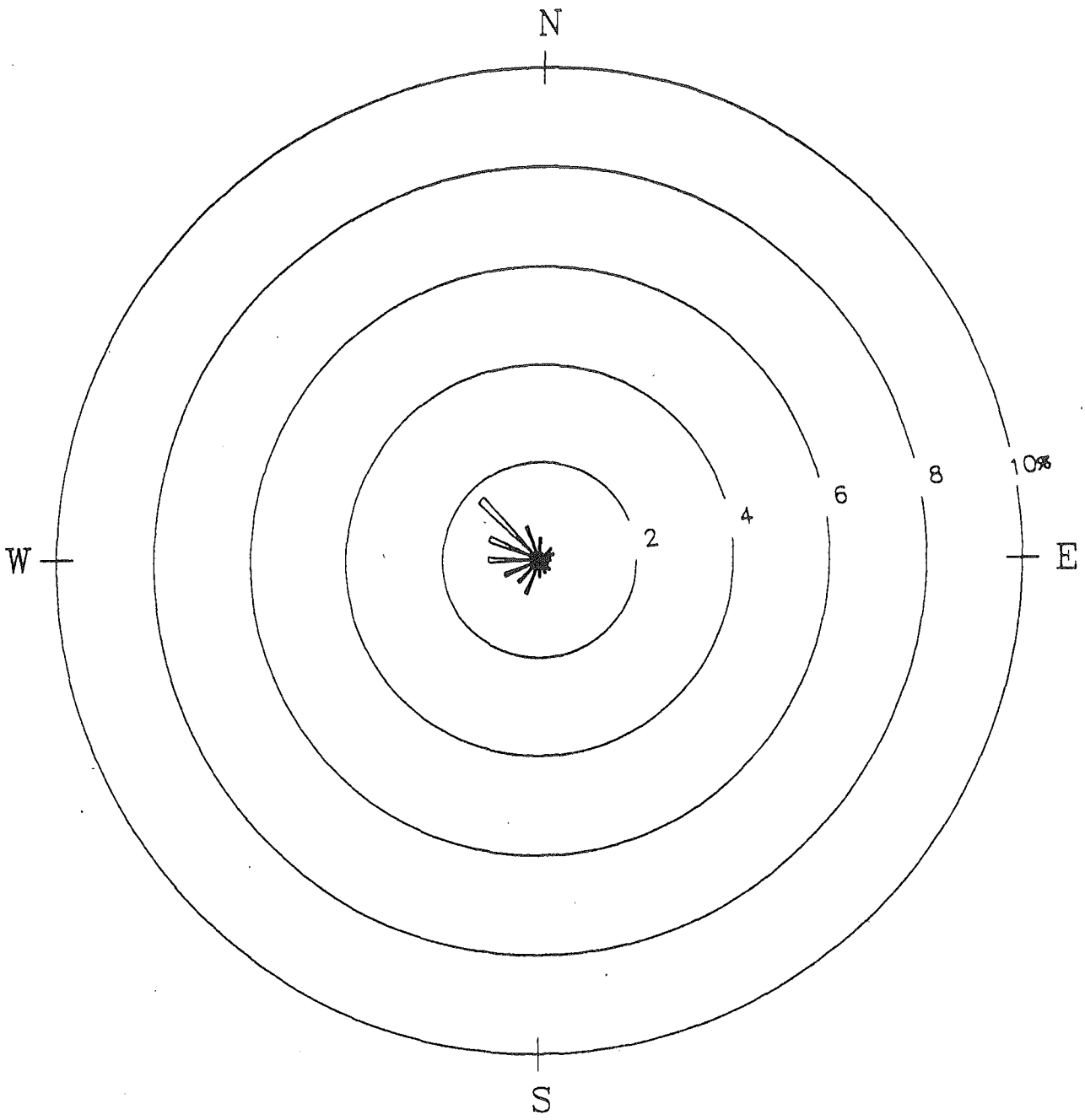


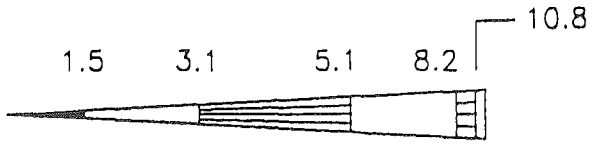


WIND SPEED CLASS BOUNDARIES
(METERS/SECOND)

NOTES:
DIAGRAM OF THE FREQUENCY OF OCCURRENCE FOR EACH WIND DIRECTION. WIND DIRECTION IS THE DIRECTION FROM WHICH THE WIND IS BLOWING. EXAMPLE – WIND IS BLOWING FROM THE NORTH .2 PERCENT OF THE TIME.

FIGURE 2-3
WINDROSE
STABILITY CLASS B
NORTHSHORE MINING
PERIOD: 1992-93



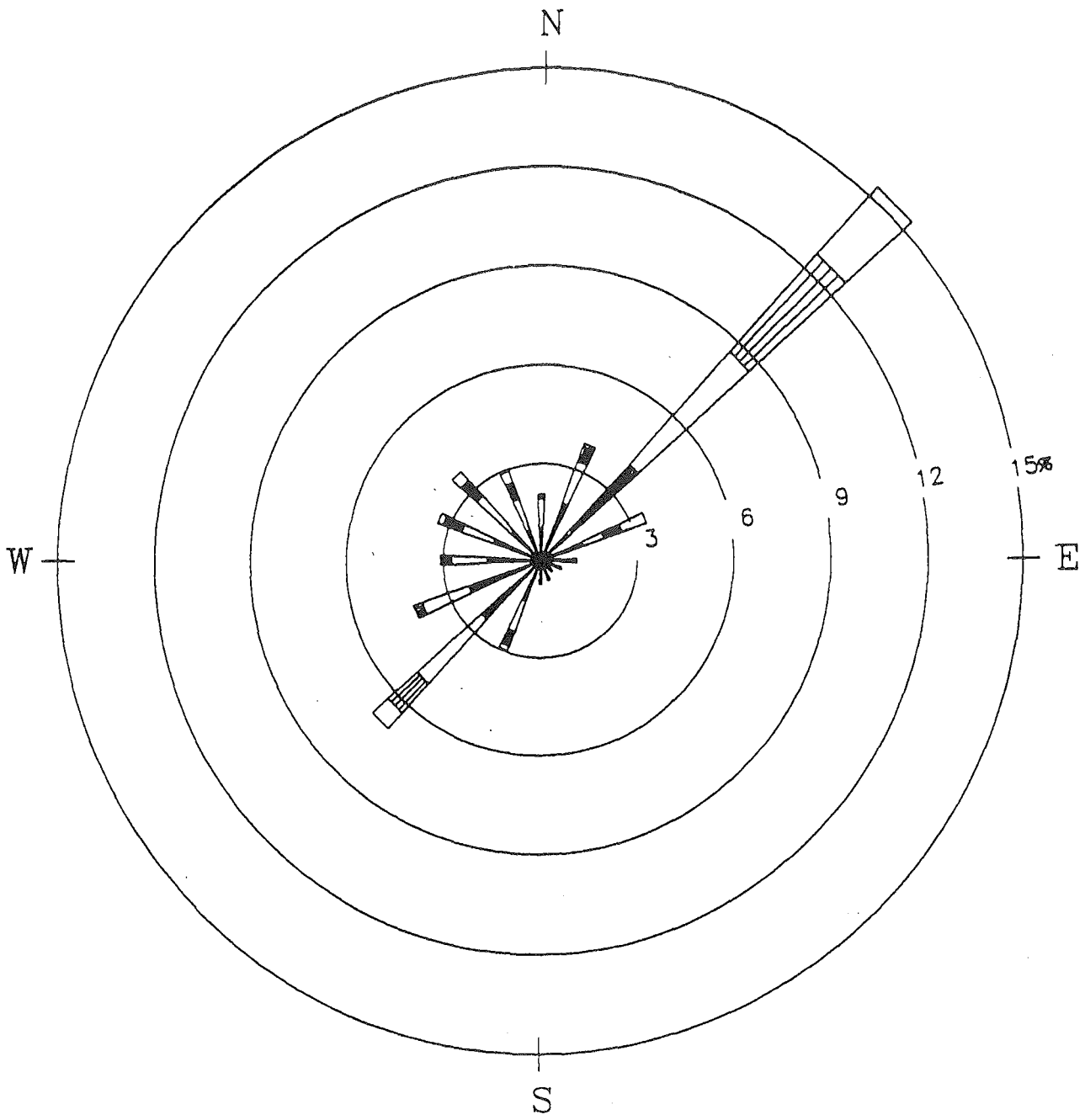


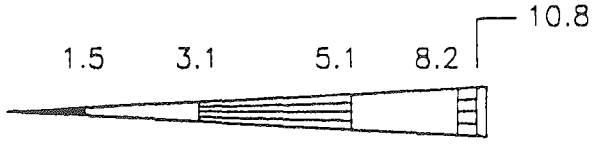
WIND SPEED CLASS BOUNDARIES
(METERS/SECOND)

NOTES:
DIAGRAM OF THE FREQUENCY OF OCCURRENCE FOR EACH WIND DIRECTION. WIND DIRECTION IS THE DIRECTION FROM WHICH THE WIND IS BLOWING. EXAMPLE – WIND IS BLOWING FROM THE NORTH .5 PERCENT OF THE TIME.

FIGURE 2–4
WINDROSE

STABILITY CLASS C
NORTHSHORE MINING
PERIOD: 1992–93

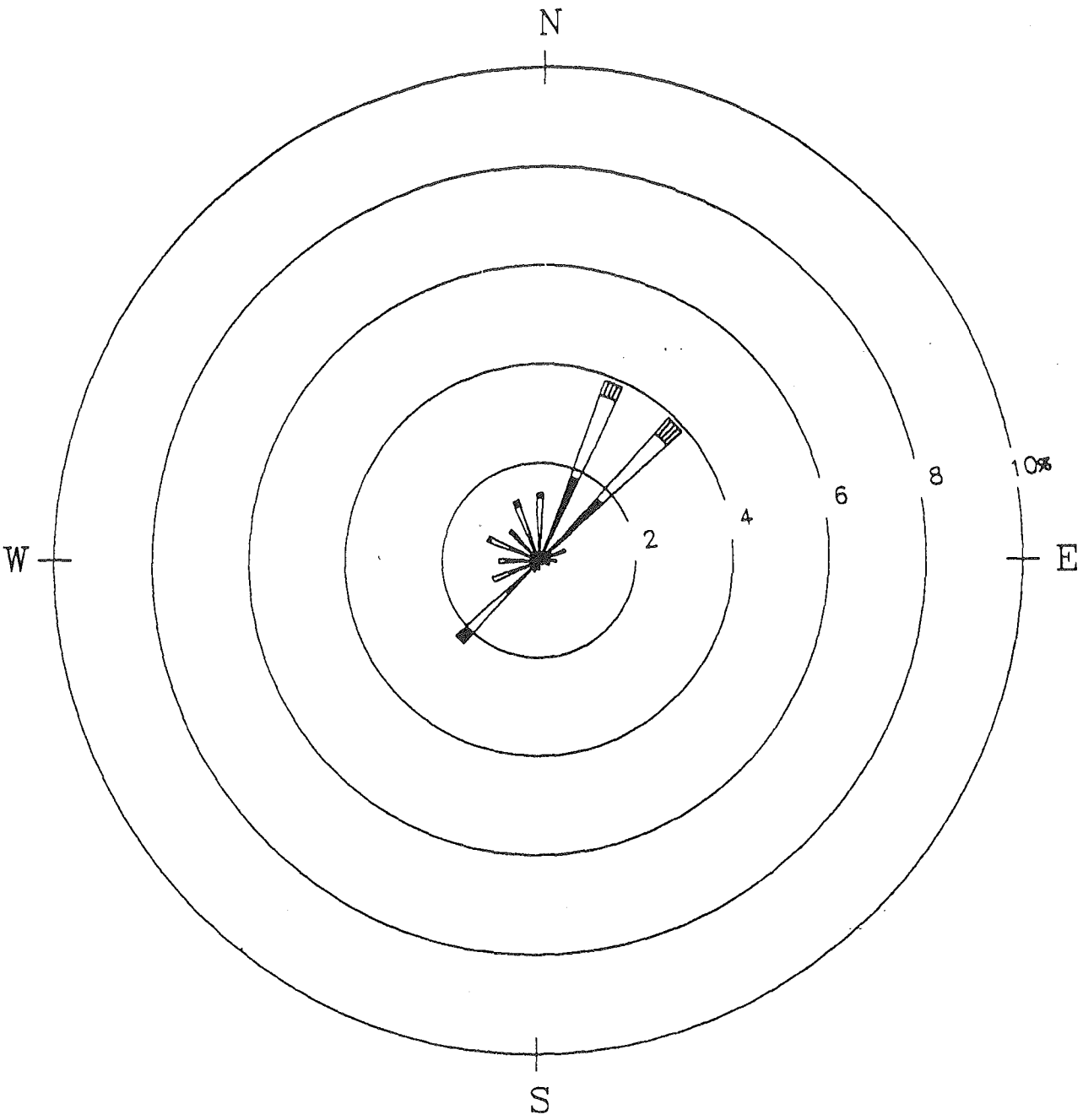


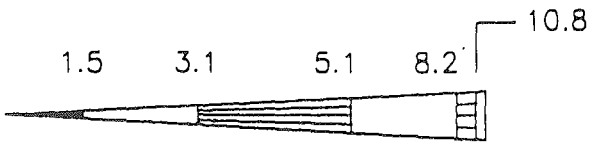


WIND SPEED CLASS BOUNDARIES
(METERS/SECOND)

NOTES:
DIAGRAM OF THE FREQUENCY OF OCCURRENCE FOR EACH WIND DIRECTION. WIND DIRECTION IS THE DIRECTION FROM WHICH THE WIND IS BLOWING. EXAMPLE – WIND IS BLOWING FROM THE NORTH 2.1 PERCENT OF THE TIME.

