United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park, NC 27711

EPA-454/R-95-008
October 1991

Air

EPA

DEVELOPMENT OF A PLAN FOR A SURFACE COAL MINE STUDY

Office of Air Quality
Clean Air
OAQPS
Planning and Standards

EPA-454/R-95-008

DEVELOPMENT OF A PLAN FOR A SURFACE COAL MINE STUDY

U.S. Environmental Protection Agency
Region 5, Library (PL-12J)
77 West Jackson Boulevard, 12th Floor
Chicago, IL 60604-3590

Emission Factor And Inventory Group
Emissions, Monitoring, And Analysis Division
Office Of Air Quality Planning And Standards
U. S. Environmental Protection Agency
Research Triangle Park, NC 27711

October 1991

This report has been reviewed by the Office Of Air Quality Planning And Standards, U. S. Environmental Protection Agency, and has been approved for publication. Any mention of trade names or commercial products is not intended to constitute endorsement or recommendation for use.

EPA-454/R-95-008

PREFACE

This interim report was prepared by Midwest Research Institute under U.S. Environmental Protection Agency (EPA) Contract No. 68-DO-0137, Work Assignment No. 68. The principal authors of this report are Dr. Greg Muleski of MRI and Mr. Clifford Cole and Mr. Steve Vardiman of TRC Environmental Consultants. Dr. Muleski was assisted by Dr. Chatten Cowherd and Ms. Karen Connery of MRI. Mr. Joe Touma and Mr. Dennis Shipman of the Office of Air Quality Planning and Standards served as EPA's technical monitors of the work.

Approved:

for Charles F. Holt, Ph.D., Director
Engineering and Environmental
Technology Department

October 29, 1991

CONTENTS

Preface iii
Executive Summary ES-1

1. Overview 1
   1.1 Site selection 2
   1.2 Evaluation of emission factor/dispersion model methodology 2
   1.3 Pit retention 3
2. Test Mine Site Selection Criteria 7
3. Emission Factor Verification and Dispersion Model Evaluation . 9
   3.1 Short-term testing for emission factors 9
   3.2 Long-term monitoring for dispersion model evaluation 17
   3.3 Data analysis and model evaluation 24
4. Pipit Retention 27
   4.1 "Checkout" study 27
   4.2 Field pit retention measurements 28
   4.3 Data analysis and model-building 29

References 31

Appendix

Synopsis of prior coal mine dispersion model evaluation studies A-1

EXECUTIVE SUMMARY

At present, ambient particulate matter (PM_{10}) impacts from surface coal mining operations are assessed in the following ways:

1. The mine's operating plan is reviewed to identify major PM_{10} emission sources, such as blasting, overburden removal, haul trucks, etc. The plan is also reviewed to determine source activity rates—such as tons of coal mined or tons of overburden removed per year—over the effective life of the mine.

2. An emission factor (mass emitted per unit source activity) is proposed for each major source. Factors are usually selected from Section 8.24 of AP-42.

3. Values from items 1 and 2 above are combined to estimate annual and worst-case-day PM_{10} emission rates from the mine.

4. Dispersion models (such as the Industrial Source Complex [ISC] model) are then used to simulate the atmospheric transport of the estimated emissions. Resulting ambient air concentration estimates are then compared against National Ambient Air Quality Standards (NAAQSs) or Prevention of Significant Deterioration (PSD) increments.

The study proposed here addresses issues involving the modeling process described above for surface coal mines. Specifically, the Clean Air Act Amendments (CAAA) requires the Administrator to "analyze the accuracy of. . . models and emission factors and make revisions as may be necessary to eliminate any significant overprediction." The purposes of this study are to:

- Improve available emission factors for surface coal mines.

- Develop a comprehensive data base of source activity levels, on-site meteorological conditions, and air quality data.

- Conduct a model evaluation study to assess how the current methodology predicts the ambient air quality impact from mines.

In general terms, the study combines extensive long-term air quality and meteorological monitoring with intensive short-term, source-directed testing. The long-term data collection is necessary to answer the following questions:

- Does the current methodology result in systematic overprediction of air concentrations?
- If so, what is the degree of overprediction?
- How well do ISC model results match measurements in time and space?

If the answers to these questions show that problems exist, a different approach is necessary to find out how and why differences occur.

No matter how sophisticated, long-term monitoring of ambient "far-field" concentrations alone cannot answer questions such as the following:

- What portion or portions of the methodology are most responsible for overprediction?
- Can the identified portions be modified so that systematic overprediction is effectively removed?
- What fraction of material emitted at the bottom of the pit eventually escapes?

To answer these types of questions, the long-term monitoring program must be supplemented with the intensive short-term monitoring and pit retention tracer programs that incorporate more source-directed measurements. Quantitative examination of separate steps in the emission factor/dispersion model methodology is necessary to answer the "how" and "why" questions. Furthermore, the particulate tracer studies will provide a quantitative basis for development of a pit retention algorithm.

The proposed program represents an excellent opportunity for cooperative agreements between agency and coal companies/trade groups. A variety of participation levels are available.

- At a minimum, industry will be asked to provide historical source activity data, such as production rates and maintenance records for mine equipment. This information can be treated as "CBI"—confidential business information
- Mines may also be asked to supply historical ambient air quality monitoring and meteorological data

- With agreement from state and regional offices, some mine air quality or meteorological equipment could be relocated or loaned out for use at another mine during the long-term monitoring program.

- For mines selected as test sites, higher levels of cooperation are possible, ranging from arranging for electrical power drops and for field laboratory space to providing technician help who, under direct supervision by the contractors, would assist in field team support.

SECTION 1

OVERVIEW

This section presents an overview of major components of the proposed study. The field sampling program consists of extensive long-term air quality and meteorological monitoring combined with intensive, short-term source testing. In addition, pit retention will be studied under a separate set of experiments. It should be noted that substantial cost savings are expected if sets of experiments are conducted and coordinated at the same mines.

To avoid confusion about what is meant by terms such as "ambient air" and "near-source," the following defines terms that are used throughout this document.

"Source tests" refer to air quality/meteorological measurements made in the immediate vicinity of an individual emission source (such as a road) with the intention of characterizing that source. Most of these measurements are required for "exposure profiling," which relies on simultaneous multipoint concentration and wind speed measurements over the effective cross-section of the dust plume to determine source strength. As such, these measurements are those necessary to develop the improved emission factors.

"Near-field air monitoring" refers to measurements made further away than source tests, but still within the vicinity of an individual source. A major difference is that near-field measurements do not normally span the plume cross section. Rather, these measurements will generally be made at a height of 1 to 2 meters and are usually made for comparison with ISC or other model-generated concentration estimates. Unless otherwise specified, near-field measurements will be made within the pit.

"Far-field air monitoring" will refer to measurements made at a considerable downwind distance from the nearest emission source. As such, these measurements focus on characterizing the air quality impact of the mine as a whole rather than on any individual source or source category. Unless specifically stated otherwise, far-field measurements will be made beyond the rim pit (i.e., at surrounding grade). In this document, "ambient" and "far-field" are equivalent terms. These are the measurements that will be compared against dispersion model predictions to evaluate the current methodology.