FIGURE 2–5
WINDROSE
STABILITY CLASS D
NORTHSHORE MINING
PERIOD: 1992–93

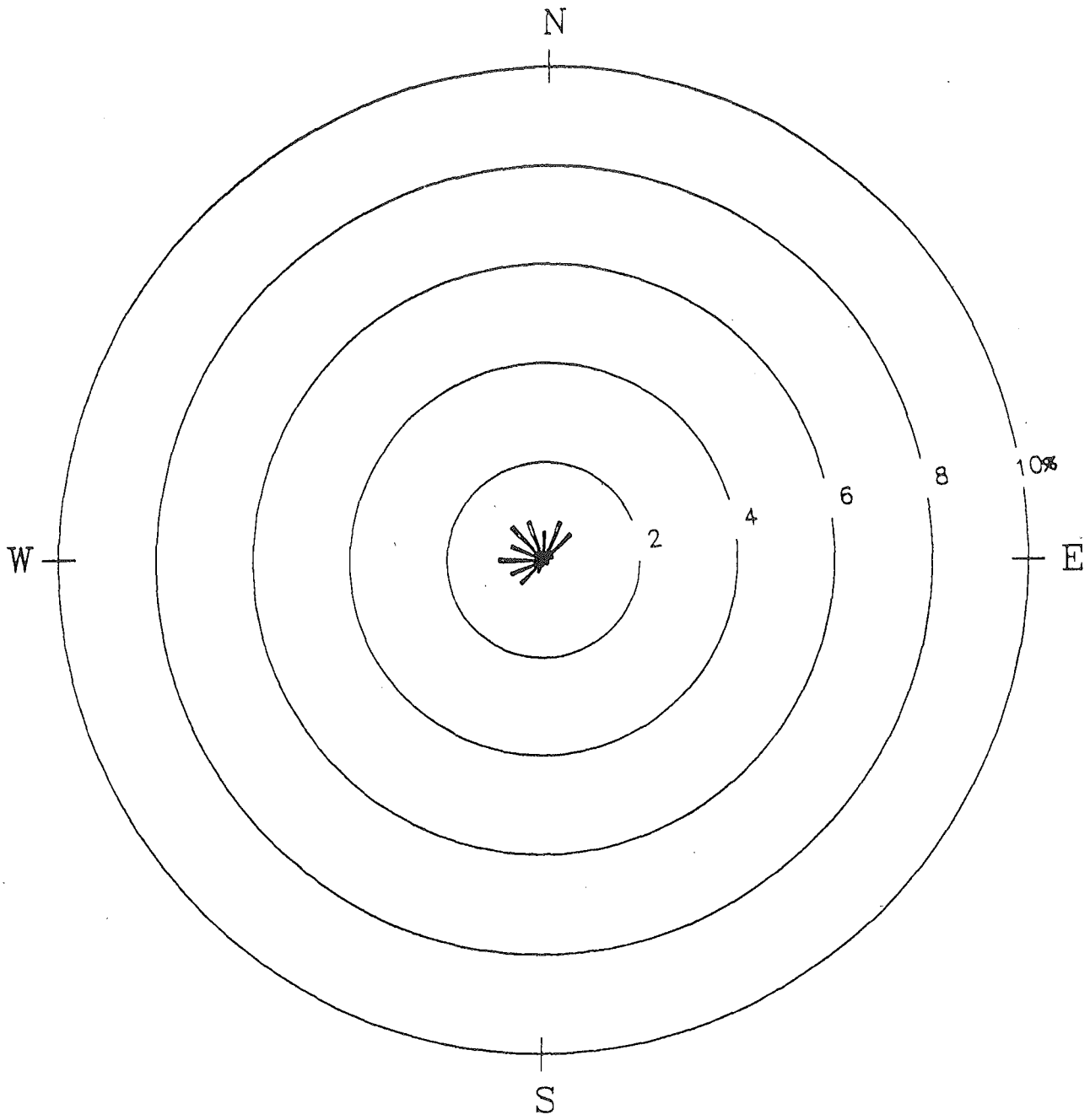


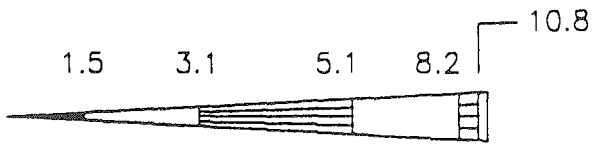


WIND SPEED CLASS BOUNDARIES
(METERS/SECOND)

NOTES:
DIAGRAM OF THE FREQUENCY OF OCCURRENCE FOR EACH WIND DIRECTION. WIND DIRECTION IS THE DIRECTION FROM WHICH THE WIND IS BLOWING. EXAMPLE – WIND IS BLOWING FROM THE NORTH 1.4 PERCENT OF THE TIME.

FIGURE 2-6
WINDROSE
STABILITY CLASS E
NORTHSHORE MINING
PERIOD: 1992-93

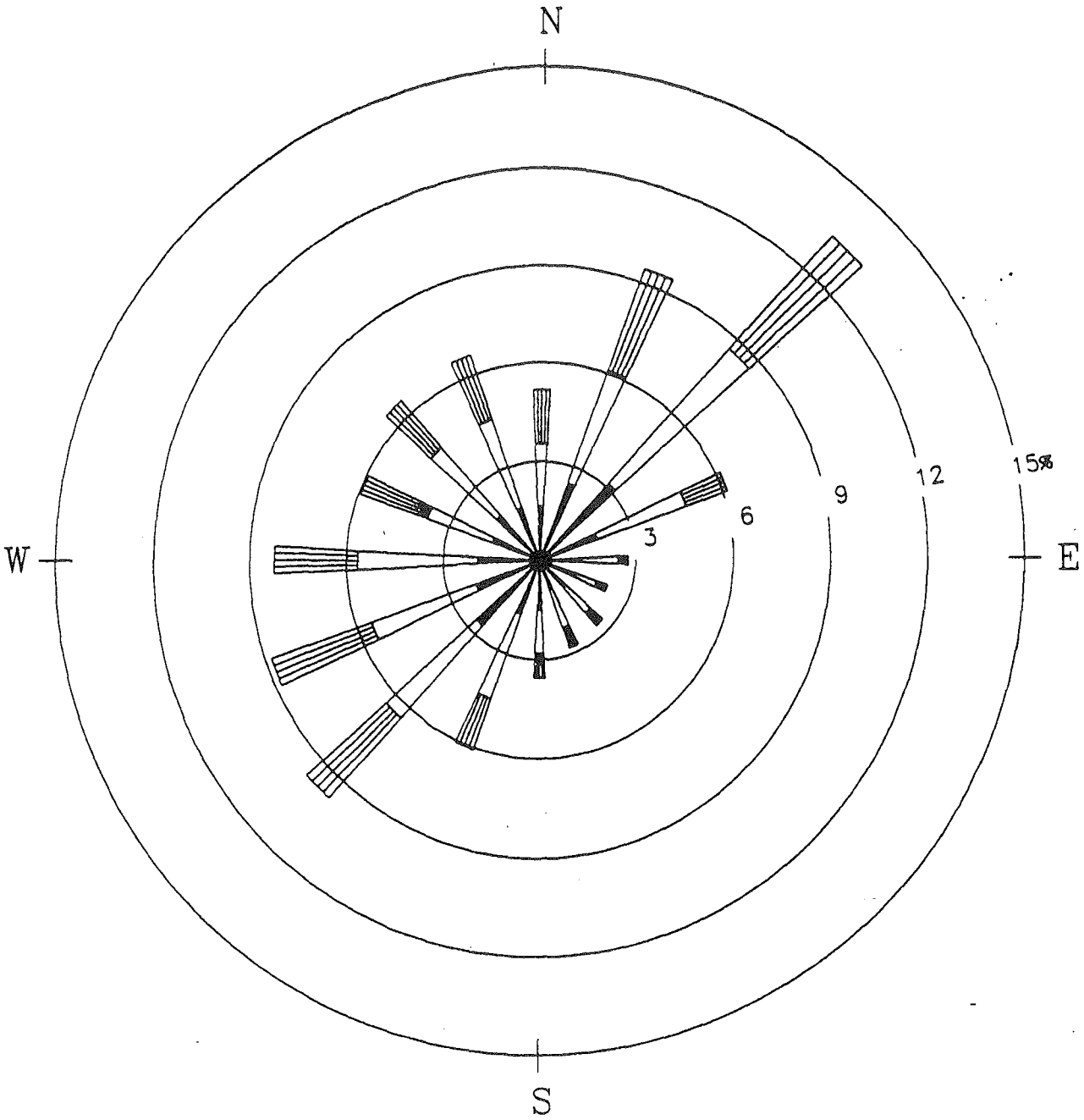


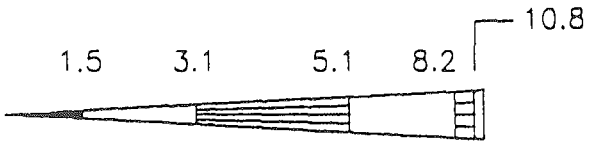


WIND SPEED CLASS BOUNDARIES
(METERS/SECOND)

NOTES:
DIAGRAM OF THE FREQUENCY OF OCCURRENCE FOR EACH WIND DIRECTION. WIND DIRECTION IS THE DIRECTION FROM WHICH THE WIND IS BLOWING. EXAMPLE – WIND IS BLOWING FROM THE NORTH .6 PERCENT OF THE TIME.

FIGURE 2–7
WINDROSE
STABILITY CLASS F
NORTHSHORE MINING
PERIOD: 1992–93

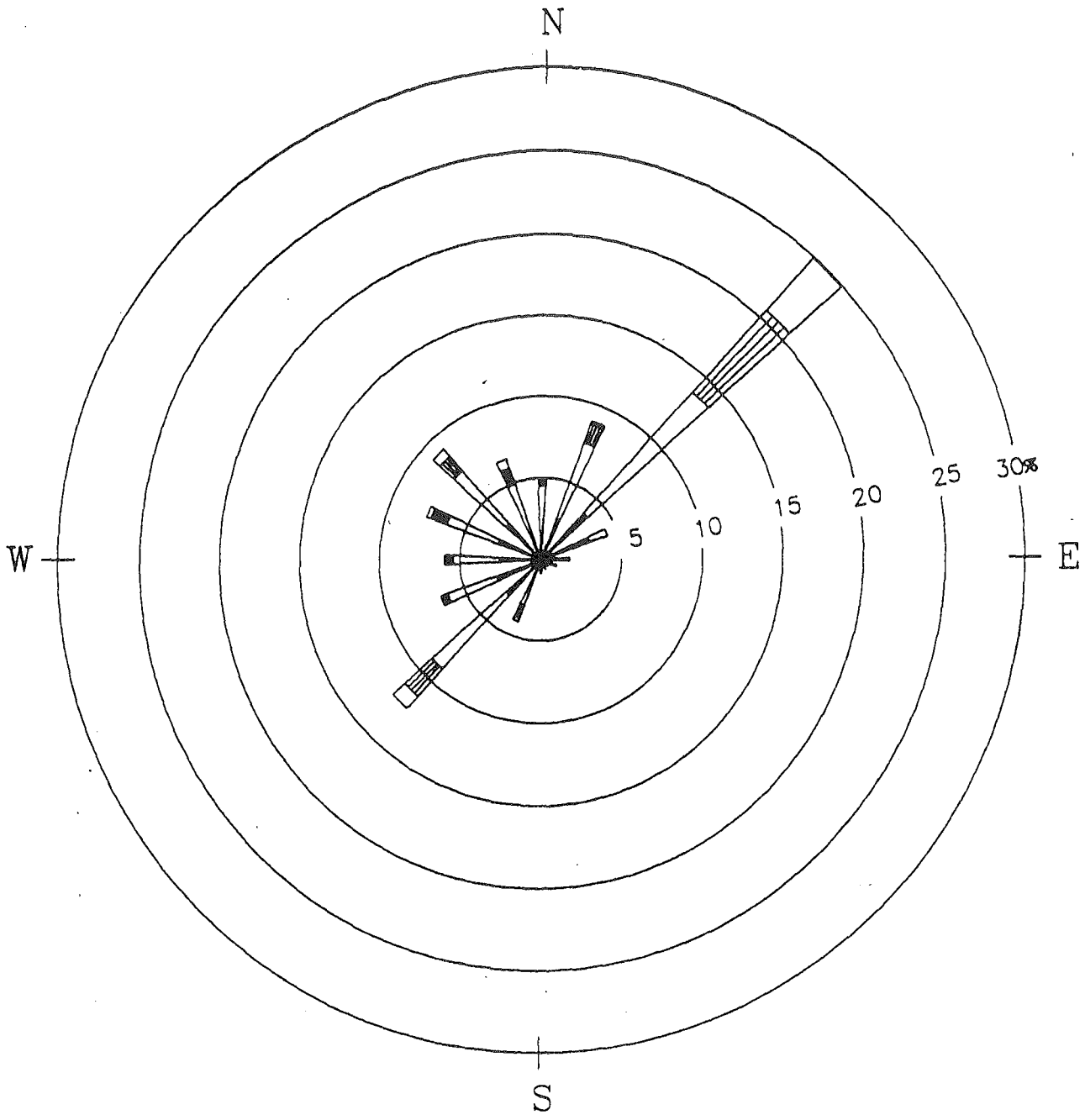


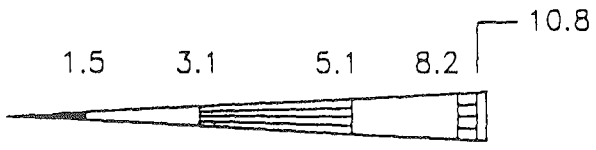


WIND SPEED CLASS BOUNDARIES
(METERS/SECOND)

NOTES:
DIAGRAM OF THE FREQUENCY OF OCCURRENCE FOR EACH WIND DIRECTION. WIND DIRECTION IS THE DIRECTION FROM WHICH THE WIND IS BLOWING. EXAMPLE – WIND IS BLOWING FROM THE NORTH 5.2 PERCENT OF THE TIME.

FIGURE 2-8
WINDROSE
WINDS BELOW 4 m/s
NORTHSHORE MINING
PERIOD: 1992-3





WIND SPEED CLASS BOUNDARIES
(METERS/SECOND)

NOTES:
DIAGRAM OF THE FREQUENCY OF OCCURRENCE FOR EACH WIND DIRECTION. WIND DIRECTION IS THE DIRECTION FROM WHICH THE WIND IS BLOWING. EXAMPLE – WIND IS BLOWING FROM THE NORTH 4.9 PERCENT OF THE TIME.

FIGURE 2-9
WINDROSE

WINDS ABOVE 4 m/s
NORTHSHORE MINING
PERIOD: 1992-3

The higher wind speeds are predominately along the shoreline and secondarily offshore. With the conversion to mps, no wind speeds were exactly 4 mps, thus the values are all above or below 4 mps.

2.5 AIR QUALITY

A description of the field program is contained in the protocol submitted for this model evaluation, the PSD permit application and the progress reports submitted by Interpoll. A brief summary of the data collection program is provided below.

The original monitoring program was directed towards compliance based on the early modeling results. Shortly after the program was initiated, the possibility of facility modification became apparent and the monitoring program was upgraded to a PSD level monitoring program. The first field alignment of the monitors had one station located in a residential situation, two on the Radio Tower Hill, and one at Northshore's main office building. After nearby meteorological data revealed the strong northeast component of the winds, the MPCA requested a relocation of one station to the shoreline southwest of the facility. The realization that the monitoring station at the offices was measuring the heating exhaust lead to a relocation of that monitor to the hillside. After a meeting with EPA and MPCA in Chicago, during which some preliminary results of the data collection program were reviewed, a final transfer of a station to the hillside was made. These were the final locations of the monitoring sites for the model evaluation study.

The electronic data were retrieved by both Interpoll and Northshore. In the quality assurance of the data for this evaluation, Northshore used these daily printouts to compare with the data files used in both the meteorological and air quality data sets. This provided a valuable cross check and the ability to fill data that had been lost during Interpoll's data download queries.

2.6 EMISSIONS

The protocol described in detail the methods for calculating the facility's emissions. In addition, the final emission values were reviewed by the MPCA prior to use in the model evaluation calculations. As a result of this review, several refinements were incorporated into the emission values. The values were calculated in a LOTUS program generated by Northshore.

Three CEMs were mounted on the stacks of power boiler #2 and pellet machines 11 and 12. Both SO_2 and NO_x were monitored with the CEM. However, since the SO_2 emissions from the pellet machines were below the detectable limits of the CEMs, these values were calculated following the modeling protocol. The power boiler and the heating boiler did not have CEMs so all emissions from these sources were calculated.

For those hours in which the CEMs did not supply emission values, the emissions were either calculated or the equipment was not operating. No missing data existed in the emissions data set.

Once the emissions were generated in the LOTUS format, they were sent to WGBA where they were converted to an ASCII format and printed. The initial expectation was that there would be long periods of relatively constant emissions and stack parameters. However, a review of the emissions and stack parameters revealed pronounced changes even on an hourly basis. Thus, input files for ISCST2 and BEEST-X had to be generated for each hour within the evaluation period.

Four sets of input files had to be generated: candidate and reference model for both SO_2 and NO_x. Each hour's file was generated and emissions, temperature and velocity information was input from the parameters supplied by Northshore. Copies of these files were then made and renamed to NO_x files. The temperature and velocity remained the same for each hour, so the only edits required were emissions to reflect the new pollutant.

The difference between the candidate and reference files was simply downwash and terrain considerations. Therefore, the reference model files could be copied to form the next set of files. These new files were renamed "candidate"; terrain was removed and building downwash modified using a program written for this purpose. At this stage, all files had been built and were ready to run.

Due to the massive number of files (a year's worth of hourly data for two models and two pollutants result in more than forty thousand files), all the input files were stored in data compressed form. A program was written which would run the models in batch and process the final results into a file ready to be cut into a LOTUS worksheet. The output files generated by ISCST2 and BEEST-X were not saved due to storage capacity limitations.

2.7 SUMMARY

From the total data collection period, the twelve months of September 1, 1992 through August 31, 1993 was initially selected. This was later supplemented with April/May 1992 and September through December 1993 for the SO_2 analysis.

The reason for this data period was due to the operations at the Northshore facility. The facility shut down for the summer of 1992 and there were about three months with no emissions. During the selected period, power unit one was used and both power units were primarily on coal as a fuel. This allowed for a more robust evaluation of the sulfur emissions from the facility. The pelletizers operated on natural gas and their fuel use was selected independent of the fuel used in the power plants.

CHAPTER 3 MODELS

The Northshore facility is a "Grandfathered" facility since it was constructed and operated prior to the passage of the Clean Air Act and it amendments. However, using the standard regulatory modeling approach, there were indications that the ambient air quality standards might be violated in areas of public access. One such area is the state highway that runs through the facility. Figure 3-1 reproduces the portion of an USGS map showing the highway and the facility. As a result of this early modeling the need for a model evaluation became apparent. The early modeling showed potential exceedances several orders of magnitude over the standard. This early modeling ignored the grandfathered status of the facility and assumed allowable emissions. However, more refined modeling still showed potential problems even after more realistic emissions were used. These modeled values were several times higher than the field monitoring was measuring. The monitored data indicated values only about 25% or less than the state standard; much less for the federal standard. This was after the monitoring program was located at the hot spot locations as defined by the modeling program and wind roses.

3.1 HISTORY OF THE REGULATORY MODELING APPROACH

The Reserve Mining Company was jointly operated by ARMCO and LTV steel companies. LTV declared bankruptcy and ARMCO indicated that they could not maintain Reserve Mining alone. Reserve Mining

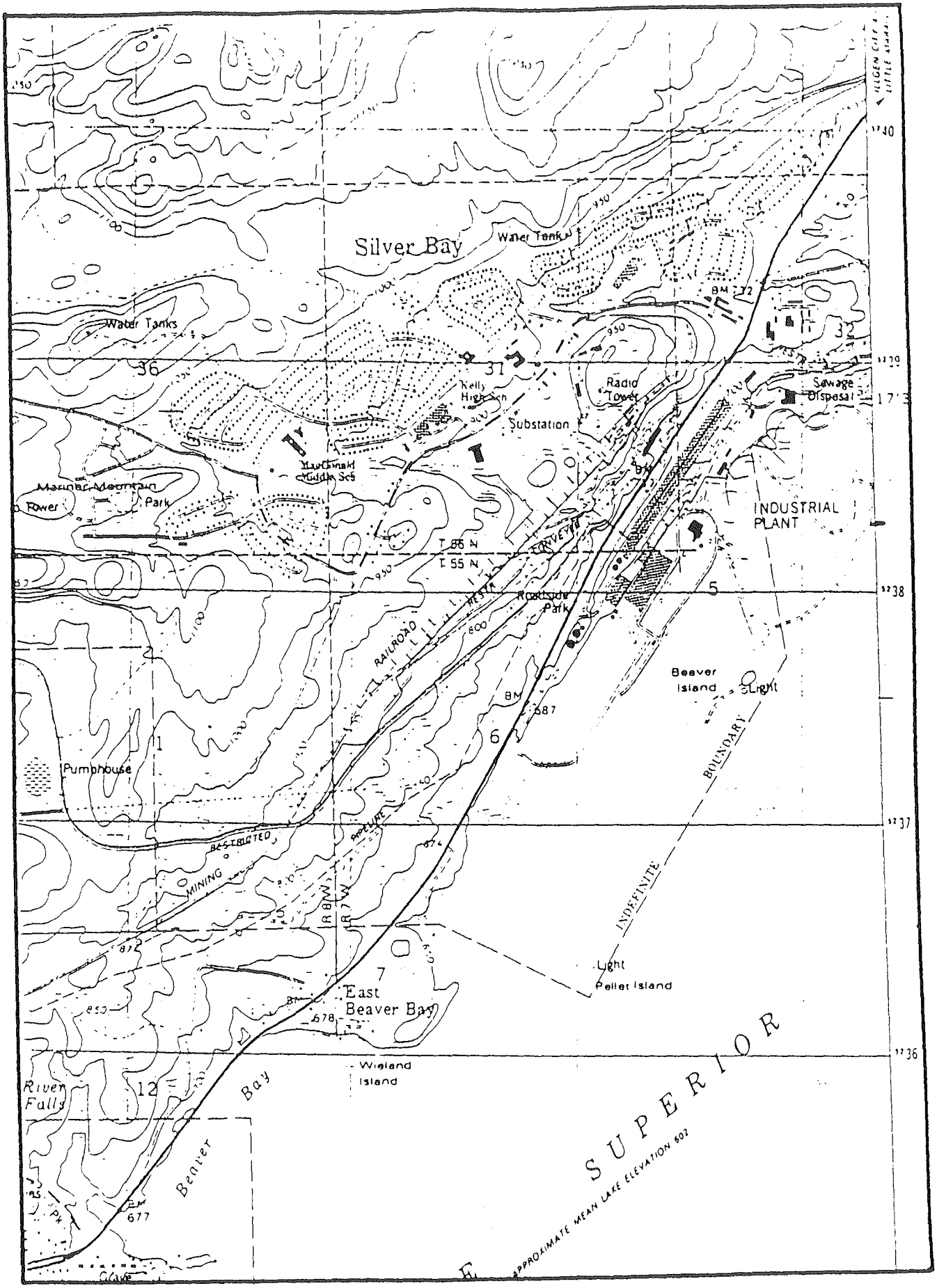


FIGURE 3-1 TOPOGRAPHIC MAP OF SILVER BAY AREA

therefore also declared bankruptcy and placed the facility on the market for acquisition. As part of preparing for acquisition, a review of the air permitting was conducted by the state. This review showed potential air quality violations by the facility.

A recent PSD application showed compliance with the standards under certain operating conditions but did not leave room for flexibility in the operations of the facility. This model evaluation program was proposed as a means of providing flexibility in the facility operations.

3.2 SELECTION OF THE CANDIDATE MODEL

The Northshore facility is located on the Northwestern shore of Lake Superior. Immediately to the northwest of the facility there is higher terrain with elevations equaling or exceeding the plume height elevations. Figure 3-1 is a reproduction of a topographic map of the area showing the facility and terrain features in the immediate area.

Figure 3-1 shows several complicating factors from a modeling perspective. The first is the high terrain running from northeast to southwest just to the northwest of the facility. There are two ridges of concern, one close to the facility and the second to the northwest of the Silver Bay community.

A second feature is the proximity of a land/water interface. The facility location on the shore of Lake Superior allows for direct loading of product into seafaring ships for transport to market locations. However, this land/water interface also raises the possibility of land/sea breeze complications in the air flows at the site. The sea breeze would transport emissions toward the terrain on the one hand, yet could also provide for an up-slope flow thus transporting the plume to higher elevations and possibly over the top of the terrain.

A third consideration is the possibility of the plume descending the lee side of the ridge and impacting the community of Silver Bay. The initial compliance monitoring program was designed to provide answers to this question. Historical monitoring programs have shown that the movement of pollutants into the community by traversing over the ridge is unlikely. The modeling presented in Appendix C of the Protocol confirmed the monitoring results. The modeled concentrations within Silver Bay are less than the "hot spots" which occur along the ridges or to the southwest of the plant.

Lake Superior is the largest of the Great Lakes and the largest body of fresh water in the world. It has an area of 31,820 square miles, which is about the size of the state of South Carolina. It is a deep, cold lake with an average annual surface temperature of 41°F. Most of the lake is frozen for three to four months in the winter. Since the winds of interest in this modeling program are onshore - i.e., the air flow is off the lake onto the land - the air path comes from upwards of several hundred miles of lake, a relatively smooth, cold surface. These winds would be cooled from below, generating a thermal inversion. They would be at the lower end of the speed scale, thus not producing big waves and resulting in a low surface roughness for the lake. With the low wind speeds, the low surface roughness, and the cold surface producing a thermal inversion, the air onto the shore would very likely be a stable, low wind speed condition. Such a flow pattern would be simulated in the ISCST2 model with an E or F stability with little dispersion from turbulence and not much diffusion from wind speed.

The terrain impacted by the modeled calculations is very close to the shoreline, from ½ to about 1½ km inland. This close proximity would not provide much distance for the steady, laminar flow to be broken up by either the land surface heating or the increased surface roughness. It would probably induce a microclimate in the region from the shoreline to the top of the

ridge. The winds would be little influenced by the building on the hillside and would move in a potential flow pattern up the terrain. The plumes would be carried in this laminar flow horizontal to the terrain and thus not impact it directly. In fact, it would take the higher wind speeds to be influenced by the building wake effects and the terrain. Only Station 4, located on the main office building close to the heater exhaust, showed high values during calm and low wind conditions. This station was, therefore, moved as a result of this finding. The introduction of mechanical turbulence requires high wind speed conditions.

The result of these two conditions: 1) stable conditions, with flows off the lake following the terrain, and 2) high winds necessary for building wake effects, lead to the theory that the terrain and buildings were not influencing the high modeled concentrations at the facility. Thus, ISCST2 run without terrain or building wake effects was proposed as an alternative model for the site.

This theory proved to be true for NO_x but not wholly in the case for SO_2. Culpability analysis revealed determining factors to be present in the two downwash algorithms used by ISCST2. Thus the final candidate model proposed to incorporate a reduced downwash routine and no terrain.

CHAPTER 4 MODEL EVALUATION

The statistical model evaluation was conducted in accordance with the Modeling Protocol: Air Quality Model Evaluation for Cyprus Northshore Mining Company[6] and subsequent modifications[7]. The statistical procedures specified by the U.S. Environmental Protection Agency (EPA) in the Protocol for Determining the Best Performing Model (EPA's Protocol) (OAQPS, EPA-454/R-92-025, RTP, NC, December 1992) were used in this performance evaluation. The model performance comparison analyses were conducted for both SO_2 (1-, 3- and 24-hour averaging times) and NO_2 (1- and 24-hour averaging times). The period of record for on-site monitored data used in the NO_x model performance comparison was from September 1, 1992 through August 31, 1993. The SO_2 model evaluation added data from April and May 1992 plus September through December 1993. On-site meteorological data as well as modeled and measured SO_2 and NO_2 concentrations at four monitoring stations were used in the analyses.

The objective of this model comparison was to determine which model, the combined candidate or reference model, better represents this specific site. The reference and candidate models as well as the monitoring data used in the model comparison are in accordance with the approved Protocol.

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[6] Modeling Protocol Air Quality Model Evaluation for Cyprus Northshore Mining Company. January 30, 1993.

[7] See Appendix A.

4.1 STATISTICAL PROCEDURES

The statistical approach for determining the best performing model is described in EPA's Protocol document. Because preliminary modeling presented in the Protocol indicated that the reference model would fail the EPA Protocol's "screening test," the Protocol by-passed this screening test altogether and applied EPA's rigorous statistical evaluation procedures. These statistical procedures concentrate on the abilities of the reference and candidate models to predict high concentrations for both operational and scientific model evaluations. Operational evaluation focuses on the ability of a model to predict the highest concentrations regardless of time or place and thus addresses the regulatory question of the high second high ambient concentration. The scientific evaluation focuses on the ability of the model to predict the concentrations for the proper physical reasons.

Recognizing that the individual predicted and observed concentrations may be erratic, the EPA Protocol characterizes the upper end of the frequency distribution (nominally the highest 25 predicted and observed concentrations) by assigning a new variable, the robust estimate of the highest concentration. The EPA Protocol employs a composite measure of performance that combines robust estimates of highest concentration among averaging periods and integrates both the scientific and operational components of model performance. Selecting the better performing model is done by comparing the composite measures of performance for the reference and candidate models. The comparison of the composite performance measures of two models by means of their difference creates a new variable called the model comparison measure. Statistical tests are performed on the model comparison measure to determine whether the reference or candidate model better predicts the observed high concentrations.

In order to determine the variability of the composite performance measures and the model comparison measure, a resampling technique known as bootstrapping is used to generate the

distribution of feasible high concentrations. The bootstrap results are used to calculate the standard error of the model comparison measure. The standard error, in turn, is used to determine if differences in reference and candidate model performance are statistically significant. The following sections detail the statistical evaluation procedures and results.

4.2 SCIENTIFIC AND OPERATIONAL COMPONENTS

The statistical comparison involves both an operational and scientific model evaluation component. The scientific component is used to evaluate the model's ability to perform accurately throughout the range of meteorological conditions that might be expected to occur. For the scientific component, six meteorological categories were defined from two wind speed categories and three stability categories. The two wind speed categories are: low (less than 4.0 m/s) and high (equal to or greater than 4.0 m/s). The three stability categories are: unstable (class A, B, C), neutral (class D), and stable (class E, F). Thus six combinations of wind speeds and stabilities are considered under the scientific component. As described in the Protocol, measured data at four monitors were included in the evaluation of the scientific component and each monitor location was considered separately, thereby testing the ability of the models to predict at specific locations.

The rationale for the operational component is to measure the models' abilities to predict the concentrations most directly used for regulatory purposes. The operational component in this evaluation included the 1-hr, 3-hr and 24-hr average concentrations for SO_2 and 1-hr and 24-hr average concentrations for NO_2 because either state or federal ambient air quality standards have been specified for them.

4.3 ROBUST HIGHEST CONCENTRATION

The variable used to characterize the predicted and observed concentrations is the robust estimate of the highest concentrations (RHC) using the largest concentrations within a given data category. The robust estimator was used in both the scientific and operational phases of the statistical comparison. The following equation as presented in the EPA Protocol was used to calculate the RHCs for the evaluations:

$$RHC = X(N) + [\bar{X} - X(N)] \ln[\frac{3N-1}{2}]$$

where: $\bar{X}$ = average of the N-1 largest values
X(N) = Nth largest value
N = number of values exceeding the threshold value
($N \leq 26$)

The value of N is nominally set equal to 26 so that the number of values averaged (X) is arbitrarily 25. According to the EPA Protocol, the RHC acts as a "smoothed estimate" of the highest concentrations.