1.1 SITE SELECTION

An initial step in the proposed study is the identification of candidate test sites for the field work. Selection of mine sites at which testing will be conducted will begin with identification of the minimum site criteria needed to accomplish testing objectives. Candidate sites will be evaluated with respect to surrounding terrain, availability of power, ease of access to mine activities and to the mine pit, absence of outside interferences (particularly from adjacent mines), and willingness of mine owners to participate in the study. Site selection is discussed in greater detail in Section 2 of this plan for a surface coal mine study.

1.2 EVALUATION OF EMISSION FACTOR/DISPERSION MODEL METHODOLOGY

This portion of the study provides the basis for an objective evaluation of the emission factor/dispersion model methodology as currently applied. This effort will involve a relatively long-term (approximately 4 months) monitoring of air quality, meteorology and mining activity program. Data will be used to compute fugitive dust emission rates, and the dispersion/transport of emissions will be simulated with the ISC model. Modeled and measured concentrations will be compared. Model evaluations can be highly sensitive to the kind of statistical comparisons that are used to judge model performance. Consequently, considerable effort will be devoted to defining exactly how the comparison will be made, and what pairwise and ensemble statistics will be used.

The long-term data collection is necessary to answer the following questions:

1. Does the current emission factor/dispersion model (EF/DM) methodology result in systematic overprediction of air concentrations?

2. If so, what is the degree of overprediction?

3. How well do ISC model results match measurements in time and space?

Various time averaging periods are possible for PM_{10} concentrations. In the regulatory sense, 24-h concentrations are most important because the NAAQSs and PSD increments are based on that time period. On the other hand, currently available dispersion models typically use hourly meteorological data to predict hourly concentrations. The hourly predictions are then combined to provide longer-period averages.

Until recently, ambient PM_{10} concentrations could only be sampled by reference methods for periods on the order of 24 h. Within the past year, several equivalent PM_{10} measurement methods have become available, providing far greater time resolution than the older high-volume sampling methods. Table 1 summarizes the advantages and disadvantages of various field sampling equipment that could be used.

Questions such as (1) to (3) above ask only if problems exist; a different approach is necessary to find out why differences occur. No matter how sophisticated the deployment on time resolution, long-term monitoring of "far-field" concentrations cannot answer questions such as the following:

4. What portion or portions of the methodology are most responsible for overprediction?

5. Can identified portions be modified so that systematic overprediction is effectively removed from the methodology?

To answer these types of questions, the long-term monitoring program is supplemented with short-term monitoring programs. During these periods, the contractor team will make source-directed measurements. Quantitative examination of separate steps in the EF/DM methodology is necessary to answer questions such as (4) and (5).

Thus, the model evaluation portion of the proposed study combines long-term monitoring of air quality, meteorology, and source activity together with short-term field measurement of emission factors. The combination permits each step in the current methodology to be independently evaluated.

Specific details on methodology evaluation portion of the study are presented in Section 3.

1.3 PIT RETENTION

The previous portion of the proposed field study would evaluate the emission factor/dispersion model methodology as it is currently used. A separate set of field experiments has been proposed to develop the data base needed to modify the existing methodology to better account for the retention of particulate matter within the pit at a surface coal mine.

Pit retention (or "pit trapping") is the tendency for particulate matter to remain inside a mine pit, rather than dispersing downwind and impacting ambient receptors. Neither the ISC model nor the other EPA dispersion models can account for the retention of particulate matter in the mine pit—instead, ISC acts

Table 1. PM^{10} SAMPLING OPTIONS

Type	Representative samplers	Time averaging period	Advantages	Disadvantages
High volume	Wedding, Anderson	6 to 24 h	EPA Reference Method for PM_{10} Averaging period comparable to Can operate on portable generator power	Requires AC power Cannot provide fine time resolution of concentrations
Continuous	Beta gauge, TEOM (tapered element oscillating microbalance)	Continuous	Provides very fine time resolution of concentration	Requires "clean" AC power, and does not run well on portable generators Generally requires temperature-controlled enclosure for reliable operation Most expensive option
Saturation	"PRO-2"	6 to 24 h	Battery powered Least expensive option Relatively rugged and easily deployed/moved	Not an equivalent method Cannot provide fine time resolution of concentration

as if the emissions occur at grade and disperse downwind, that is, as if the pit exerts no influence. Failure to include pit retention may introduce very large overpredictions. The ISC model predicts maximum particulate concentrations during low wind speeds under stable atmospheric conditions; however, it is during these same low wind speed stable conditions that pit retention is most pronounced.

The effects of pit retention will be evaluated by releasing tracer agents (preferably particulate tracers, although some gaseous tracers may be used) at the bottom of a mine pit and measuring their concentrations at the top of the pit.

The dissemination and detection of particulate tracer materials present considerable technical challenges. Furthermore, a variety of potential tracer materials are available. In general, durable candidate materials that are easily detected (such as encapsulated dyes) tend to be expensive. Less expensive materials, on the other hand, are usually harder to detect in low concentrations. Finally, the "weatherability" of certain materials can extend their applicability in the field program.

For these reasons, candidate tracers and dissemination techniques will be evaluated during a "checkout" study. This program, to be conducted well in advance of the SCM field tests, will provide practical guidance on how the field tracer studies should be conducted.

To the extent practical, field pit retention tests will be coordinated with the source tests. This approach provides a means to simultaneously and independently evaluate each step in the emission factor/dispersion model methodology. In so doing, the sources of overprediction may be identified with confidence.

Section 4 of this report discusses the "checkout" and surface coal mine pit retention studies in greater detail.

SECTION 2

TEST MINE SITE SELECTION CRITERIA

Mine sites will be selected by comparing each candidate mine's attributes against predetermined criteria of desired location, available data, site configuration, etc. It is anticipated that at least one Wyoming surface mine will be selected. The criteria given below represent guidelines rather than "hard and fast" rules. The process of site selection requires many qualitative and subjective decisions. Candidate mines will be judged on the following criteria:

- General Location. Although mines with existing PSD monitoring networks provide ready candidates, most PSD networks are not sited to provide the data needed in this study. In addition, mines that are relatively isolated would be preferred because interference from neighboring mines may influence results. While it may not be possible to find completely isolated mines, those located away from neighboring mines would be preferred over those in proximity to other mines. Finally, the site should be isolated from terrain features influencing local airflows. That is, the terrain immediately surrounding the mine should be fairly flat.

- Source/Location Orientation. Near-source measurements of traffic source generally require long stretches of roads that are approximately perpendicular to the prevailing wind. In addition, sources should be relatively isolated from other important PM_{10} emission sources within the mine.

The following is a list of example criteria to be applied to a site for roadway source testing.

1. There should be at least 10 meters of flat, open terrain downwind of road.

2. There should be at least 30 meters of flat, open terrain upwind of road.

3. The height of nearest downwind obstruction should be less than the distance from the road to the obstruction.

4. The height of nearest upwind obstruction should be less than one-third the distance from the road to the obstruction.

5. A line drawn perpendicular to the road orientation should form an angle of 0° to 45° with the mean daytime prevailing wind direction.

6. The mean daytime wind speed should be greater than 4 mph.

7. The test road should have an adequate number of vehicle passes per hour enabling completion of a test in no more than 3 h.

8. The traffic mix should be representative of the type of vehicles that regularly use the road.

Analogous criteria have been established for nonroad sources, such as material handling operations. These include isolation from other important sources and wind obstructions, accessibility to the emission source, and orientation of the source to prevailing winds.