To determine the RHC for the operational evaluation, the 1, 3 and 24 hour averaged observed and predicted concentrations at each monitoring station were sorted by magnitude, and the RHC was calculated using the above equation. The largest observed and predicted RHCs for each averaging period, regardless of location or meteorological category, were selected for statistical comparisons. For the scientific component of the evaluation, the 1 hour average observed and predicted concentrations were sorted by the meteorological categories presented in Section 4.2, then sorted by magnitude and the RHC was then calculated for each monitoring location using the above equation. Thus a total of three RHC values were used for the operational component of the observed concentration data and twenty-four RHC values (two wind speeds times three stability classes times four monitoring stations) were

used for the scientific component of the observed concentration values for a total of twenty-seven RHC values. Likewise twenty-seven RHC values were calculated for the reference model and twenty-seven RHC values were calculated for the candidate model.

4.4 ABSOLUTE FRACTIONAL BIAS

In order to determine the ability of the reference and candidate models to predict the observed high concentrations, the absolute fractional bias (AFB) of the RHCs was calculated. The expression for the AFB is given by:

$$AFB = 2\left|\frac{OB-PR}{OB+PR}\right|$$

where: AFB = absolute fractional bias
OB = the RHC of the observed data
PR = the RHC of the predicted data

The AFB is a bounded statistic. Values for the AFB range between 0.0 (no bias or perfect prediction ability) and 2.0 (no prediction ability). An AFB of >0.66 indicates a model that does not predict the observed RHC within a factor of two.

4.5 COMPOSITE PERFORMANCE MEASURE

A composite performance measure (CPM) was computed for each model as a weighted linear combination of the individual absolute fractional bias components detailed above. Essentially, the CPM is a scoring scheme used to weight the relative importance of the various scientific and operational components of the statistical evaluation. The project specific CPM was presented and approved in the Protocol. The scientific component has been given an overall weight of 1/3 of the CPM, while the operational component has been given an overall weight of 2/3 of the CPM, reflecting the

importance of the regulatory compliance issues. Each meteorological class and station were weighted equally within the scientific component of the CPM. For the operational component of the CPM, the 1 hour averaging time was weighted most heavily (1/2 for SO_2 and 0.6 for NO_2) because the state 1-hr standards for both SO_2 and NO_2 are the most restrictive standards. The 3- and 24-hour averaging times were given less weight for the operational component of the CPM.

As specified in the Protocol, the following equations were used to calculate the CPM for SO_2 and NO_2, respectively:

$$CPM_{SO_2} = \frac{1}{3}\overline{(AFB)_{i,j}} + \frac{2}{3}\left[\frac{1}{2}AFB_1 + \frac{1}{4}AFB_3 + \frac{1}{4}AFB_{24}\right]$$

$$CPM_{NO_2} = \frac{1}{3}\overline{(AFB)_{i,j}} + \frac{2}{3}\left[0.6\ AFB_1 + 0.4\ AFB_{24}\right]$$

where: $AFB_{i,j}$ = Absolute Fractional Bias for meteorological category i at station j
AFB_1 = Absolute Fractional Bias for 1-hr averages
AFB_3 = Absolute Fractional Bias for 3-hr averages
AFB_{24} = Absolute Fractional Bias for 24-hr averages.

A value of 0.0 for the CPM would be awarded to a model with no bias for any of the measures. The larger the value of the CPM, the more poorly the model performs.

As defined in EPA's Protocol, the difference between the composite performance of the reference model and candidate model is referred to as the model comparison measure (MCM). The expression for the model comparison measure is given by:

$$MCM = (CPM)_1 - (CPM)_2$$

where: $(CPM)_1$ = Composite Performance Measure for Model 1
$(CPM)_2$ = Composite Performance Measure for Model 2

A negative value of the MCM implies that Model 1 performed better than Model 2 for this year of observed and predicted concentration data. For this evaluation study, Model 1 is always the candidate model and Model 2 is always the reference model; thus a negative value of the MCM indicates that the candidate model performs better than the reference model. The abilities of the reference and candidate models to predict SO_2 and NO_x were evaluated separately and "winning" models for each pollutant were selected separately.

4.6 STANDARD ERROR DETERMINATION

The MCM calculated above determines which model performed better for the period of observed and predicted concentration values. The base data used in this study included hourly average SO_2 and NO_2 concentrations for four monitors along with corresponding predictions using the reference and candidate models and associated categories of meteorological conditions. It is possible that, given a different year of meteorology, a different model might be selected. For this reason, it is desirable to determine whether or not the differences in the model performance were statistically significant or were simply within the range of natural variability.

As the EPA Protocol notes, the MCM is "a rather involved statistic" and the population distribution of the MCM is not known. Therefore, a nonparametric method was used by the EPA Protocol to estimate the standard error (and thus the confidence interval) associated with the MCM.

The EPA Protocol used a nonparametric blocked data bootstrap resampling technique to estimate the standard error associated with the MCM. The original period of observed and predicted data was partitioned into 3-day blocks. Within each season, 3-day blocks were sampled with replacement until a total bootstrap season was created. This process was repeated using each of the four seasons to construct a complete bootstrap period of observed and predicted concentrations.

The data generated for each bootstrap period were used to calculate the CPM for each model. A model with the distribution of CPM values closer to zero performs better than a model with higher CPM values (i.e., the lower the CPM, the lower the weighted Average Fractional Bias). One thousand bootstrap periods of data were generated to calculate a representative standard error for the MCM. The standard error was calculated as the standard deviation of the MCM for the one thousand bootstrap periods.

4.7 SELECTION OF THE BEST PERFORMING MODEL

In EPA's Protocol, the ratio of the MCM to the standard error of the MCM is used as a measure of the significance for the differences in model performance. EPA's Protocol states that ratios larger than the absolute value of 1.7 are significant, while ratios less than the absolute value of 1.7 are not significant at approximately the 90 percent confidence level.

CHAPTER 5 RESULTS AND CONCLUSIONS

The reference and candidate models described in Chapter 3 were run using site specific source and meteorological data. These SO_2 and NO_2 predictions were then compared with observed ambient concentration data for the same time periods using the statistical model evaluation approach discussed in Chapter 4.

5.1 CANDIDATE vs. REFERENCE MODEL PERFORMANCE EVALUATION

5.1.1 NITROGEN DIOXIDE

Figure 5-1 presents the top 30 NO_2 hourly average values predicted by the reference and candidate models along with those observed on the monitoring network. The Minnesota Ambient Air Quality Standard (AAQS) of 1130 $\mu g/m^3$ is also indicated on the figure. Note that no observed concentrations exceed the standard. The candidate model underpredicts the observed concentrations while the reference model overpredicts the concentrations. Table 5-1 presents the same information in tabular format, along with the time (hour ending) and location for each observed or predicted event. The observed top 30 concentration events tend to be at sites CNM10 and 11 to the southwest of the facility. The reference model tends to predict the maximum concentrations at CNM5 and 6 in elevated terrain to the northwest. The candidate model predicts concentrations in the top 30 primarily at stations 10 and 11, in agreement with the observed data.

Figure 5-1

Top 30 1-hr NO2 values, Observed, Reference and Candidate

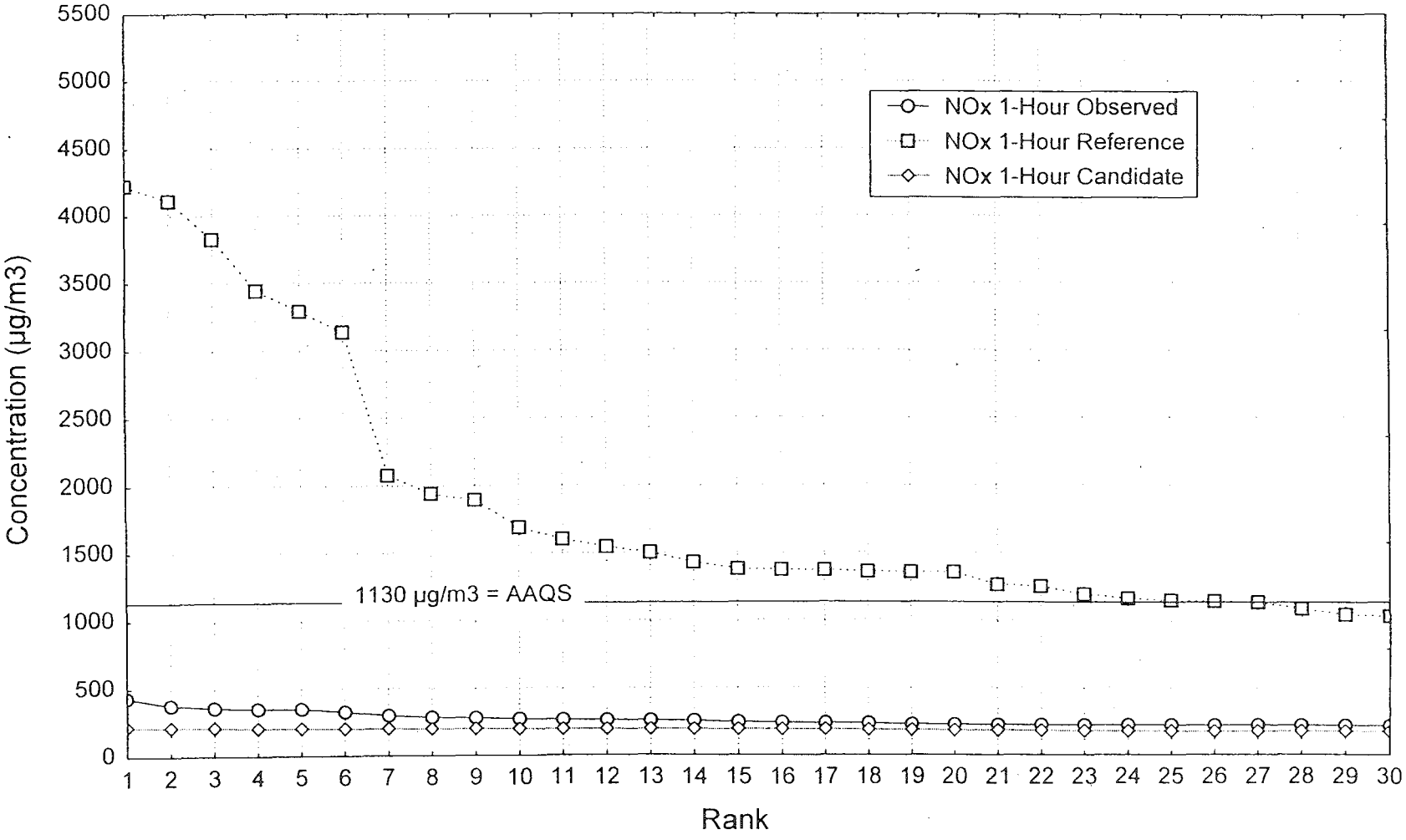


Table 5-1

Top 30 1-Hour Background adjusted NO_2, Observed, Reference, Candidate Model Predicted Concentration (µg/m3)

	Observed					STN#		Reference					STN#		Candidate					STN#
Rnk	(µg/m3)	YR	Mnth	DY	HR	CNM	Rnk	(µg/m3)	YR	Mnth	DY	HR	CNM	Rnk	(µg/m3)	YR	Mnth	DY	HR	CNM
1	433.8	92	11	19	24	11	1	4222.3	93	5	4	20	6	1	214.7	93	6	24	12	10
2	376.4	92	11	19	23	11	2	4113.6	93	5	2	24	6	2	211.9	93	6	3	14	11
3	357.9	93	6	22	22	10	3	3825.1	93	5	11	3	6	3	209.2	93	6	24	11	10
4	348.8	93	6	22	23	10	4	3444.1	93	7	13	20	6	4	204.3	93	6	24	9	10
5	346.7	92	11	19	22	11	5	3291.2	93	3	6	22	6	5	201.0	93	2	3	14	6
6	325.3	93	6	22	20	10	6	3139.0	93	2	1	18	6	6	200.1	93	5	12	13	11
7	298.2	93	6	22	21	10	7	2078.5	92	9	24	1	6	7	200.1	93	6	23	18	10
8	283.9	92	11	19	18	11	8	1942.7	93	4	11	23	5	8	197.4	93	6	23	14	10
9	277.0	92	11	20	2	11	9	1893.2	92	12	27	6	6	9	197.1	93	6	3	13	11
10	269.8	93	6	22	24	10	10	1688.0	92	12	13	23	5	10	194.9	93	6	28	12	6
11	262.5	92	11	20	1	11	11	1600.4	93	1	11	23	5	11	194.0	93	4	16	15	11
12	261.8	93	4	27	20	10	12	1545.7	93	2	1	2	5	12	193.0	93	6	2	9	6
13	255.3	93	4	24	2	10	13	1500.6	93	1	11	22	5	13	192.7	93	6	23	17	10
14	254.5	93	4	17	12	11	14	1427.6	93	2	8	20	6	14	191.3	93	6	24	10	10
15	242.1	92	11	19	16	11	15	1378.1	92	12	17	23	6	15	189.9	93	6	23	19	10
16	239.6	93	6	8	14	10	16	1371.4	93	1	11	20	5	16	189.3	93	6	23	16	10
17	235.2	93	6	8	16	10	17	1368.4	92	12	13	1	5	17	188.9	93	6	23	13	10
18	234.0	93	4	27	21	10	18	1358.2	92	12	13	10	5	18	185.5	93	6	23	9	10
19	226.1	93	4	27	19	10	19	1356.5	92	10	22	22	6	19	185.3	93	6	22	18	10
20	222.8	93	6	30	20	10	20	1351.5	93	1	11	21	5	20	182.4	93	8	9	6	6
21	222.0	92	11	19	21	11	21	1261.9	93	5	28	2	6	21	182.4	93	6	22	17	10
22	220.1	93	6	8	3	10	22	1248.0	93	2	6	11	5	22	180.3	93	6	3	11	6
23	219.5	93	4	20	16	6	23	1191.3	92	12	13	11	5	23	177.7	93	7	27	20	10
24	219.5	93	6	8	17	10	24	1157.6	93	1	20	24	11	24	176.1	93	6	20	12	10
25	219.3	93	5	8	6	10	25	1142.4	93	6	15	21	6	25	175.2	93	7	27	18	10
26	217.5	93	4	8	6	10	26	1138.6	93	8	20	14	5	26	174.6	92	11	19	22	5
27	216.8	93	4	24	12	10	27	1131.1	93	2	3	5	6	27	174.0	93	6	30	12	10
28	216.3	92	12	13	4	11	28	1083.5	92	12	21	3	5	28	173.7	93	6	24	7	10
29	215.4	93	6	7	23	10	29	1039.6	92	11	20	2	11	29	173.2	93	6	24	6	10
30	214.5	92	11	19	20	11	30	1027.0	93	7	15	3	6	30	172.4	92	11	19	18	5

Figure 5-2 and Table 5-2 present similar results for 24-hour average NO_2 concentrations. Twenty-five out of thirty top observed 24-hour average NO_2 concentrations occurred at site CNM10. The reference model predicts high concentrations at all monitoring stations while the candidate model predicts all the top 30 values at CNM10. Again the reference model overpredicts while the candidate model exhibits little bias and is generally within ten percent of the observed concentrations throughout the top thirty.

Figure 5-3 presents histograms for the NO_2 reference and candidate model of the Composite Performance Measures (CPMs) over 1000 periods of bootstrapped meteorology. The candidate model CPMs are shown by the open bars and the reference model CPMs are shown by the shaded bars. A perfect model would have all 1000 events indicated at a CPM value of zero, i.e., no absolute fractional bias indicated. Higher values of the CPM indicate more bias and poorer performance. In this case, the candidate model CPMs are closer to zero than the reference model, indicating that the candidate model is less biased. Also indicated are the 95% level of the CPM distribution for the candidate model and the 5% level of the CPM distribution for the reference model. Considering the strong tendency of the reference model to overpredict NO_2 concentrations as shown in the preceding figures and tables, the better performance of the candidate model as indicated by the CPM is expected.

The NO_2 Model Comparison Measure (MCM) histogram is shown in Figure 5-4. The MCM is calculated as the candidate model CPM minus the reference model CPM, and thus a negative value of the MCM indicates a win for the candidate model (i.e. the candidate model CPM less than the reference model CPM). The ratio of the MCM (calculated from the original monitoring and modeling year) divided by the standard deviation (σ) of the MCMs calculated from the bootstrap results is also presented. The MCM/σ ratio value for NO_2 is -5.23. The EPA protocol notes that ratio values less than approximately -1.7 are considered statistically significantly different, awarding a "win" to the candidate model for NO_2.

Figure 5-2

Top 30 24-hr NO2 values, Observed, Reference and Candidate

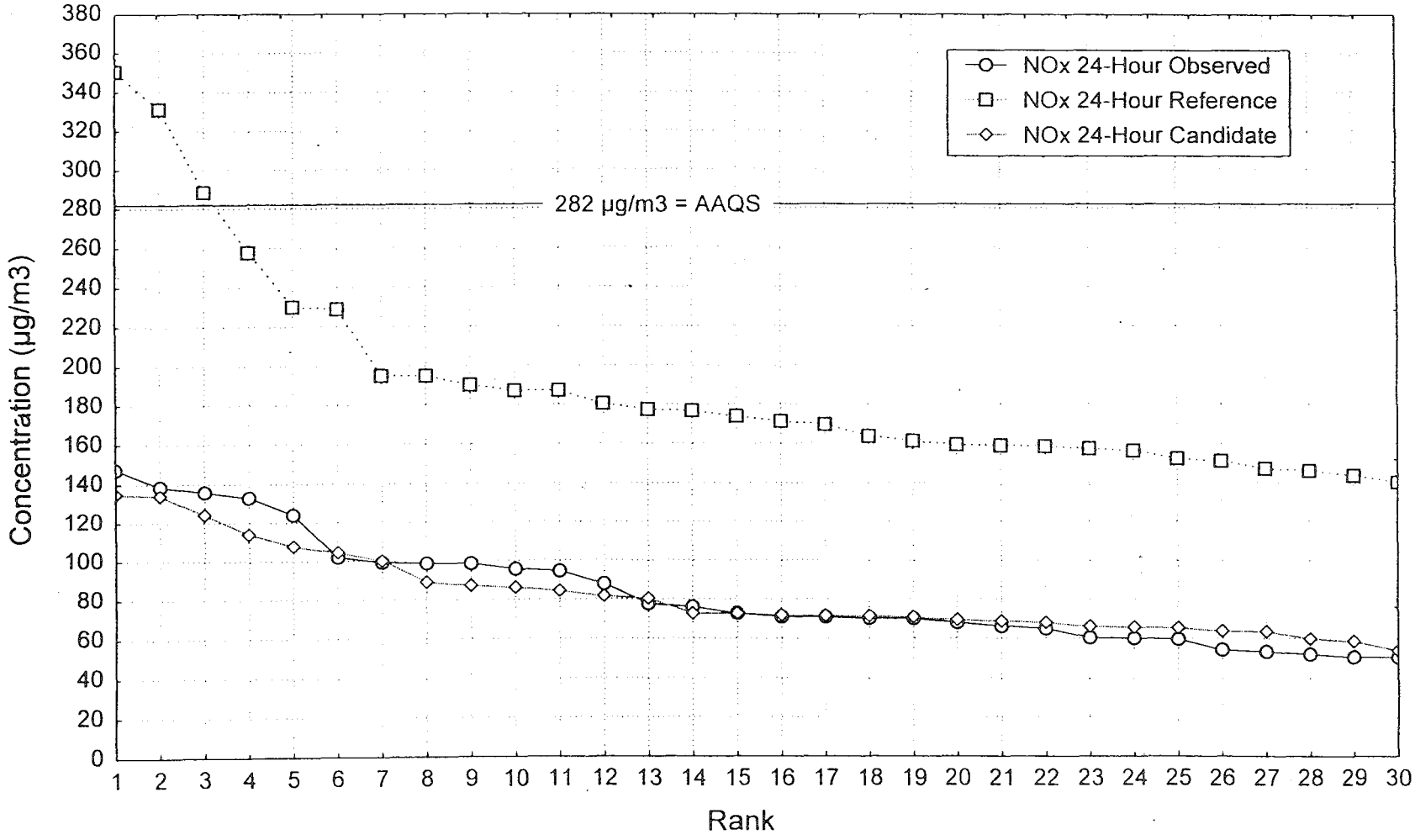


Table 5-2

Top 30 24-Hour Background adjusted NO_2, Observed, Reference, Candidate Model Predicted Concentration (µg/m3)

	Observed					STN#		Reference					STN#		Candidate					STN#
Rnk	(µg/m3)	YR	Mnth	DY	HR	CNM	Rnk	(µg/m3)	YR	Mnth	DY	HR	CNM	Rnk	(µg/m3)	YR	Mnth	DY	HR	CNM
1	147.4	93	6	8	24	10	1	350.4	92	11	19	24	11	1	134.8	93	6	23	24	10
2	138.6	93	6	30	24	10	2	331.3	92	12	13	24	5	2	134.1	93	6	30	24	10
3	135.8	92	11	1	24	11	3	288.5	93	1	11	24	5	3	124.3	93	6	8	24	10
4	133.0	92	11	19	24	11	4	257.8	92	11	19	24	5	4	114.1	93	5	7	24	10
5	124.0	93	4	27	24	10	5	230.1	92	11	20	24	11	5	107.7	93	5	8	24	10
6	102.0	93	5	8	24	10	6	229.0	93	5	1	24	10	6	104.5	93	6	7	24	10
7	99.2	93	4	8	24	10	7	195.2	93	5	30	24	10	7	100.1	93	5	1	24	10
8	98.7	93	6	7	24	10	8	195.1	93	6	23	24	10	8	89.1	93	6	12	24	10
9	98.5	93	6	22	24	10	9	190.2	93	1	12	24	5	9	87.3	93	7	1	24	10
10	95.6	93	5	7	24	10	10	187.4	93	6	30	24	10	10	86.3	93	6	22	24	10
11	94.5	93	6	16	24	10	11	187.4	93	5	7	24	10	11	84.5	93	7	24	24	10
12	88.0	93	4	24	24	10	12	180.5	93	6	8	24	10	12	81.7	93	5	22	24	10
13	77.7	93	6	23	24	10	13	177.4	93	5	4	24	6	13	80.5	93	6	11	24	10
14	76.1	93	7	16	24	10	14	176.7	93	6	7	24	10	14	72.8	93	5	30	24	10
15	72.7	93	7	24	24	10	15	173.8	93	5	9	24	10	15	72.7	93	7	17	24	10
16	70.9	93	5	23	24	10	16	171.4	93	5	2	24	6	16	71.9	93	6	24	24	10
17	70.8	93	8	14	24	10	17	169.7	93	4	23	24	10	17	71.7	93	5	9	24	10
18	70.1	93	7	25	24	10	18	163.8	93	6	12	24	10	18	71.5	93	4	23	24	10
19	70.0	93	7	1	24	10	19	161.3	93	6	11	24	10	19	70.9	93	4	24	24	10
20	67.9	93	5	1	24	10	20	159.4	93	5	11	24	6	20	69.5	93	4	27	24	10
21	66.1	93	7	23	24	10	21	159.0	93	5	22	24	10	21	68.7	93	5	27	24	10
22	64.9	93	2	5	24	11	22	158.6	93	5	8	24	10	22	68.1	93	6	19	24	10
23	60.4	93	6	19	24	10	23	157.5	93	7	24	24	10	23	66.2	93	7	25	24	10
24	60.1	93	5	2	24	10	24	156.3	93	2	1	24	6	24	65.7	93	6	29	24	10
25	59.7	93	5	27	24	10	25	152.4	92	11	1	24	11	25	65.5	93	7	27	24	10
26	54.3	93	7	4	24	10	26	151.1	92	12	12	24	11	26	63.8	93	7	4	24	10
27	53.3	93	7	17	24	10	27	147.2	92	11	8	24	5	27	63.5	93	4	8	24	10
28	52.0	93	5	30	24	10	28	146.1	93	2	11	24	11	28	59.8	93	5	2	24	10
29	50.6	93	2	11	24	11	29	143.8	93	7	13	24	6	29	58.4	93	7	3	24	10
30	50.6	93	1	12	24	11	30	140.4	93	2	1	24	5	30	54.0	93	7	23	24	10

Figure 5-3

Composite Performance Measure for NO2

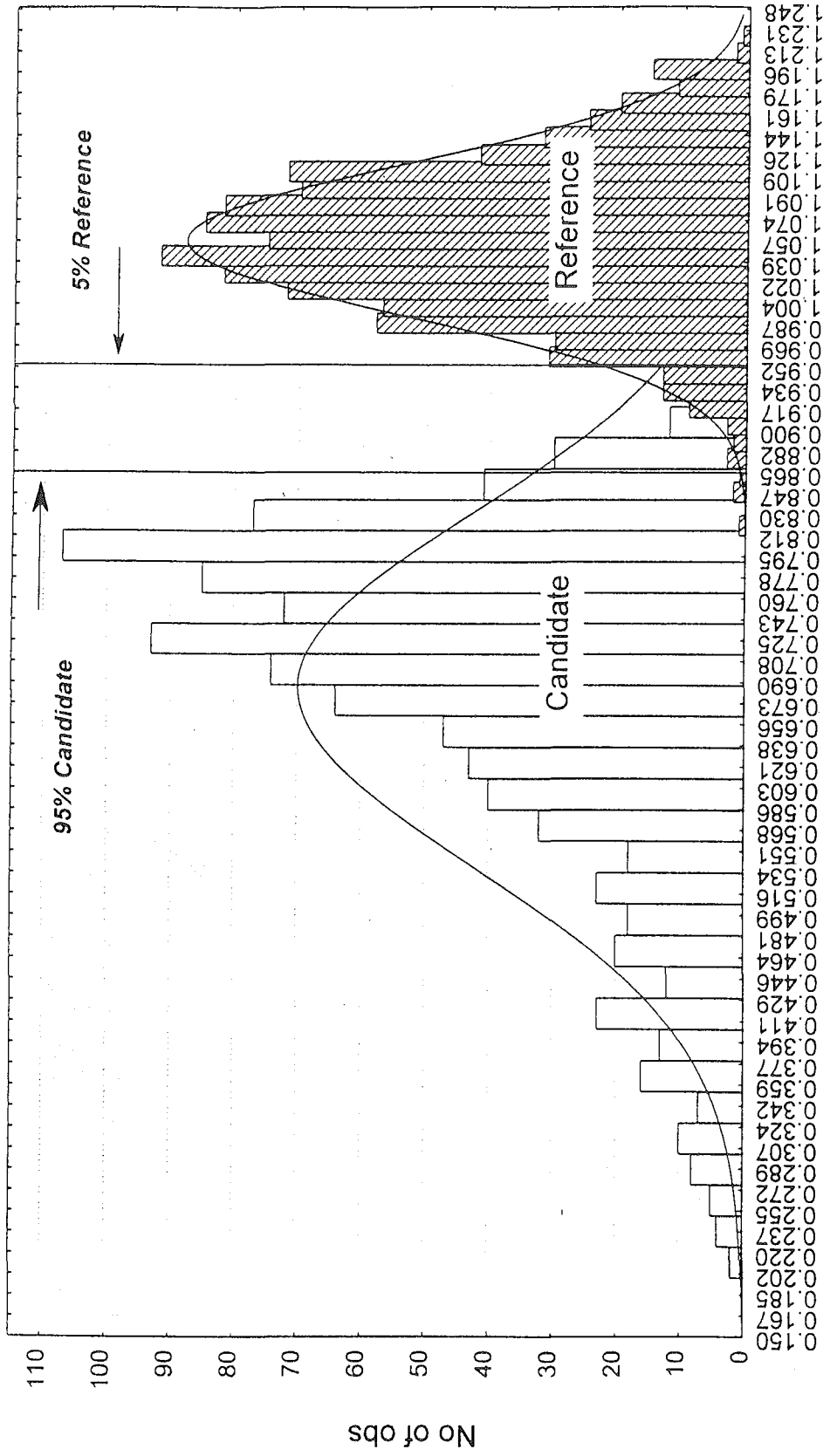


Figure 5-4

Model Comparison Measure for NO2

Thus, for NO_2 predictions, the candidate model is selected as providing statistically significantly superior performance to the reference model. The candidate model is recommended for NO_x regulatory modeling purposes for the Northshore facility.

5.1.2 SULFUR DIOXIDE

The predicted and observed SO_2 concentrations for the candidate and reference models for 1-, 3-, and 24-hour averaging times are shown in Figures 5-5 through 5-7 and Tables 5-3 through 5-5. No observed concentrations exceed AAQS. The reference model overpredicts the top 30 for all averaging times, actually predicting exceedances for the 1-hour averaging period. The amount of reference model overprediction decreases as the averaging time increases. The candidate model underpredicts at all averaging times. Generally, the candidate model does a better job of predicting the location of the high concentration events (at site CNM10) than the reference model, which tends to predict the high concentrations in the elevated terrain at sites CNM5, 6 and 11.

The CPMs for the SO_2 reference and candidate models are shown in Figure 5-8. As with NO_2, the candidate model for SO_2 shows significantly less bias than the reference model. The CPM values for the candidate model are much closer to zero. Likewise the MCM histogram presented in Figure 5-9 is negative throughout its range, showing that for each period bootstrapped, the candidate model outperformed the reference model. The ratio of the MCM/σ value is -3.48, again less than EPA's recommended limit of -1.7, and thus the MCMs indicate statistically significantly better performance for the candidate model than the reference model for predicting SO_2 concentrations.

Thus, for SO_2 predictions, the candidate model is selected as providing statistically significantly superior performance over the reference model. The candidate model is recommended for SO_2 regulatory modeling purposes for the Northshore facility.