- Mine Activity. Quantification of the mining activity (traffic volumes, amount of coal removed, amount of overburden disturbed, etc.) is needed for the mine model validation effort. Candidate mines will be judged on the availability of historical data and on the ease with which these data could be collected during any field study.

- Logistics. There is a need to locate instruments near dust-producing activities, at locations up and downwind of the mine, and at the top of the mine pit highwall. The candidate mines will be evaluated on the basis of being able to accommodate the wide variety of sampling locations necessary.

- Representativeness. Preference will be given to mines that are neither at the start nor near the end of operation according to the mine plan. Furthermore, geographic diversity of the test sites is a desired goal.

It is anticipated that EPA will initially contact the owners or operators of candidate mine sites. Once contacted, the contractor team can make written requests of information that relate to location, mine activity, power, and logistics. Based upon a qualitative assessment of each of these criteria and on each mine's willingness to participate in a study of this sort, the candidates will be reduced to a number of sites to be visited by MRI/TRC personnel. The final selection used will be based on reexamination, using the same general criteria.

SECTION 3

EMISSION FACTOR VERIFICATION AND DISPERSION MODEL EVALUATION

Evaluation of the emission factor/dispersion model methodology requires two types of field sampling. The first examines, over a period of 4 months, whether the current overall methodology results in systematic overprediction of the overall air quality impact of surface coal mines. This examination involves gathering the data needed to compare ISC-generated concentrations with measured concentrations to determine how well the current methodology allows one to predict concentrations near a surface coal mine.

The second type of sampling is directed to answering why overprediction occurs and how well each step in the EF/DM methodology predicts measured values. This portion of model evaluation involves short-term measurements both in terms of individual tests (on the order of 1 to 3 h) and in time spent on-site (estimated as two or three 2- to 3-week periods distributed throughout the 4-month long-term monitoring period). See Table 2.

3.1 SHORT-TERM TESTING FOR EMISSION FACTORS

A review of emission factors applicable to surface coal mines has been recently completed (MRI, 1991). This review also presented recommendations for future source testing, which are summarized in Tables 3 and 4. The proposed source testing program focuses on the following major sources:

- Coal and overburden
- Haul roads
- General traffic (light- and medium-duty)
- Overburden material handling operations
- Coal material handling operations

These sources typically account for 70% or more of particulate emissions at surface coal mines (Cole et al., 1985).

The source-directed field sampling will employ the "exposure profiling" concept to quantify source emission contributions and near-field concentrations.

Table 2. PROPOSED SCHEDULE

Activity (Relevant Section)	Estimated Cost ($1000)	1991 O	N	D	1992 J	F	M	A	M	J	J	A	S	O	N	D	1993 J	F	M	A	M	J	J	A	S	O	N
1. Program Planning																											
General Testing Protocol	\a	*	*	*	*				*	*	*																
Particulate Tracer "Check-out" Study (4.1)	135																										
- Identification of candidate tracers				*	*	*																					
- Field Exercise						*	*	*	*	*	*																
- Data Reduction and Recommendation of "model-based" or "mass-balance" tracer methodologies								*	*	*	*																
2. Surface Mine Site Selection/Equipment Mobilization/Supply Acquisition (2.0)	70			*	*	*	*	*	*	*						*	*										
3. Short-term Testing for Emission Factors (3.1)																											
Travel-related (line) sources \b																											
Western Mine #1																											
- Uncontrolled Emissions	45\c																										
Source testing								*	*	*																	
Sample analysis									*	*	*	*															
Data reduction										*	*	*	*	*													
- Controlled Emissions	105\c																										
Source testing												*	*	*	*												
Sample analysis													*	*	*	*											
Data reduction															*	*	*	*									
Western Mine #2																											
- Uncontrolled Emissions	55																										
Source testing										*	*																
Sample analysis											*	*	*	*	*												
Data reduction														*	*	*	*	*									

Table 2 (continued)

Activity (Relevant Section)	Estimated Cost ($1000)	1991 O	N	D	1992 J	F	M	A	M	J	J	A	S	O	N	D	1993 J	F	M	A	M	J	J	A	S	O	N
Sample analysis															*	*	*	*	*								
Data reduction																*	*	*	*	*							
Mine #3 *																											
– Uncontrolled Emissions	55\c,d																										
Source testing																			*	*	*						
Sample analysis																				*	*	*					
Data reduction/																					*	*	*				
– Controlled Emissions	120\c,d																			*	*	*	*	*	*		
Source testing																						*	*	*	*		
Sample analysis																							*	*	*	*	*
Data reduction																											
Material handling sources \b																											
Western Mine #1	70\c																										
Source testing								*	*	*																	
Sample analysis									*	*	*																
Data reduction										*	*	*	*														
Western Mine #2	80\c																										
Source testing											*	*	*														
Sample analysis												*	*	*	*												
Data reduction													*	*	*	*											
Mine #3 *	80\c,d																					*	*				
Source testing																							*	*	*		
Sample analysis																								*	*	*	*
Data reduction																											
4. Source Activity Monitoring (3.3)	\e																										
Travel-related (line) sources	20																										
Western Mine #1								*	*	*	*	*	*														
Western Mine #2										*	*	*	*		*	*											
Mine #3 **																			*	*	*	*	*	*	*	*	
Material handling sources	20																										
								*	*	*	*	*	*														

Table 2 (continued)

Activity (Relevant Section)	Estimated Cost ($1000)	1991 O	N	D	1992 J	F	M	A	M	J	J	A	S	O	N	D	1993 J	F	M	A	M	J	J	A	S	O	N
Western Mine #2										**	**		**	**													
Mine #3 **																			**	*******			**				
Misc. sources (blasting, road grading, etc.)	20																										
Western Mine #1								******			***																
Western Mine #2										**	**		**	**													
Mine #3 **																			**	*******			**				
5. Long-term Monitoring for Dispersion Model Evaluation																											
Acquisition system design	25					*****	***																				
Western Mine #1	90																										
- Equipment deployment/shakedown period								***																			
- Long-term (4 month) "far-field" monitoring (3.2)	\e								*****		*****																
- Particulate tracer study of Pit Retention (4.2)	\f												***														
Second Year Mine **	95\d																										
- Equipment deployment/shakedown period																			*	**							
- Long-term (4 month) "far-field" monitoring (3.2)	\e																			******			****				
Construction of data base	25												**	******									*****				
6. Model Evaluation Protocol (3.1)	30			***	****																						
7. Emission Factor Review/Development	30														***	*							*******			**	

Table 2 (continued)

Activity (Relevant Section)	Estimated Cost ($1000)	- 1991			1992									1993								
		O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N
9. Program Management and Reporting	75																										
Interim Report																		*									
Draft Final Report																										*	
Final Report																											*

Notes:

* Depending upon the results of the first testing season (i.e., spring-fall 1992), the third mine used for emission factor development/verification may be either western or eastern.

** The long-term air quality and source activity monitoring program during the second testing season (i.e., 1993) will be at a western mine (which may be the same as the second mine used for emission factor work during the 1992 testing season).

\a Cost of preparing protocol included in current OTS work assignments.

\b Emission sources to be considered are summarized in Table 3.

\c Estimated cost assumes that emission factor experiments are interspersed with long-term monitoring program.