Figure 5-5

Top 30 1-hr SO2 values, Observed, Reference and Candidate

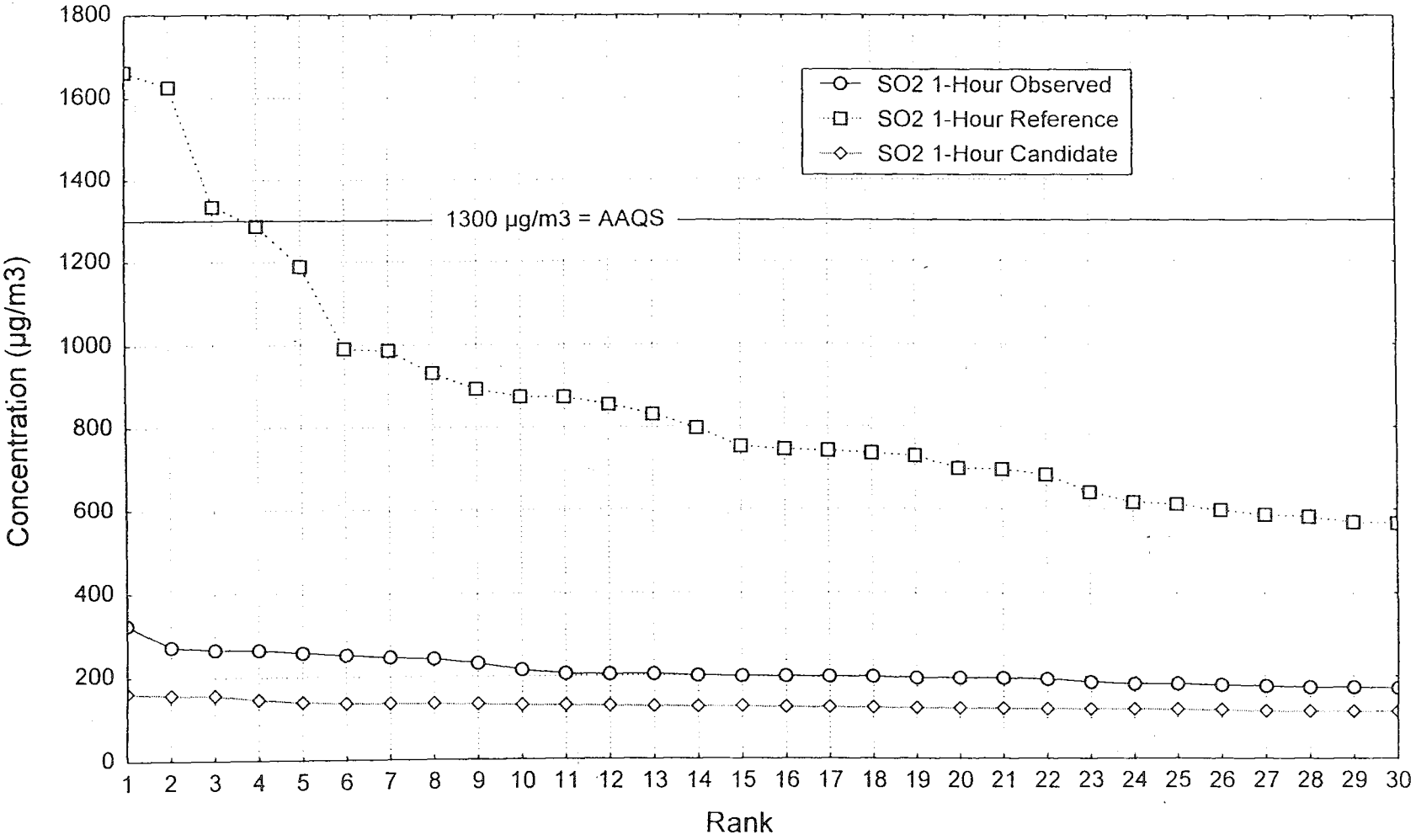


Figure 5-6

Top 30 3-hr SO2 values, Observed, Reference and Candidate

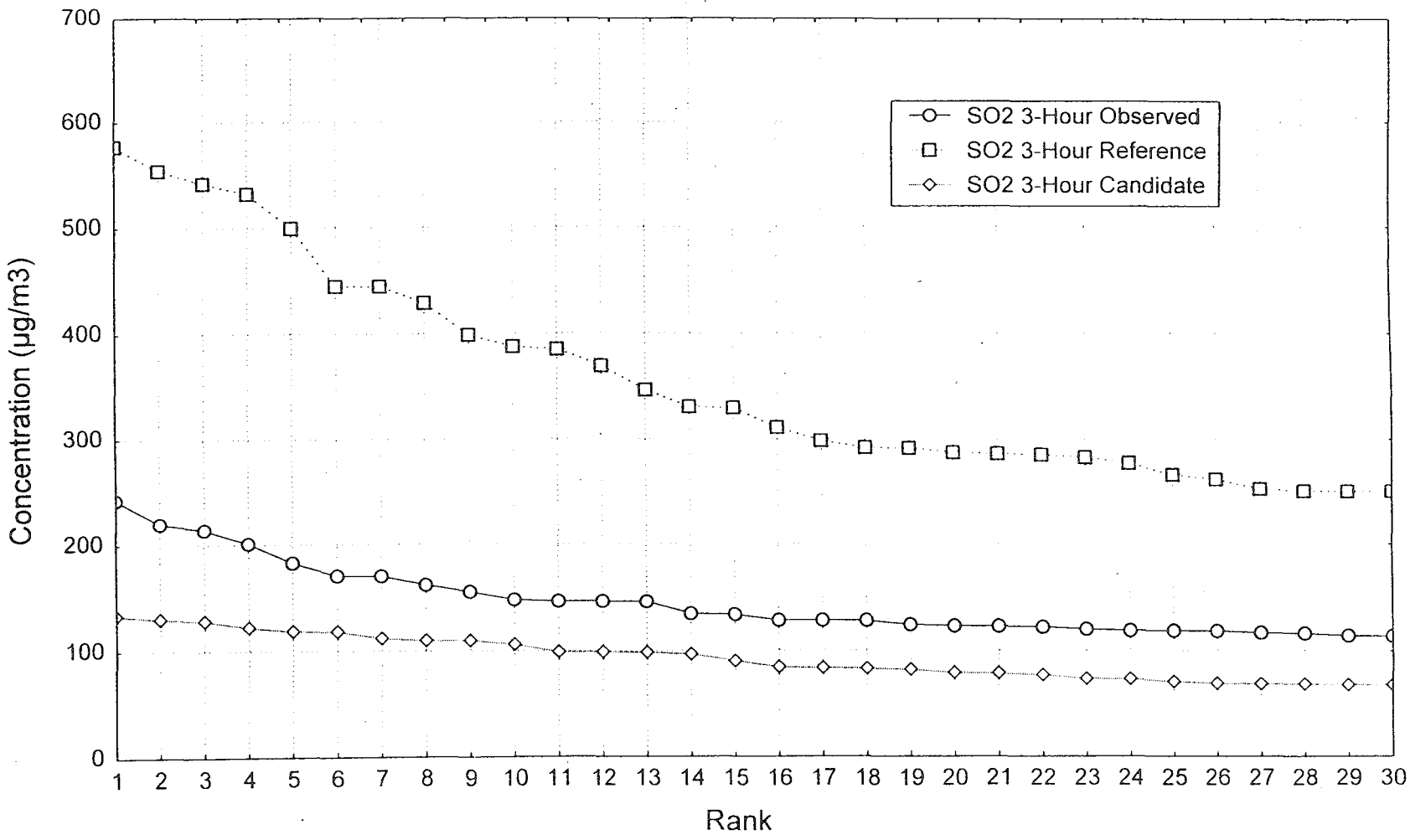


Figure 5-7

Top 30 24-hr SO2 values, Observed, Reference and Candidate

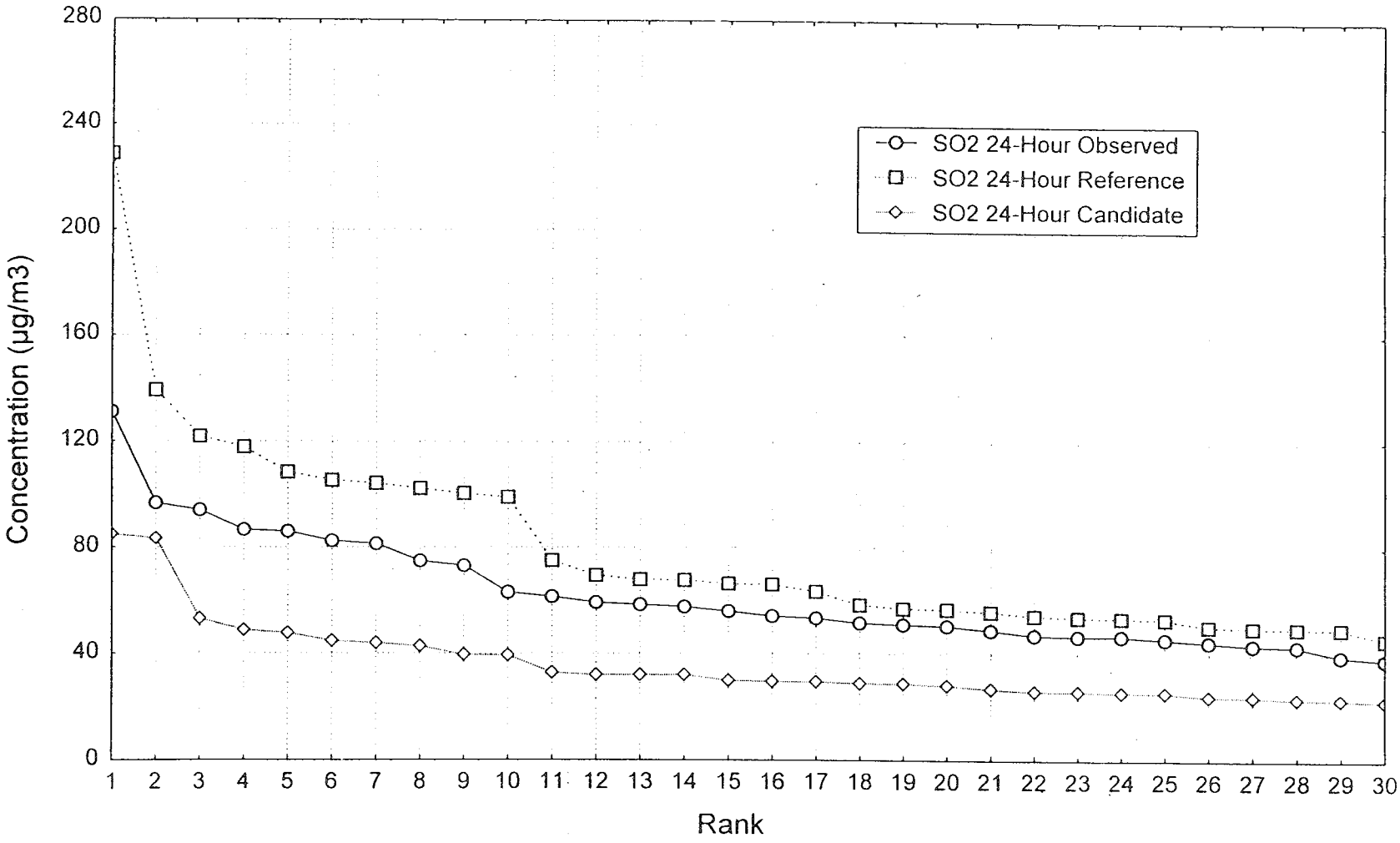


Table 5-3

Top 30 1-Hour Background adjusted SO_2, Observed, Reference, Candidate Model Predicted Concentration (µg/m3)

	Observed							Reference							Candidate						
Rnk	(µg/m3)	YR	Mnth	DY	HR	STN# CNM	Rnk	(µg/m3)	YR	Mnth	DY	HR	STN# CNM	Rnk	(µg/m3)	YR	Mnth	DY	HR	STN# CNM
1	324.4	93	4	24	2	10	1	1662.6	93	10	17	7	6	1	161.1	93	10	19	21	11
2	271.7	93	4	23	17	10	2	1626.0	93	5	28	2	6	2	156.4	92	11	19	22	5
3	264.7	93	6	22	22	10	3	1334.3	93	2	3	5	6	3	156.1	92	11	19	18	5
4	264.3	93	4	17	22	10	4	1286.7	93	6	15	21	6	4	146.0	93	6	22	17	10
5	258.0	93	6	22	23	10	5	1189.6	93	10	19	21	11	5	140.1	93	6	23	16	10
6	252.1	93	6	22	21	10	6	990.3	93	7	13	20	6	6	137.5	92	11	20	1	5
7	245.9	93	6	22	20	10	7	986.7	93	7	15	3	6	7	136.6	93	6	23	14	10
8	242.8	93	4	24	12	10	8	931.6	93	3	1	24	6	8	136.5	93	6	23	18	10
9	231.8	93	4	24	10	10	9	892.4	93	3	5	1	5	9	134.4	93	6	28	12	6
10	214.8	93	4	24	13	10	10	873.7	93	9	7	21	6	10	131.5	93	6	30	13	10
11	205.5	93	6	22	24	10	11	873.1	93	5	5	23	6	11	130.8	93	6	24	11	10
12	204.6	93	4	20	16	6	12	854.8	93	5	27	21	11	12	129.0	93	6	22	18	10
13	204.6	93	4	15	19	10	13	830.9	92	4	24	3	6	13	127.2	93	6	30	12	10
14	200.3	93	4	17	21	10	14	797.6	92	4	23	20	6	14	126.8	93	6	23	13	10
15	198.7	93	6	4	14	11	15	751.7	93	10	24	6	11	15	126.8	93	6	29	24	10
16	198.2	93	6	30	19	10	16	745.0	93	11	1	19	6	16	124.9	93	6	29	23	10
17	197.8	93	6	30	20	10	17	741.9	92	9	27	18	5	17	124.4	93	6	30	1	10
18	197.5	93	4	24	4	10	18	736.3	93	11	1	20	6	18	124.3	93	6	24	12	10
19	194.3	93	3	28	7	6	19	729.6	92	11	19	22	5	19	123.7	93	6	23	17	10
20	194.3	93	6	30	3	10	20	699.7	92	11	19	18	5	20	122.2	93	6	23	9	10
21	193.9	93	6	30	4	10	21	696.7	93	2	8	19	6	21	121.6	93	6	23	15	10
22	191.8	93	5	17	15	11	22	684.5	93	2	19	18	6	22	121.0	93	6	28	22	10
23	184.9	93	4	24	11	10	23	641.6	93	11	12	20	11	23	120.9	93	11	12	20	11
24	180.1	93	6	30	18	10	24	617.3	92	12	27	5	6	24	120.9	93	6	23	19	10
25	179.9	93	4	17	12	11	25	611.7	93	3	24	23	11	25	119.0	92	11	19	23	5
26	177.2	93	3	22	12	11	26	597.1	92	11	20	1	5	26	118.1	93	6	24	9	10
27	174.7	93	6	30	6	10	27	585.8	93	12	17	21	11	27	115.5	92	11	19	24	5
28	171.8	92	5	24	15	6	28	581.1	93	11	12	16	5	28	115.0	93	6	29	22	10
29	171.7	93	6	30	7	10	29	568.2	92	9	21	5	11	29	114.3	93	2	3	5	6
30	170.4	93	6	30	2	10	30	566.1	93	11	26	18	6	30	114.1	93	6	30	11	10

Table 5-4

Top 30 3-Hour Background adjusted SO_2, Observed, Reference, Candidate Model Predicted Concentration (µg/m3)

	Observed					STN#		Reference					STN#		Candidate					STN#
Rnk	(µg/m3)	YR	Mnth	DY	HR	CNM	Rnk	(µg/m3)	YR	Mnth	DY	HR	CNM	Rnk	(µg/m3)	YR	Mnth	DY	HR	CNM
1	242.8	93	6	22	24	10	1	577.3	92	11	19	24	5	1	133.4	93	6	23	18	10
2	219.8	93	4	24	12	10	2	554.2	93	10	17	9	6	2	130.3	92	11	19	24	5
3	214.0	93	6	22	21	10	3	542.0	93	5	28	3	6	3	128.3	93	6	23	15	10
4	201.1	93	4	23	18	10	4	532.2	92	11	19	15	5	4	122.3	93	6	29	24	10
5	182.7	93	4	24	3	10	5	499.7	93	11	1	21	6	5	118.7	93	6	22	18	10
6	170.5	93	6	30	6	10	6	444.8	93	2	3	6	6	6	118.5	93	6	24	12	10
7	170.3	93	6	30	21	10	7	444.5	93	11	12	21	11	7	112.3	93	6	30	12	10
8	161.8	93	6	30	3	10	8	428.9	93	6	15	21	6	8	110.2	93	6	30	15	10
9	155.4	93	6	30	9	10	9	398.6	93	10	19	21	11	9	110.0	93	6	30	9	10
10	147.8	93	5	8	6	10	10	387.4	92	11	19	18	5	10	106.1	93	6	24	9	10
11	146.1	93	4	10	15	6	11	385.0	93	11	12	18	5	11	99.1	92	4	10	15	11
12	146.1	93	10	25	9	10	12	369.5	92	4	10	15	11	12	99.1	93	6	30	3	10
13	145.6	93	4	24	6	10	13	346.3	93	11	25	9	11	13	98.6	93	6	23	12	10
14	134.2	93	7	1	24	10	14	330.1	93	7	13	21	6	14	96.8	92	11	19	15	5
15	133.6	93	6	30	18	10	15	328.9	93	7	15	3	6	15	90.4	93	6	22	12	10
16	128.2	93	5	8	9	10	16	310.5	93	3	1	24	6	16	84.8	92	11	19	18	5
17	128.2	93	5	7	3	10	17	297.8	93	3	5	3	5	17	84.1	93	6	30	6	10
18	127.8	92	12	13	3	11	18	291.2	93	9	7	21	6	18	83.2	93	11	12	21	11
19	124.2	93	6	7	24	10	19	291.0	93	5	5	24	6	19	82.5	93	6	29	18	10
20	123.0	93	6	29	21	10	20	287.0	93	11	25	12	11	20	79.5	93	11	25	9	11
21	122.8	93	4	27	9	10	21	286.0	92	11	20	3	5	21	79.2	93	7	27	18	10
22	122.2	93	6	8	6	10	22	284.9	93	5	27	21	11	22	77.3	92	11	1	12	5
23	120.0	93	6	8	18	10	23	282.4	93	11	12	24	11	23	73.8	93	6	23	9	10
24	118.9	93	6	30	12	10	24	277.0	92	4	24	3	6	24	73.7	93	6	23	3	10
25	118.6	92	4	19	6	10	25	265.9	92	4	23	21	6	25	70.9	93	7	27	21	10
26	118.3	92	4	18	21	10	26	261.7	93	2	12	3	11	26	69.3	93	6	23	6	10
27	116.8	93	4	17	21	10	27	252.4	93	11	26	6	11	27	68.7	93	6	22	9	10
28	116.3	92	4	18	24	10	28	250.6	93	10	24	6	11	28	68.7	93	7	1	6	10
29	114.2	92	5	1	3	10	29	250.4	92	4	10	12	11	29	68.1	93	5	30	12	10
30	113.7	92	4	19	3	10	30	250.4	92	11	1	12	5	30	68.0	93	2	11	15	11

Table 5-5

Top 30 24-Hour Background adjusted SO_2, Observed, Reference, Candidate Model Predicted Concentration (µg/m3)

	Observed					STN#		Reference					STN#		Candidate					STN#
Rnk	(µg/m3)	YR	Mnth	DY	HR	CNM	Rnk	(µg/m3)	YR	Mnth	DY	HR	CNM	Rnk	(µg/m3)	YR	Mnth	DY	HR	CNM
1	131.3	93	6	30	24	10	1	229.0	92	11	19	24	5	1	85.1	93	6	23	24	10
2	96.8	93	4	24	24	10	2	139.4	93	11	25	24	11	2	83.4	93	6	30	24	10
3	94.2	93	6	8	24	10	3	121.9	93	2	11	24	11	3	53.1	93	6	22	24	10
4	86.7	92	4	19	24	10	4	117.8	92	4	10	24	11	4	48.7	93	6	29	24	10
5	86.1	93	5	8	24	10	5	108.4	93	6	23	24	10	5	47.6	92	11	19	24	5
6	82.4	93	10	25	24	10	6	105.4	93	11	12	24	11	6	44.7	93	7	1	24	10
7	81.3	93	4	27	24	10	7	104.2	93	6	30	24	10	7	43.9	93	6	24	24	10
8	74.8	93	5	7	24	10	8	102.3	92	11	20	24	11	8	42.7	93	6	7	24	10
9	73.0	93	6	22	24	10	9	100.4	93	11	26	24	11	9	39.6	93	6	12	24	10
10	62.9	93	6	16	24	10	10	99.0	92	11	1	24	5	10	39.4	93	6	8	24	10
11	61.3	93	9	20	24	10	11	74.9	93	10	17	24	6	11	33.0	93	6	11	24	10
12	59.2	93	4	15	24	10	12	69.4	93	11	1	24	6	12	32.2	93	2	11	24	11
13	58.5	93	7	1	24	10	13	67.9	92	12	12	24	11	13	32.2	93	7	27	24	10
14	57.7	93	6	23	24	10	14	67.7	93	5	28	24	6	14	32.2	93	5	30	24	10
15	56.0	92	4	18	24	10	15	66.4	93	6	22	24	10	15	30.1	93	5	7	24	10
16	54.2	93	6	7	24	10	16	66.1	93	1	12	24	5	16	29.8	93	5	1	24	10
17	53.4	93	4	23	24	10	17	63.4	93	6	29	24	10	17	29.7	93	11	25	24	11
18	51.6	93	4	8	24	10	18	58.4	93	7	1	24	10	18	29.0	92	11	1	24	5
19	51.0	93	5	27	24	10	19	57.1	93	11	25	24	5	19	28.9	92	4	10	24	11
20	50.6	93	7	23	24	10	20	56.8	93	6	24	24	10	20	28.3	93	7	24	24	10
21	48.9	93	7	24	24	10	21	55.9	93	2	3	24	6	21	27.1	93	6	19	24	10
22	47.1	93	6	19	24	10	22	54.5	93	6	7	24	10	22	26.3	92	5	10	24	10
23	46.7	92	12	13	24	11	23	53.9	93	6	15	24	6	23	26.2	93	4	23	24	10
24	46.7	93	7	25	24	10	24	53.6	93	11	12	24	5	24	25.8	93	5	8	24	10
25	45.7	93	8	14	24	10	25	53.2	93	6	12	24	10	25	25.7	93	7	3	24	10
26	44.6	92	11	1	24	11	26	50.6	93	2	12	24	11	26	24.4	92	4	19	24	10
27	43.5	92	4	15	24	10	27	50.0	93	6	8	24	10	27	24.2	93	7	4	24	10
28	43.0	93	5	23	24	10	28	49.8	93	10	19	24	11	28	23.5	93	5	22	24	10
29	39.4	93	5	1	24	10	29	49.6	93	3	3	24	11	29	23.2	93	7	17	24	10
30	38.2	92	4	20	24	10	30	45.7	93	5	30	24	10	30	22.5	92	4	15	24	10

Figure 5-8

Composite Performance Measure for SO2

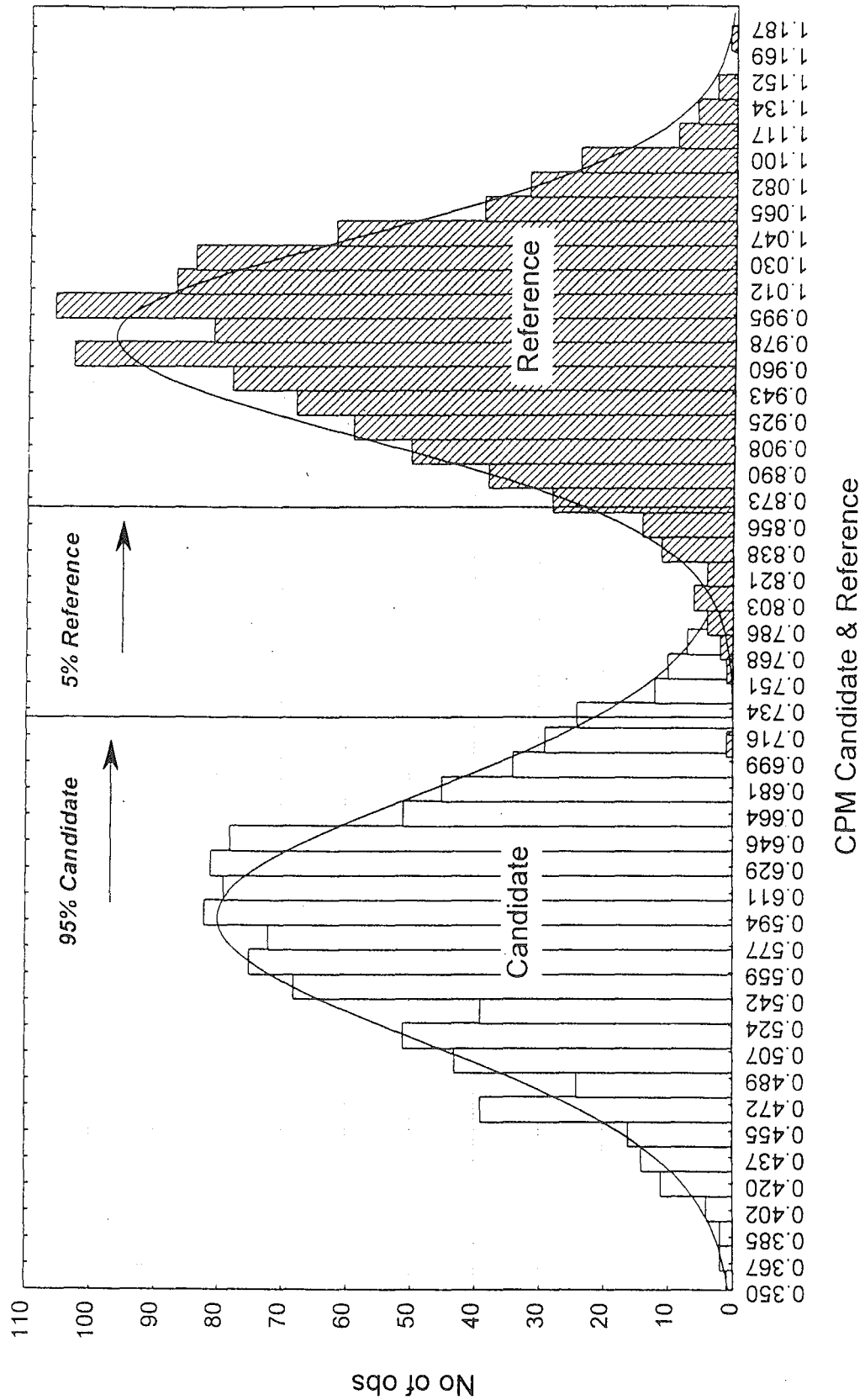
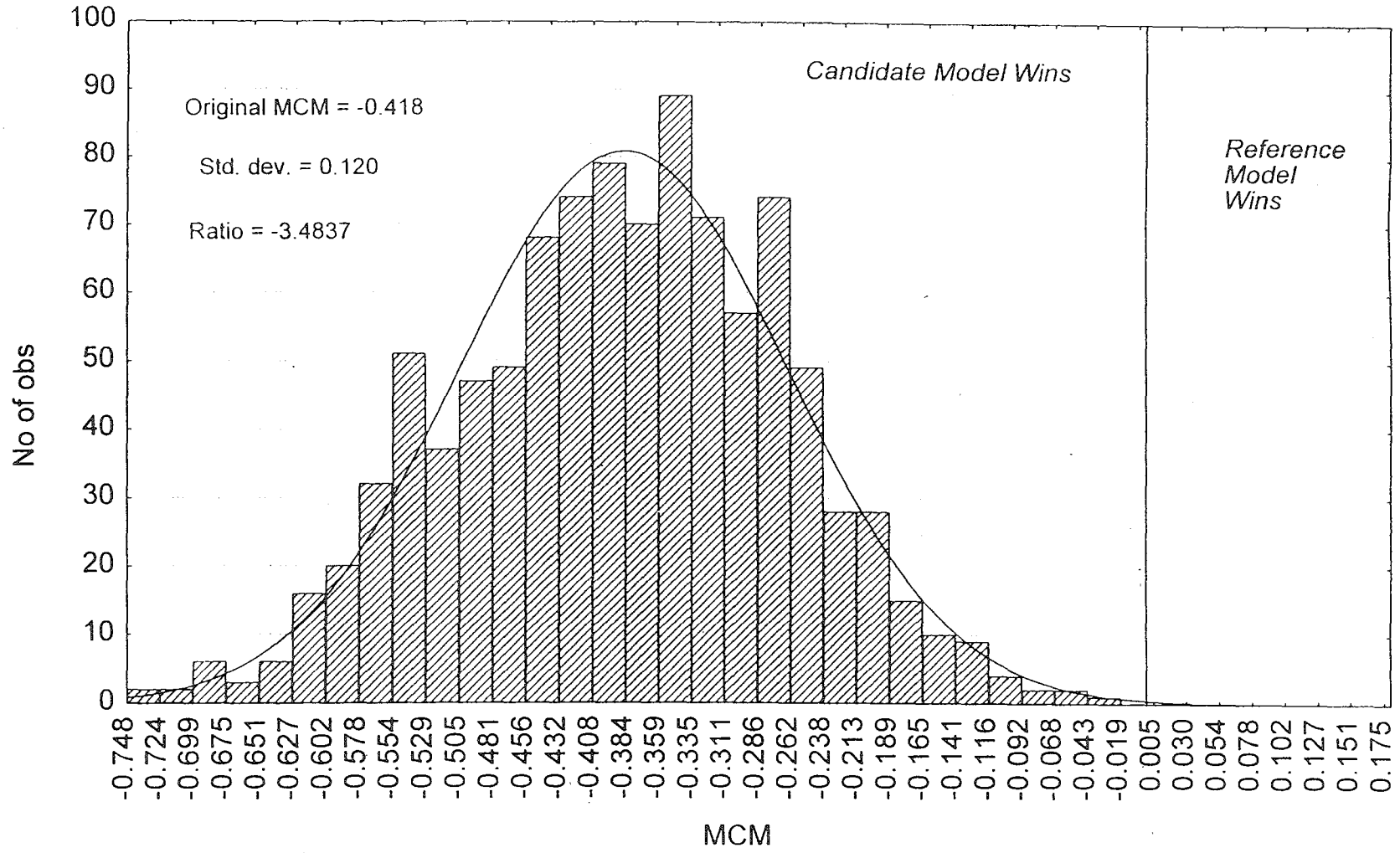


Figure 5-9

Model Comparison Measure for SO2



5.2 UNDERPREDICTION ANALYSIS

The protocol requires an analysis to determine whether the winning model over- or under-predicts. A two level test was presented in the protocol to determine over- or under-prediction of the modeled concentrations.

The first test takes a ratio of the second-highest monitored to the second-highest modeled (predicted) concentrations, paired in space. Thus, if any of the four ratios are greater than 1, then the winning model under-predicts. The second level test determines the adjustment factor if required.