\d Cost dependent upon location of test mines during the second test season. Estimate given assumes that long-term and short-term monitoring are interspersed at the same location. See notes * and ** above.

\e Source activity levels will be recorded during all periods that field crews are present at mines. Consequently, the estimated cost assumes certain savings because this activity is concurrent with others. Additional source activity data may be collected by survey of mining companies and trade groups.

\e Cost estimates assume that sampling Option A is selected (i.e., two or three primary monitoring locations combined with 20 to 30 saturation samplers. Should Option B (exclusive use of continuous samplers) be selected, it is estimated that additional cost will be approximately $500,000 for the first test season and $250,000 for the second test season.

\[illegible] dependent upon results from "check-out" study. Preliminary cost estimate is about $325,000, assuming that the pit retention study

Table 3. EMISSION SOURCES RECOMMENDED FOR EVALUATION

	Recommended number of tests per mine[a]	Overall priority
Lines sources (travel-related) to be considered[b]		
1. Haul trucks	3-6U, 6-12C	1
2. General mine traffic	3-6U, 6-12C	3
3. Haul trucks (overburden)	3-6U, 6-12C	2
"Grouped" approach to material handling emissions[c]		
1. Overburden removal and placement in trucks[d]	3-6	4T
2. Overburden replacement by dragline[d]	3-6	4T
3. Misc. overburden handling operations[d]	3-6	4T
4. Misc. coal handling operations[e]	3-6	8[f]

Notes:

[a] U = uncontrolled, C = controlled. Uncontrolled if not indicated.

[b] Depending on the road network at the mine, it may not be possible to separate various travel-related emission. In that case, because of the importance of travel-related emissions, additional toads or other line sources (such as scraper travel [see note f below] or road grading) will be tested. These tests are expected to be of uncontrolled emissions.

[c] Emission factor development will group operations with like materials regardless of the equipment involved. This approach is expected to be particularly beneficial for overburden-related emissions from draglines, power shovels, truck dumps, etc. It is further expected that test results will be combined with the generic materials handling emission factor data base.

[d] Dependent upon the type of mine operation (i.e., dragline or shovel/truck).

[e] Including truck dumps, loadout for transit, etc Again, emission factor development will group across operations with the same material.

[f] Scrapers in travel mode rated as 7th overall priority

Table 4. SUMMARY OF THE PROPOSED FIELD STUDY

		Sampler Deployment				
Testing phase	Objectives of testing phase	Far-field	Source	Near-field	Testing duration	Testing time frame
Tracer "Check-out" Study (Section 4.1)	1. Identify suitable materials and release techniques 2. Compare model-based and mass-balance approaches	X	X		30 min to 2 h	Spring 92
Long-term monitoring for dispersion model evaluation (Sections 3.2 and 3.3)	1. Collect source activity, ambient air and meteorological data 2. Compare "whole-mine" impact against ISC model	X			Mostly 24 h with some continuous or ~ 1 h running average samples	Spring-Summer 92 Spring-Summer 93
Short-term testing for emission factors (Section 3.1)	1. Focus on individual sources rather than whole mine impact 2. Determine how well individual "steps" in EF/DM approach match with measurements, (e.g., source terms, deposition, dispersion, etc.)		X	X	30 min to 3 h	Spring-Summer 92 Spring-Summer 93
Pit retention (Section 4.2)	1. Measurement method depends on result of checkout study	X[a]			30 min to 3 h	Summer 92

[a] Far-field measurements directed toward source characterization in a mass-balance approach.

This established and widely accepted test methodology for fugitive emission sources is briefly discussed below.

The "exposure profiling" technique for source testing of open particulate matter sources is based on the isokinetic profiling concept that is used in conventional (stack) testing. The passage of airborne pollutant immediately downwind of the source is measured directly by means of simultaneous multipoint sampling over the cross section of the open dust source plume. This technique uses a mass flux measurement scheme similar to EPA Method 5 stack testing rather than requiring indirect emission rate calculation through the application of generalized atmospheric dispersion model.

For measurement of particulate emissions from roads, a vertical network of samplers is positioned just downwind and upwind from the edge of the road. The downwind distance of 5 m is far enough that interference with sampling due to traffic-generated turbulence is minimal but close enough to the source that the vertical plume extent can be adequately characterized with a maximum sampling height of 5 to 7 m. In a similar manner, the 10-m distance upwind from the road's edge is far enough from the source that (a) source turbulence does not affect sampling, and (b) a brief reversal would not substantially impact the upwind samplers. The 10-m distance is, however, close enough to the road to provide the representative background concentration values needed to determine the net (i.e., due to the source) mass flux.

In addition to the source testing measurements described above, this portion of the field work will also consider near-field concentrations and deposition. That is, during source testing periods, additional air samplers and dustfall samplers will be deployed at several distance downwind of the source. To the extent practical, the deposition portion of the proposed study will be designed to augment on-going EPA studies on the subject.

Although the general testing methodology for open dust sources is reasonably well defined, the proposed study will use a "flexible" test schedule described below to best make use of available resources.

The emission factor study will emphasize source testing at mines in the western United States. During the first testing season (spring/summer 1992), the major sources at two mines in the West will be characterized in terms of emission factors. During the next testing season (spring/summer 1993), a third mine will be characterized. This mine may be either an eastern or a western mine. The final decision of the location of "Mine 3" for source testing will be made in conjunction with the EPA technical monitor during the winter of 1992-1993. Two example factors contributing to this decision will be:

- How well did the new emission measurements match with existing emission factors? That is, were some of the current emission factors "validated," or did the need for further study become apparent?

- How well did the first testing season perform in meeting the program's goals of geographic, seasonal, and meteorological diversity? Were data collected under a fairly broad range of operating practices?

(Note: Should an eastern mine be selected for emission factor validation studies during the second testing season, long-term monitoring for dispersion model evaluation during the second year will still be conducted at a western mine.)

In addition to questions involving the third test site location, the proposed "flexible" source field testing approach recognizes that no "hard and fast" decisions on the number of tests or other particulars of the program are possible at this time. For example, if it is found that currently available emission factors appear adequate for Western mines, then the second test season's resources can be redirected to a validation of the factors at eastern surface coal mines (SCMs). On the other hand, the first year's testing results may indicate that the second year's resources would be best directed to a Western mine. This might be true if a thorough reexamination of western SCM emission factors is found necessary, because the second test season provides the third test site recommended in AP-42 emission factor quality rating schemes.

3.2 LONG-TERM MONITORING FOR DISPERSION MODEL EVALUATION

In contrast to emission source testing, there is no well-established protocol for assessing the ambient air quality impact from fugitive sources. For this reason, a considerable effort will be needed to establish and implement an appropriate protocol.

Comparison of measured and modeled concentrations has been a subject of interest to modelers for several years. What is clear in all of the model evaluation studies is that the means by which the models are evaluated is crucial. How does one quantitatively judge the performance of an air quality model? For isolated stack studies, the method endorsed by the EPA compares the maximum measured and modeled concentrations without regard to time or space to allow comparison of one model against another (Cox, 1988). For surface coal mines, however, the location of modeled maxima is crucial because concentrations decrease dramatically with distance from the mine pit. The choice of model receptor locations and measured concentration locations strongly influence whether a model appears to "work" well for surface coal mines or not.