A review of the data showed that the winning combined candidate model under-predicts for both pollutants. This is illustrated in Figures 5-1 and 5-2 for NO_x and Figures 5-5 through 5-7 for SO_2; the combined candidate model concentrations fall below the observed values for the top-30 concentrations.

Since the winning combined candidate model under-predicts, an adjustment factor is required. Table 5-6 presents both the Level One and Level Two analyses assessing these ratios and factors for NO_x and SO_2. In addition, 10% of the modeled value will also be added to the final result as a regulatory safety factor.

5.3 SUMMARY

ISC in its regulatory mode is the reference model for air quality dispersion modeling at the Northshore facility. The reference model has been shown to substantially overpredict observed concentrations for both SO_2 and NO_2 in Silver Bay. The reference model predicts violations of the ambient air quality standards while none have been observed. Further, the reference model predicts that maximum concentrations will occur in elevated terrain to the west and north of the Northshore facility, while the highest observed concentrations occur to the southwest of the plant at a monitor adjacent to the roadway.

TABLE 5-6
NORTHSHORE UNDERPREDICTION FACTORS

SO_2 1-HOUR CALCULATIONS

	LEVEL ONE TEST (paired in space)				LEVEL TWO TEST
	CNM5	CNM6	CNM10	CNM11	
2ND MON	114.6	194.3	271.7	191.8	271.7
2ND PRED	156.1	114.3	140.1	120.9	156.1
RATIO	0.7	1.7	1.9	1.6	1.7

SO_2 3-HOUR CALCULATIONS

	LEVEL ONE TEST (paired in space)				LEVEL TWO TEST
	CNM5	CNM6	CNM10	CNM11	
2ND MON	47.1	80.0	219.8	111.1	219.8
2ND PRED	96.8	38.1	128.3	83.2	128.3
RATIO	0.5	2.1	1.7	1.3	1.7

SO_2 24-HOUR CALCULATIONS

	LEVEL ONE TEST (paired in space)				LEVEL TWO TEST
	CNM5	CNM6	CNM10	CNM11	
2ND MON	10.2	15.1	96.8	44.6	96.8
2ND PRED	29.0	4.9	83.4	29.7	83.4
RATIO	0.4	3.1	1.2	1.5	1.2

NO_x 1-HOUR CALCULATIONS

	LEVEL ONE TEST (paired in space)				LEVEL TWO TEST
	CNM5	CNM6	CNM10	CNM11	
2ND MON	161.2	191.5	348.8	376.4	376.4
2ND PRED	172.4	194.9	209.2	200.1	209.2
RATIO	0.9	1.0	1.7	1.9	1.8

NO_x 24-HOUR CALCULATIONS

	LEVEL ONE TEST (paired in space)				LEVEL TWO TEST
	CNM5	CNM6	CNM10	CNM11	
2ND MON	27.3	25.9	138.9	133.3	138.9
2ND PRED	34.6	13.0	134.1	27.4	134.1
RATIO	0.8	2.0	1.0	4.9	1.0

Following the Modeling Protocol: Air Quality Model Evaluation for Cyprus Northshore Mining Company approved by EPA and MPCA, and the EPA's Protocol for Determining the Best Performing Model, the abilities of a combined candidate model to predict SO_2 and NO_2 concentrations at Silver Bay were compared to the abilities of the reference model. The candidate model was statistically significantly better than the reference model for predicting both NO_2 and SO_2 concentrations. On this basis, the candidate model is selected for regulatory modeling applications involving NO_2 and SO_2 emissions from the Northshore facility.

Appendix B contains the electronic form of the winning candidate model (ISCST2 - version 93109).

APPENDIX A
LETTERS APPROVING MODIFICATIONS

Attached are four letters approving the model evaluation studies conducted at the Northshore facility.

3. March 9, 1995 MPCA letter to EPA
4. March 28, 1995 EPA letter to MPCA
5. November 13, 1995 MPCA letter to EPA
6. December 15, 1995 EPA letter to MPCA

Minnesota Pollution Control Agency

March 9, 1995

Mr. David Kee, Director
Office of Air and Radiation Division
U.S. Environmental Protection Agency
Region V (AR-18J)
77 West Jackson Boulevard
Chicago, Illinois 60604-3590

Subject: "Interim Report" - Modeling Protocol and Model Evaluation Study for Northshore Mining Company in Silver Bay, Minnesota

Dear Mr. Kee:

In a letter dated December 23, 1993, we requested your written approval of the modeling protocol for a model evaluation study for Cyprus Northshore Mining Company in Silver Bay, Minnesota. You provided written approval in a letter dated May 18, 1994.

Since then the model evaluation study has been conducted per the approved modeling protocol. In addition, Cyprus Minerals sold Cyprus Northshore Mining Company to Cleveland Cliffs in September 1994. The facility is now Northshore Mining Company, a subsidiary of Cleveland Cliffs.

We now request your approval of the completed model evaluation study for nitrogen oxides (NO_x). We also request your approval to revise the modeling protocol for sulfur dioxide (SO_2). Both requests are described in the "interim report" submitted by W. Gale Biggs Associates on February 2, 1995: "*Model Evaluation Study for the Northshore Taconite Facility located at Silver Bay, Minnesota*," dated December 1994.

This study was conducted to determine the best performing model to establish SO_2 and NO_x emission limits to demonstrate modeled attainment of National Ambient Air Quality Standards and Prevention of Significant Deterioration increments. The model evaluation study compared two applications of the U.S. Environmental Protection Agency's (EPA) Industrial Source Complex (ISC2) model (version 93109):

Reference ISC2 model with building downwash and terrain
Candidate ISC2 model with neither building downwash nor terrain.

The study found that the candidate model won for NO_x, but lost for SO_2. Because the candidate model underpredicted NO_x concentrations, future 1-hour and 24-hour NO_x modeling results will be multiplied by 2.11 and 1.65, respectively. These adjustments include the ten percent regulatory safety factor agreed to in the modeling protocol.

As a result of the SO_2 outcome, two changes are proposed for the modeling protocol. First, the revised SO_2 candidate model will add building downwash but not terrain (i.e., downwash candidate SO_2 model). The rationale for this change is described in chapter 6 of the interim report. Second, the new SO_2 study period will supplement the original 12 months (September 1, 1992, through August 31, 1993), with an additional 6 months (April 1, 1992, through May 31, 1992, and September 1, 1993, through December 31, 1992). All other SO_2 analysis procedures will remain the same.

Mr. Dennis Becker and Mr. Patrick O'Neill, of my staff, have been in contact with Mr. Randy Robinson, of your staff, regarding these matters. We request your approval to accept the NO_x study results and the proposed revisions to the SO_2 modeling protocol.

If you or your staff have any questions or comments, please contact Dennis Becker at (612) 297-7364, or Patrick O'Neill at (612) 297-4518.

Sincerely,

Lisa J. Thorvig

Lisa J. Thorvig
Division Manager
Air Quality Division

LJT:lmg

cc: Dave Thornton, Air Quality Division
John Seltz, Air Quality Division
Dennis Becker, Air Quality Division
Patrick O'Neill, Air Quality Division
Randy Robinson, EPA Region V
W. Gale Biggs, WGBA Associates
Dennis Wagner, Northshore Mining Company
MPCA/AQD File# 27A

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

MAR 28 1995

REPLY TO THE ATTENTION OF:

(AE-17J)

Lisa J. Thorvig, Manager
Air Quality Division
Minnesota Pollution Control Agency
520 Lafayette Road
St. Paul, MN 55155-4194

Dear Ms. Thorvig:

The purpose of this letter is to respond to your request of March 9, 1995, for approval of the February 2, 1995, "Interim Report" of the model evaluation study performed for Northshore Mining Company. The report includes nitrogen oxide (NO_x) study results and a revision to the protocol for sulfur dioxide (SO_2). The USEPA Region 5 accepts the NO_x results with the understanding that they will be applied in accordance with the agreed upon conditions stated in the December 23, 1993, protocol (i.e., underprediction factors, geographic applicability, source specific applicability). The USEPA Region 5 also accepts the proposed SO_2 study protocol revisions as detailed in the February 2, 1995, report. The revisions consist of a new candidate model and the addition of six months of data to the original 12 month study period.

If you have any questions or comments, please contact Randy Robinson, of my staff, at (312) 353-6713.

Sincerely yours,

William L Jones

for William L. MacDowell, Chief
Regulation Development Section

cc: Dennis Becker, Air Quality Division, MPCA
Dennis Wagner, Cyprus Northshore Mining Corp.
W. Gale Biggs, W. Gale Biggs and Associates

Minnesota Pollution Control Agency

November 13, 1995

Mr. David Kee, Director
Office of Air and Radiation Division
U.S. Environmental Protection Agency, Region V (AR-18J)
77 West Jackson Boulevard
Chicago, Illinois 60604-3590

Subject: Final Report - Model Evaluation Study for Northshore Mining Company in Silver Bay, Minnesota, and Supplemental Modeling Protocol Revision

Dear Mr. Kee:

In a letter dated December 23, 1993, we requested your written approval of the modeling protocol for a model evaluation study for [Cyprus] Northshore Mining Company in Silver Bay, Minnesota. Mr. Randy Robinson, of your staff, provided written approval in a letter dated May 18, 1994.

In a letter dated March 9, 1995, we requested your written approval of the completed model evaluation study for nitrogen oxides (NOx) and permission to revise the modeling protocol for sulfur dioxide (SO2). Mr. Randy Robinson, of your staff, provided written approval in a letter dated March 28, 1995.

We now request your concurrent approval of two items. First, we request your interim approval of the completed model evaluation study for SO2. Second, we request your approval to revise the modeling protocol for both NOx and SO2 to allow for a potentially better site-specific model. These requests are summarized below and are detailed in the following submittals sent to Mr. Randy Robinson under separate cover:

> Final Report - Model Evaluation Study for the Northshore Taconite Facility Located at Silver Bay, Minnesota, prepared for Northshore Mining Company, and prepared by W. Gale Biggs Associates, July 1995;
>
> Letter from Mr. Dennis Wagner of Northshore Mining Company dated October 9, 1995.

The original study was conducted to determine the best performing model to establish SO2 and NOx emission limits to demonstrate modeled attainment of National Ambient Air Quality Standards and Prevention of Significant Deterioration increments. The model evaluation study

compared two applications of the U.S. Environmental Protection Agency's (EPA) Industrial Source Complex (ISC2) model (version 93109):

Reference ISC2 model with building downwash and terrain
Candidate ISC2 model with neither building downwash nor terrain.

The original study found that the candidate model won for NOx, but lost for SO2. Because the candidate model underpredicted NOx concentrations, future 1-hour and 24-hour NOx modeling results will be multiplied by 2.11 and 1.65, respectively, in accordance with the modeling protocol. These adjustments include the 10 percent regulatory safety factor agreed to in the modeling protocol. As a result of the SO2 outcome, a follow-up SO2 study was conducted to compare the following models:

Reference ISC2 model with building downwash and terrain
Candidate ISC2 model with building downwash but not terrain.

The follow-up study found that the revised (downwash) candidate model won for SO2. Because it underpredicted SO2 concentrations, future 1-hour, 3-hour, and 24-hour SO2 modeling results will be multiplied by 1.9, 1.9, and 1.3, respectively, in accordance with the modeling protocol. These adjustments include the 10 percent regulatory safety factor agreed to in the modeling protocol.

As a result of analyzing stack-by-stack contributions (culpability analysis) from these two studies, we now propose a supplemental modeling protocol revision to allow for possible refinement of the site-specific model(s). This supplement will provide the company three options to hopefully improve the site-specific models. All options will consider building downwash for stacks presently subject to the current Huber-Snyder building downwash algorithm, while ignoring building downwash where it (1) does not apply, or (2) where the current Schulman-Scire algorithm is normally used. As before, all stacks will be adjusted by the appropriate underprediction factor, if necessary. If these three options are unsuccessful, then the model evaluation studies conducted to date will be used for future SO2 and NOx modeling at Northshore Mining Company.

Mr. Dennis Becker, of my staff, has been in contact with Mr. Randy Robinson, of your staff, regarding these matters. We request your approval to accept the NOx and SO2 studies conducted to date. We also request your approval of the supplemental modeling protocol revision to allow Northshore Mining Company the opportunity to further refine its site-specific model.

If you or your staff have any questions or comments, please contact Dennis Becker at (612)297-7364.

Sincerely,

Rodney E. Massey, P.E.
Acting Division Manager
Air Quality Division

REM:jmd

cc: W. Gale Biggs, WGBA Associates
Dennis Wagner, Northshore Mining Company
Randy Robinson, EPA - Region V
Lisa J. Thorvig, Air Quality Division
J. David Thornton, Air Quality Division
John Seltz, Air Quality Division
Dennis Becker, Air Quality Division
Patrick O'Neill, Air Quality Division
MPCA/AQD File# 27A (Northshore Mining Company, Silver Bay, MN)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO IL 60604-3590

DEC 13 1995

REPLY TO THE ATTENTION OF

(AT-18J)

Rodney Massey, Acting Manager
Air Quality Division
Minnesota Pollution Control Agency
520 Lafayette Road
St. Paul, Minnesota 55155-4194

Dear Mr. Massey:

In a letter dated November 13, 1995, the Minnesota Pollution Control Agency (MPCA) requested approval of the document entitled "Final Report - Model Evaluation Study for the Northshore Taconite Facility located at Silver Bay, Minnesota", dated July 1995 (Final Report). In that letter, MPCA also requested our concurrence with a proposed revision to the modeling protocol as detailed in an October 9, 1995, letter from Mr. Dennis Wagner, Northshore Mining Company.

The July 1995, Final Report establishes an air dispersion model for use in regulatory modeling of sulfur dioxide emissions from the Northshore Taconite Facility. A dispersion model for use with nitrogen oxide emissions was evaluated in a separate report, dated December 1994. The United States Environmental Protection Agency (USEPA) approved the use of the nitrogen oxide model in a letter dated March 28, 1995.

Based upon recent analysis of the results of the sulfur dioxide and nitrogen oxide model evaluation studies, it was agreed that a refinement to the current models may result in a better regulatory model. This potential revision to the protocol would allow the company three options which may improve the current models. The details of the analysis and the three options are included in the Dennis Wagner letter mentioned above.

The USEPA approves the Final Report for sulfur dioxide with the understanding that it be applied with the agreed upon conditions stated in the Model Evaluation Study Protocol, dated December 1994. The USEPA also concurs with the decision to develop a supplemental protocol to allow the investigation of three options which may result in a better dispersion model. If none of the three options are successful, then the sulfur dioxide and nitrogen oxides models already approved and mentioned above will be used for future regulatory modeling at Northshore Mining Company.

Mr. Randy Robinson, of my staff, has been in contact with Mr. Dennis Becker, of your staff, regarding these issues. If you have any questions or comments, please contact Randy Robinson at (312) 353-6713.

Sincerely yours,

Gary Gulezian, Chief
Air Toxics and Radiation Branch
Air and Radiation Division

cc: Dennis Becker, Air Quality Division, MPCA
Dennis Wagner, Northshore Mining Corp.
W. Gale Biggs, W. Gale Biggs and Associates

APPENDIX B
ELECTRONIC FORM OF ISCST2

Attached in plastic jackets on the back cover of the document are two diskettes containing the electronic form of the winning model of ISCST2 (version 93109). Also included are the meteorological data sets used in the analysis.