The issues of model performance and model "verification" have been studied extensively for isolated stack sources but have received little attention for fugitive dust sources. (The few prior model evaluations at surface coal mines are discussed in the Appendix.) There is virtually no uniformity between the evaluation approaches used previously. The previous studies have all had to "make do" with the data that were available, and little thought was given to "designing" a study for the purposes of evaluating model performance.

A review of these previous studies, and an understanding of how the Gaussian models function, suggests that the following are desirable features in designing a mine dispersion model evaluation study:

- Time Resolution. The time period over which ambient measurements are made, over which emission rates are computed, and over which source locations are idealized should be as short as practicable. The performance of an air quality model should improve when the input data have better ("finer") resolution. Nevertheless, any analysis of a model's performance in predicting PM_{10} concentrations must consider 24-h time intervals because many mines have more difficulty demonstrating compliance with 24-h rather than annual increments or standards.

- Evaluation Protocol. It is clear that the means by which models are evaluated is crucial. The approaches and statistics used to judge a model's performance are as important (and, possibly, more important) than the input data themselves. The Cox approach (Cox, 1988) is widely used to compare performance of one model to another for isolated stack sources. Use of this same Cox protocol (with a variation to accommodate fugitive dust sources and modeled versus measured concentrations) is desirable.

- Random Error. Quantification of fugitive dust emission rates, use of on-site meteorological data, and model simulations are all subject to random error. The error in any one measurement propagates throughout the process and can adversely affect the comparison of modeled concentrations (Cole et al., 1985). To the extent possible, these random errors must be minimized by employing as many samples and as large a data base as possible. In addition, the use of the robust-highest-concentration (RHC) statistic inherent in the Cox approach helps to overcome random error.

Unlike the studies described in the Appendix, the dispersion model evaluation study proposed here is being designed "from the ground up" and can incorporate all of these features. In updating meteorological data every hour and by tracking source activity and emissions, this model evaluation will achieve far better time resolution than any previous fugitive emissions model evaluation

study. By using a variant of the Cox evaluation approach, this study will conform to accepted statistical practice. Four months of sampling at each of two separate mines overcomes random errors to yield statistically significant results.

In brief, the emission factor and dispersion model methodology will be evaluated as follows. A meteorological station will be installed at the surface coal mine, and a monitoring network will be sited to measure maximum concentrations due both to individual emission sources and to combined sources at the mine. For a period of approximately 4 months, PM_{10} will be measured at each of the monitors in the sampling grid. For the purpose of discussion, there are two basic sampling options available.

"Option A" seeks to combine the best features of the available PM_{10} sampling methods by combining two or three continuous monitors with 6 to 10 high-volume samples and 20 to 30 "saturation" samplers. In this way, a high degree of temporal resolution is accomplished at a few locations within a generally well-monitored geographic area.

Under "Option B," a network of continuous PM_{10} monitors would be established, with the concentration at each monitoring location averaged on a 1-h basis. Although, these monitors provide the finest time resolution possible, they typically require temperature-controlled enclosures and "clean" electric power. The enclosure and power requirements accentuate the high purchase cost of continuous samplers. In summary, continuous monitors provide a very high degree of temporal resolution but can provide adequate spatial coverage only at a very high level of cost.

Throughout the sampling program, field crews will record (a) activity parameters (number of blasts, amount of coal and overburden removed, vehicle miles travelled by mobile equipment, etc.); (b) independent variables related to emission potential (silt, moisture, etc.); and (c) the exact location of emission sources.

The "dynamic" emission inventory maintained over the 4-month period will serve as input to the ISC model. Activity parameters and independent variables will be used in conjunction with available emission factors to compute hourly average particulate emission rates.

A comparison of measured and modeled PM_{10} concentrations, made in accordance with a well-defined evaluation protocol, will determine how well the emission factor (EF) and dispersion model (DM) combination performs. The following subsections describe the various components of the model evaluation study in greater detail.

3.2.1 Model Evaluation Protocol

As explained previously, it is anticipated that the Cox approach will be used as a basis for evaluating model performance. In the Cox approach, the individual fractional bias and the absolute fractional bias will be used to determine whether the ISC model and the emission factors overpredict measured concentrations. Bias is a measure of the overall tendency for the models to over or underpredict the measured values.

Whatever the final sampler selection under Options A and B, a key factor in the dispersion model evaluation process must be the so-called "operational" component. That is, fractional bias statistics will be computed for 24-h averaging periods because that is the time basis for the applicable standards and increments. The operational component thus addresses regulatory concerns.

The "scientific" component, on the other hand, is concerned with a dispersion model's ability to perform accurately throughout a range of meteorological conditions and throughout the geographic area surrounding the emission source. Clearly, the degree to which the scientific component may be assessed depends upon the final selection of Option A or B. Both options afford the opportunity to compute approximately 1-h fractional bias statistics.

Thus, with respect to the model evaluation procedures, the principal difference between Options A and B appears to be the relative importance paid to assessing the scientific component in addition to the operational component.

In virtually all other respects, the rest of the model evaluation protocol will follow the Cox approach. Background PM_{10} concentrations determined from upwind samplers will be subtracted from downwind measured concentrations so that the analysis looks only at mine particulate contributions. Measured and modeled PM_{10} concentrations will be used to determine the robust highest concentrations (RHC), thereby eliminating a great deal of random error. Fractional bias will be used as a basis for comparison because of its attractive attributes (symmetrical, bounded, and dimensionless), and because increasingly it is becoming the standard for comparison for model evaluations. Each of the above is analogous to the Cox approach for single stack sources.

It is expected that the model evaluation protocol will parallel the Cox approach in that concentrations will be compared unpaired in time and space. However, "unpaired in space" takes on a slightly different meaning for surface mines than for isolated stack sources. At a surface mine, the measured and modeled concentrations decrease drastically with distance from the mine (PEDCo 1982) so that the robust highest concentration (RHC) will almost always be at the location closest to the mine in the predominant downwind direction.

3.2.2 Recommended Field Sampling Approach

3.2.2.1 Sampling Equipment

The dispersion model evaluation portion of the proposed study requires monitored air quality values. Earlier, two sampling options were presented:

Option A combines a few continuous samplers with numerous so-called "saturation" samplers. The latter samplers require on the order of 6 to 24 h to collect a sample on a filter. Thus, Option A uses a network of samplers to directly measure the 24-h concentration of regulatory interest and to provide PM_{10} concentrations referenced to other averaging periods ranging from 1 h and up.

Option B uses continuous PM_{10} monitors exclusively to collect far-field samples. In this sampling network, concentrations are referenced to 1-h averaging periods, which are combined to form the 24-h averages needed for regulatory interpretations.

It is recommended that Option A be employed for the proposed field study. This option is viewed as providing the greatest spatial coverage possible at a reasonable cost while still providing the type of data needed to assess the scientific component of the dispersion model. Specifically, the following types of equipment are proposed for the study.

1. Two or three primary monitoring stations, each station with:

   a. A continuous PM_{10} monitor such as a beta gauge or tapered element oscillating microbalance.

   b. At least one each Andersen size-selective-inlet (SSI) and Wedding PM_{10} inlet mounted on a high-volume sampler.

   c. At least one saturation sampler.

   d. A recording meteorological station.

   The different samplers will be colocated. Furthermore, the "whole-air" (i.e., noncontinuous) samplers will be operated over the same time periods. If only one set of high-volume samplers is available, then they will be operated on a 24-h schedule. If more than one of each type is available, then shorter periods (such as 8 and 12 h) are recommended.

   Each of the primary sampling locations will be equipped with a trailer and either a power drop or a heavy-duty diesel generator to provide the

"clean" electrical power needed to operate the continuous monitors. (If generators are used, special precautions will be taken to avoid sample contamination by exhaust.)

2. Approximately 20 to 30 saturation samplers deployed throughout the geographic area downwind of the mine.

This recommended sampling approach permits evaluation of both the operational and the scientific components of a dispersion model evaluation and also provides a spatially thorough monitoring network at a reasonable cost.

The next section discusses how the recommended sampling equipment would be sited to meet the requirements of the proposed study. The stylized mine used as an example in the siting discussion is based on TRC's and MRI's experience at surface coal mines.

3.2.2.2 Sampler Deployment

To adequately test ISC, the model predictions and measured concentrations should be made at the location of the maximum predicted concentration because this is the value of regulatory interest.

For illustration purposes, a stylized power shovel mine is shown in Figure 1. At the example mine, the major sources are found to be coal haul trucks, overburden haul trucks, overburden handling, and overburden dumping. General traffic is also important but is confined to the two roads shown in the figure.

Mining activity rates and locations at the example mine have been evaluated along with the site-specific meteorological data to determine prevailing wind direction and the sampler locations. It is proposed that at least three portable samplers be placed in an arc immediately downwind of the major sources.

Significant mining emission sources are rarely grouped together; rather the sources may be spread over distances on the order of miles. To measure the cumulative effect of separate sources, the model should be tested at not only the points of maximum concentration from individual sources but also at points where the combined effect is greatest. A second set of samplers is placed at the points where emissions from individual sources combine to produce a secondary maximum (Figure 1). To determine what the background contribution is, three additional locations are proposed, placed in upwind and crosswind directions

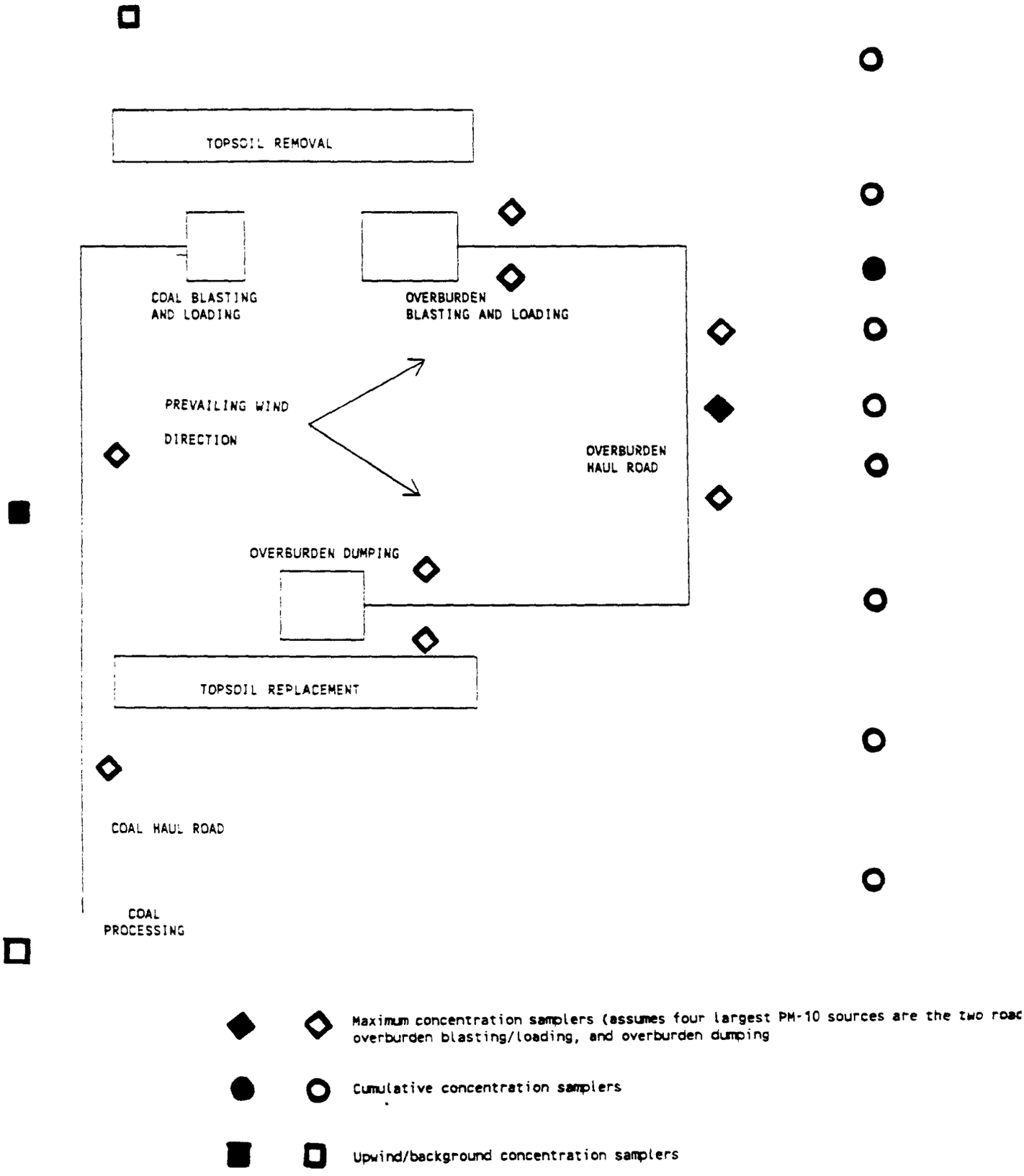

Figure 1. Proposed sampling arrays at a stylized truck-shovel mine. Filled symbols represent primary sampling locations, hollow symbols represent saturation samples.

from the mining activities. It is proposed that roughly half of the saturation PM_{10} samplers be sited to sample combined concentrations.

The exact placement of samplers at the actual mines tested will be a function of both the configuration of the mine and the local meteorology. Until the time that an actual test site decided upon, exact placement of samplers cannot be made.

3.2.3 Source Activity Monitoring

A "dynamic" emissions inventory will be necessary to accomplish the goals of the model evaluation. Unlike most regulatory modeling exercises, which are interested in "annual average" or "worst-case" conditions, this program needs to track actual source activity over time. Source activity levels will be recorded during the entire period that field test crews are present at surface coal mines.

Source extent activity data will be collected with a variety of tools. For example, in addition to visual observation and note taking, video cameras and/or time-lapse photography may be used to determine activity on roads or at other mining sources. For roads and other travel-related sources (such as coal or overburden truck dumps), pneumatic axle counters will be used to supplement other approaches.

The use of a variety of data acquisition methods aids in resolving source activity levels on an appropriate temporal basis. Source activity (both rate and physical location) will be resolved to 4-h or shorter time periods. The 4-h period corresponds to one-half work shift at a mine. Based on MRI's and TRC's experience at coal mines, most emission sources can be viewed as relatively constant in time and space over a work shift. The use of a half-shift as the basic time averaging unit provides a margin of safety. In addition, at the start of each day, the field crew chief will ask the mine superintendent or his designee to describe any unusual events (equipment downtime, etc.) during the past 24 h.

3.3 DATA ANALYSIS AND MODEL EVALUATION

The final task will be to tabulate measured and modeled values and to determine the performance of the ISC model in accordance with the model evaluation protocol discussed earlier to present a "finished product." That is to

say, the interim and final reports will present all data analysis and interpretation of the results, including:

- Comparison of measured and estimated emission factors.
- Any modifications to emission factor models.
- Comparison of measurements and individual steps in the EF/DM methodology.
- Performance (as will be defined in the evaluation protocol) of ISC in assessing the "whole mine" impacts.

SECTION 4

PIT RETENTION

The result of prior pit retention work funded by EPA was a first-cut pit retention algorithm as a function of meteorological and pit dimension data. The available pit retention work suffers from two deficiencies; however. First, the field data upon which the analytical work was based consisted of videotapes of smoke puffs released from inside mine pits, and from these videotapes, opacity (and particulate concentrations) was inferred. Second, the majority of the analytical means of quantifying the effect of pit retention that were derived were very involved, and did not lend themselves to inclusion into the ISC model.

Unlike the studies discussed in Section 3, there is very little technical basis upon which a pit retention field study can be built. Therefore, far more initial effort is required to develop appropriate techniques. Candidate materials and techniques will be evaluated during a "check-out" study.

4.1 "CHECKOUT" STUDY

Dissemination and detection of particulate tracers in appropriate particle size ranges present a formidable technical challenge. For this reason, a preliminary "checkout" study is proposed. This program would be carried out during the fall of 1991 in the general Kansas City area.

The first step in the checkout study involves identification of several candidate tracer materials (such as encapsulated Rhodamine B or other dyes and other less expensive materials) and associated analysis methods. Concurrently, a suitable test site in the Kansas City area will be identified. The site should consist of a parallel road and ridge which are roughly perpendicular to prevailing winds. The ridge should be largely unvegetated; an abandoned or inactive quarry site may be ideal.

Next, methods of releasing the tracer material into the wake of a moving vehicle will be examined. At present, it is anticipated that a simple auger feed in an induced draft may be suitable. In a separate set of experiments to be conducted at MRI's main laboratories, weathering characteristics of the tracer

material will be examined to determine if the material would be acceptable as an "on/off indicator" of wind erosion during the dispersion model evaluation study.

The final step in the checkout study involves near- and far-field air measurements to determine what release rates are necessary and how escape fractions calculated by different measurement approaches compare. Note that a line source arrangement should eliminate difficulties in locating samplers near the plume centerline. To the extent practical, different distances from the ridge to the release point will be examined to determine how the necessary release rate and relative accuracy between the measurement approaches vary as a function of distance to the samplers.

4.2 FIELD PIT RETENTION MEASUREMENTS

In this task the tracer releases will be made and concentrations at the top of the pit will be measured. Meteorological data will be measured and recorded at the surface for subsequent correlation with measured escape fractions. A 10-m meteorological tower and wind speed/direction and radiometer (or ΔT) instrumentation will be positioned in the prevailing upwind location from the pit at surrounding grade. Only one major meteorological instrument tower has been proposed because ISC allows only one set of met data to be input. Recall that one of the site selection criteria requires that the area immediately surrounding a source test site be relatively free of factors influencing wind flow. Recall too that by coordinating tracer studies with the short-term, near-field experiments, concurrent in-pit wind measurements will be obtained.

At present, it is not possible to provide a definitive measurement approach. A major outcome of the "checkout" study will be determination of what techniques provide acceptable accuracy.

4.3 DATA ANALYSIS AND MODEL-BUILDING

The final task in this portion of the work deals with data analysis and development of an algorithm for use with the ISC dispersion model. As was discussed in the preceding section, the interim and final reports will present all data analyses and interpretations, including:

- Comparison of measured escape fractions with estimates from available models (such as the Fabrick and Winges equations).
- Interpretations of measured escape velocity as a function of meteorological conditions and pit/source geometry.
- Recommendation of an algorithm for use with ISC to account for pit retention at SCMs.

REFERENCES

Cole, C. F., and A. J. Fabrick, "Surface Mine Pit Retention," *Journal of Air Pollution Control Association*, V 34, No. 6, p. 674 (June 1984).

Cole, C. F., B. L. Murphy, J. S. Evans, A. Garsd, 1985, "Quantification of Uncertainties in EPA's Fugitive Emissions and Modeling Methodology at Surface Coal Mines," for National Coal Assoc., by TRC Environmental Consultants Inc., Englewood, Colorado (February 18, 1985).

Cole, C. F., J. S. Touma, J. L. Dicke, and K. D. Winges, 1989, "Pit Retention of Particulate Matter at Surface Coal Mines," Paper No. 89-114.5, presented at the 82nd Annual Meeting of the Air & Waste Management Assoc., Anaheim, California (June 25-30, 1989).

Cox, W. M., 1988, "Protocol for Determining the Best Performing Model," U.S. EPA, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina (June 1982).EPA, 1983, "Studies Related to Retention of Airborne Particulates in Coal Mine Pits—Data Collection Phase," Contract No. 68-03-3037, U.S. EPA, IERL, Cincinnati, Ohio (August 1983).

EPA, 1985, "Dispersion of Airborne Particulates in Surface Coal Mines—Data Analysis," EPA-450/4-85-001, U.S. EPA, Research Triangle Park, North Carolina (January 1985).

EPA, 1986, "Continued Analysis and Derivation of a Method to Model Pit Retention," EPA-450/4-86-003, U.S. EPA, Research Triangle Park, North Carolina (January 1986).

EPA, 1990, *Draft Supplement B to the Guideline on Air Quality Models (Revised)*, U.S. EPA, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina (September 1990).

Holzworth, G.C., 1971, "Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States," EPA AP-101, U.S. EPA (May 10, 1971).

MRI, 1991. "Review of Surface Coal Mining Emission Factors," Interim Report, Contract No. 68-DO-0137, Assignment No. 10, U.S. EPA, OAQPS, Research Triangle Park, North Carolina (July 1991).

PEDCo, 1982. "Characterization of PM_{10} and TSP Air Quality Around Western Surface Coal Mines," by PEDCo Environmental, Inc., Kansas City, missouri and TRC Environmental Consultants, Inc., Englewood, Colorado, for U.S. EPA, Air Management Technology Branch, Research Triangle Park, North Carolina (June 1982).

APPENDIX

SYNOPSIS OF PRIOR COAL MINE DISPERSION MODEL EVALUATION STUDIES

SYNOPSIS OF PRIOR COAL MINE DISPERSION MODEL EVALUATION STUDIES

Although model evaluations of isolated point sources are relatively common, model evaluations of surface coal mines are rare. It is instructive to examine the few coal mine model evaluations in order to discover what work has been done, and to determine how mine model evaluations can better be conducted. This appendix discusses the methodology, findings, and shortcomings of the surface mine model evaluations known to the authors.

1. KOMP et al.

SYNOPSIS:

Mark J. Komp and others (Komp et al., 1984) report the findings of a study comparing the performance of the CDM and the ISCLT model used to predict annual average TSP concentrations in the Powder River Basin of Wyoming. The scale of the output was 25 x 40 km (regional scale). Using identical source emission rates and locations, the ISCLT and CDM models were run, and resulting isopleths of concentration were plotted. TSP emission rates were based on permitted production rates at each of six mines in the basin, and for this reason it is likely that modeled concentrations overpredicted actual TSP concentrations because these mines are all permitted for greater production than is actually achieved. The authors found that the ISCLT model and CDM model isopleths were nearly identical, judged in a qualitative sense. Another run of the ISCLT model was made with deposition, and the resulting concentrations were found to be significantly smaller. Comparisons of modeled and measured TSP were made for calendar years 1980, 1981, and 1982 at 11 hi-vols located near the mines. However, it appears that the same meteorological data were used for all three years. Modeled concentrations invariably overpredicted measured concentrations.

COMMENTS:

This study shows the "equivalence" of two long-term Gaussian models. The use of permitted rather than actual production rates likely accounts for the models' overprediction of measured concentrations. Consequently, the findings are of little interest in judging performance of emission factors and models.

TIME RESOLUTION:
- EMISSION RATES: Annual average
- MEASURED CONCENTRATIONS: Annual average
- MET DATA: Annual STAR data

POLLUTANT: TSP
METHOD: Paired in time and space
STATISTICS: None

2. DAILEY, B.

SYNOPSIS:

Bernie Dailey of Wyoming DEQ used actual production data, combined with Wyoming emission factors, and the CDMW and ISCLT models to predict geometric mean annual average TSP concentrations in the Powder River Basin of Wyoming (Dailey, 1984). Various combinations of central wind speed categories, wind speed exponents, available meteorological data sets, and several model refinements were used to compare measured and modeled TSP values at 15 regional hi-vols, for calendar years 1980 through 1983.

In general, the CDMW model tended to underpredict concentrations at receptors far from the mines. Dailey also compared ISCLT and CDMW, finding no appreciable difference in model performance. Despite high correlation coefficients ($r = 0.92$ in some comparisons), Dailey concluded that simple model correction factors would not suffice to improve performance. Instead, he recommended a full examination of emission factors, meteorological data sets, and deposition phenomenon as future investigations. The work in this unpublished review is thorough and well planned—an ambitious undertaking for 1984.

Measured and modeled TSP annual means in all instances were compared with regression plots of geometric mean values, with least square fits and correlation coefficients.

COMMENTS:

Again, this study shows the "equivalence" of two long-term Gaussian models but is restricted to annual average TSP concentrations at hi-vols some distance from the mines. The findings are of limited interest in answering the question "How well do the emission factors/models predict short-term concentrations that would be used to permit a mine?"

TIME RESOLUTION:
- EMISSION RATES: Annual average
- MEASURED CONCENTRATIONS: Annual average
- MET DATA: Annual STAR data

POLLUTANT: TSP
METHOD: Paired in time and space
STATISTICS: Regression analyses; correlation coefficient

3. TRC

SYNOPSIS:

As part of its Emission Factor Development Study (EDS), TRC Environmental Consultants compared long-term (annual average) and short-term (6-h) TSP concentrations with ISCST and ISCLT modeled concentrations near the Belle Ayr Mine in Wyoming (TRC, 1981). The emission rates were computed using TRC's EDS emission factors—in fact, to the extent that the measured and modeled concentrations agreed, the model comparison was viewed as a verification of the emission factors.

Comparison was generally good, although limited data pairs were available. For short-term (6-h) periods, examination of 48 data pairs indicated that agreement of measured/modeled concentrations was "within a factor of two" 41% of the time; and "within a factor of three" for 56% of the pairs. For annual average time intervals, comparison of annual average TSP measured at 4 hi-vols near the Belle Ayr Mine is extremely good—all annual average measured and modeled concentrations agreed within a few micrograms per cubic meter over a range of 24 to 68 $\mu g/m^3$.

The major drawback to the study is that it used the EDS emission factors, which have not gained widespread use and which have not been subject to review. TRC had the definite advantage of having detailed on-site activity parameters and independent variables for the study. In fact, the use of activity data and emission factors which were measured at the very same mine from which the verification study was performed certainly helps the model/emission factor performance, but raises doubts about the representativeness of the model comparison findings.

COMMENTS:

The fact that the emission factors and the model test data were derived from the same mine casts doubt on the findings. Use of both short-term and annual average concentrations is welcome. The fact that the EDS emission factors have not been widely used detracts from the usefulness of this model performance study.

TIME RESOLUTION:
- EMISSION RATES: 6-h values
- MEASURED CONCENTRATIONS: Annual average and 6-h
- MET DATA: On-site hour-by-hour; on-site STAR data

POLLUTANT: TSP
METHOD: Paired in time and space
STATISTICS: Regression analyses; correlation coefficient

4. TRC (confidential)

SYNOPSIS:

A comparison of measured and modeled PM_{10} and TSP concentrations at a Midwestern surface coal mine over a 5-month period was performed in an unpublished, confidential study (TRC, 1986). The ISC model and the AP-42 emission factors were used as a basis, and 120 individual days were examined at five different sampling locations. PM_{10} concentrations at the mine averaged about one-third the magnitude of the TSP values. Great care was taken in locating source locations individually for every day of the test period, and PM_{10} and TSP emission rates were similarly computed on a daily basis.

TSP concentrations were overpredicted slightly on average; PM_{10} values were severely overpredicted on average. Individual 24-h values showed a large degree of scatter. The overpredictions were attributed to ISC's failure to properly account for particle deposition (as opposed to settling) in the ISC model. However, the locations of all of the samplers were sufficiently close to the mine sources that the study was not a good test of deposition—insufficient travel distance between sources and samplers would not permit deposition to reach equilibrium.

COMMENTS:

This study is an improvement over prior comparisons in that it strives to examine short- and long-term concentrations of both TSP and PM_{10}, and it uses 24-h resolution of source emission rates and source locations. However, the large scatter in individual short-term results is discouraging; and the fact that the study has not been released minimizes its usefulness to the modeling community.

TIME RESOLUTION:
- EMISSION RATES: 24-h values
- MEASURED CONCENTRATIONS: 5-month average and 24-h
- MET DATA: On-site hour-by-hour

POLLUTANT: TSP and PM_{10}
METHOD: Paired in time and space
STATISTICS: Regression analyses; correlation coefficient; scatter plots

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1 REPORT NO EPA-454/R95-008	2	3 RECIPIENT'S ACCESSION NO
4 TITLE AND SUBTITLE Development of a Plan For Surface Coal Mine Study		5 REPORT DATE October 28, 1991 6 PERFORMING ORGANIZATION CODE
7. AUTHOR(S)		8 PERFORMING ORGANIZATION REPORT NO
9. PERFORMING ORGANIZATION NAME AND ADDRESS Midwest Research Institute Kansas City, Missouri		10 PROGRAM ELEMENT NO. 11 CONTRACT/GRANT NO
12. SPONSORING AGENCY NAME AND ADDRESS Emission Factor and Inventory Group (MD-14) Emissions Monitoring and Analysis Division Office of Air Quality Planning and Standards U. S. Environmental Protection Agency Research Triangle Park, NC 27711		13. TYPE OF REPORT AND PERIOD COVERED 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

This report outlines the steps and considerations involved in developing test plans and protocols for improving emission factors for western surface coal mines in response to requirements of Section 234 of the Clean Air Act of 1990.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES 43
	20. SECURITY CLASS *(This page)*	22 PRICE

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE