MRI REPORT

Survey of Construction/Demolition Open Source Regulations and Dust Control Plans

For U.S. Environmental Protection Agency
Industrial Studies Branch, ESD (MD-13)

EPA Contract 68-02-4395
Assignment No. 48
MRI Project No. 8987-K(48)

September 25, 1990

MIDWEST RESEARCH INSTITUTE 425 Volker Boulevard, Kansas City, MO 64110-2299 • (816) 753-7600

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For U.S. Environmental Protection Agency
Industrial Studies Branch, ESD (MD-13)
Research Triangle Park, North Carolina 27711

Attn: Wm. Larry Elmore, P.E.

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PREFACE

This report was prepared for the U.S. Environmental Protection Agency, under Work Assignment 48 of EPA Contract No. 68-02-4395. Mr. Wm. Larry Elmore, P.E., of the EPA's Industrial Studies Branch served as technical representative. The report was prepared by Dr. Gregory E. Muleski and Ms. Deann K. Hecht who are members of the Air Quality Assessment Section in the Institute's Engineering and Environmental Technology Department.

Approved for:

MIDWEST RESEARCH INSTITUTE

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

September 25, 1990

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SECTION 1

INTRODUCTION

Open dust sources at construction and demolition (CD) sites contribute significantly to ambient PM10 (particulate matter less than or equal to 10 microns in aerodynamic diameter) concentrations in many areas of the United States. Besides emissions associated with on-site activities--such as materials handling and vehicular traffic--substantial amounts of dust may result from the reentrainment of mud and dirt tracked out from the site and deposited onto nearby public paved roads.

While the potential importance of particulate emissions from CD sites has long been recognized by U.S. Environmental Protection Agency (EPA) and other air pollution control agencies, relatively little has been done to regulate dust from these sites. Although emissions may be broadly classified as "nuisance dust," relatively few pollution control agencies have specifically addressed this source category.

This report presents an example regulation for the control of dust emissions at CD sites. The example is partially the result of a review of certain existing and draft regulations. The EPA intends that the example serve as a format that state and local control agencies could use in developing their own regulations.

Because the example regulation requires preparation of a formal dust control plan, example plans are also presented in this report. Each plan is presented in sufficient detail to instruct readers in the preparation of their own plans.

The example dust control plans presented in Section 4 make use of the following four construction/demolition "scenarios:"

Scenario 1. This example considers the erection of a 20-story building in a busy downtown area (see Figure 1). The site is fenced off and only one access point is used by vehicles entering or leaving the site. The access road is scheduled to be paved near the end of the construction. Table 1 summarizes additional details of the construction project.

(Note that throughout this report common English units--such as miles, feet, and tons--are used. This approach has been taken because persons preparing dust control plans for CD sites will probably be more familiar with this system of units than with the metric system.)

Scenario 2. In this example, suburban housing is being developed in two phases (see Figure 2) on a 20-acre site. No material will be transported off-site nor will any other "foreign" fill material be brought in during a 40-working day site preparation period. Present plans call for preparing the entire 20 acres. After site preparation, 20 homes will be built over a 7-month period (150 working days) in the area west of Suburban Drive; the remaining half of the prepared site will be left alone. Another 20 homes will be constructed during a second period which is scheduled to begin one year from now. Table 2 summarizes other details of the project.

Scenario 3. The multiyear construction of a limited access roadway in an urban area is the subject of this example (see Figure 3). Traffic enters and leaves the site by the ramp shown in the figure. Table 3 presents details of the construction project for the time period of interest for this example. Note that, because of the long duration and changing nature of roadway construction, a month-long period is considered in this example rather than the entire project.

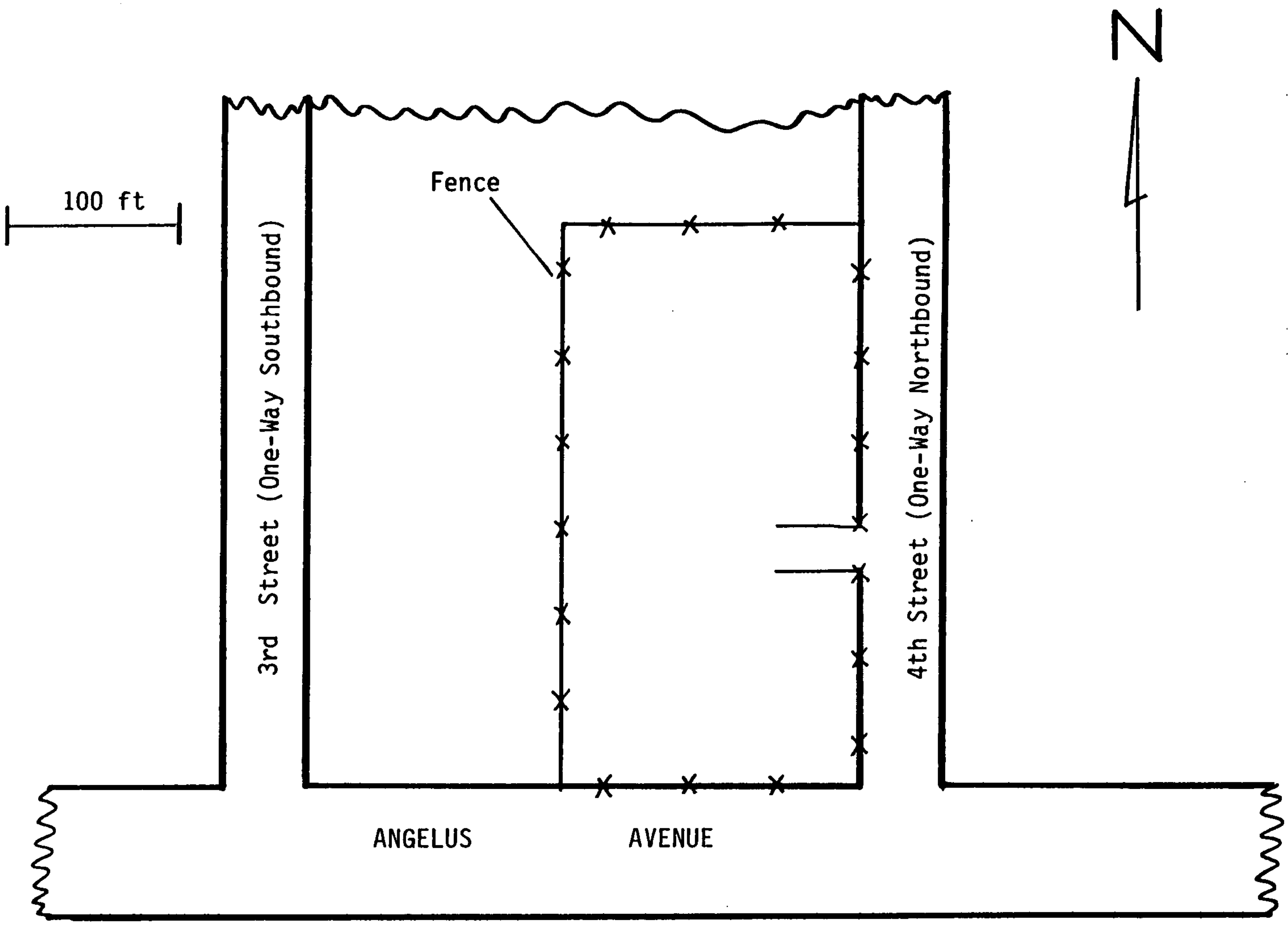

Figure 1. Hypothetical construction site in Scenario 1.

TABLE 1. DETAILS ABOUT SCENARIO 1

Total area disturbed:	1.2 acres
Duration of the excavation phase:	20 workdays, 30 calendar days
Volume of material excavated and hauled:	5,000 ton/workday
Haul truck net capacity:	15 ton
Average haul travel distance on site (round trip):	150 ft
Average haul truck speed on site:	15 mph
Number of wheels on haul truck:	10
Tare weight of haul truck:	20 ton
Duration of construction phase:	8 months, 160 workdays, 240 days
Total vehicles entering site:	40/workday[a]
Traffic rate on 4th Street:	5,000 ADT (average daily traffic)

[a] After the excavation phase; includes cement mixers, structural steel and other deliveries.

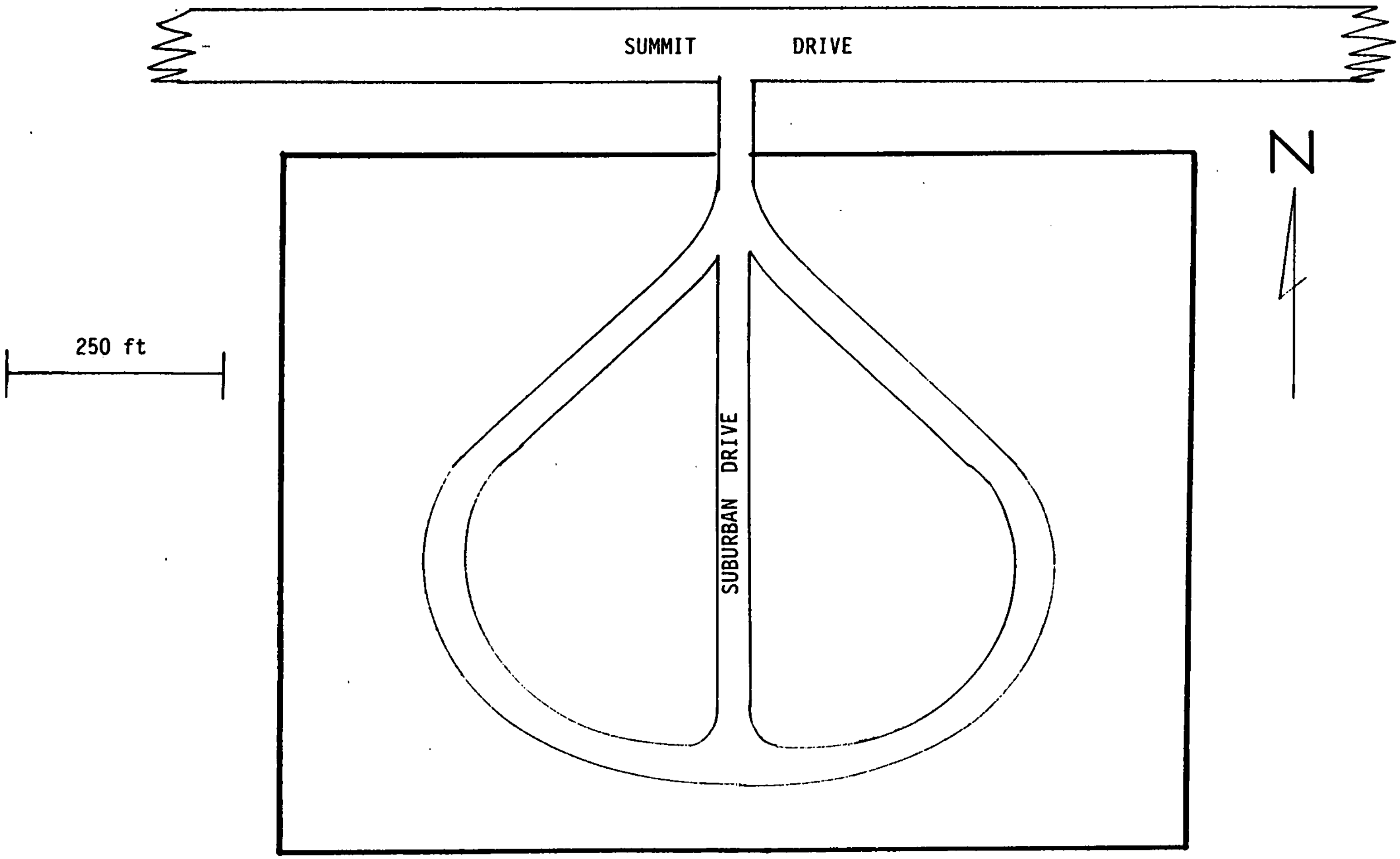

Figure 2. Hypothetical construction site in Scenario 2.

TABLE 2. DETAILS ABOUT SCENARIO 2

Duration of site preparation:	40 workdays, 60 calendar days[a]
Total area disturbed:	20 acres
Number of scrapers in use:	2
Hours each scraper used per workday:	8
Average travel speed of scraper:	5 mph
Number of dozers in use:	3
Hours each dozer used per workday:	8
Duration of construction (first 20 homes):	150 workdays, 7 months
Total area disturbed:	10 acres
Total vehicles entering site:	40
Traffic rate on Summit Drive:	6,000 ADT

[a] Time required to prepare entire 20-acre site.

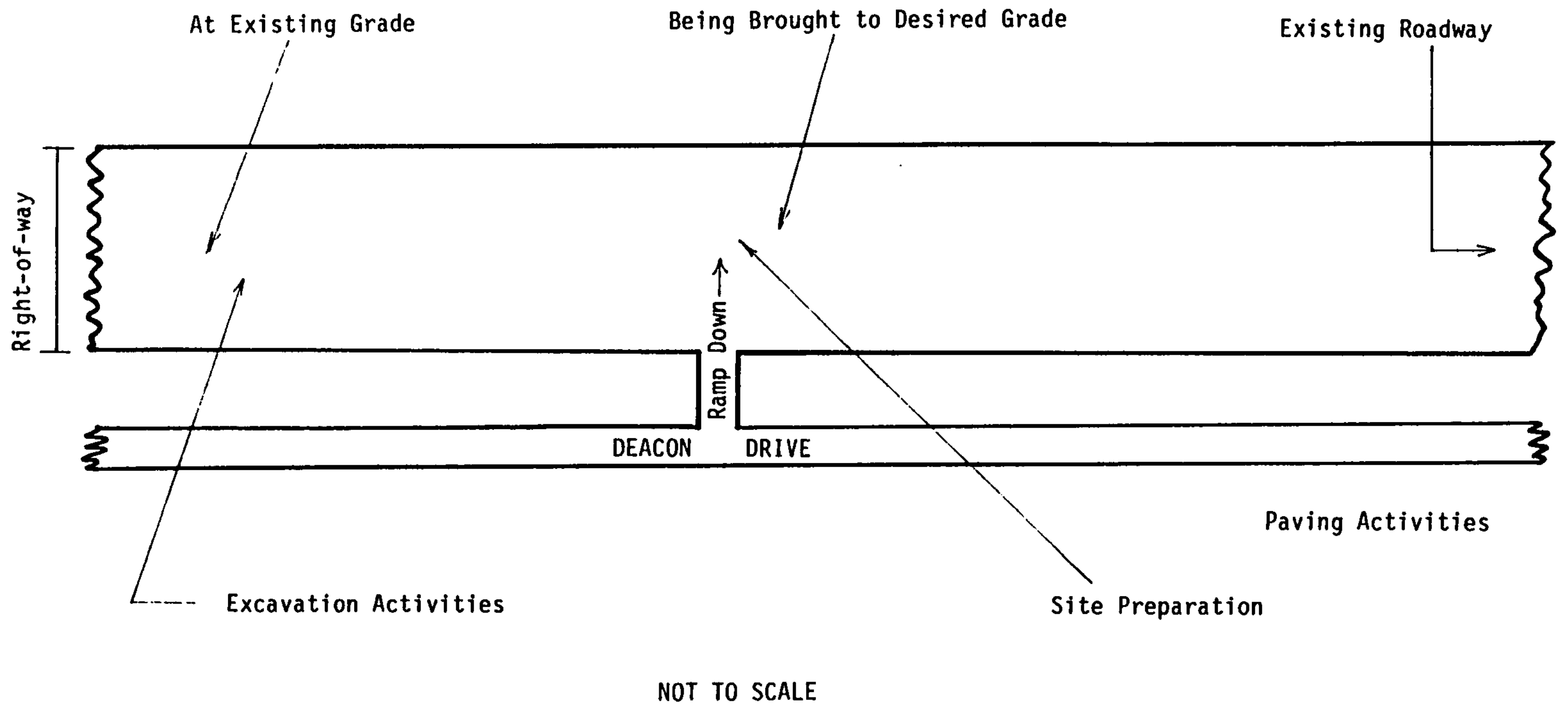

Figure 3. Hypothetical construction site in Scenario 3.

TABLE 3. DETAILS ABOUT SCENARIO 3

Total area disturbed in base month:	15 acres
Workdays in base month:	21
Number of scrapers in use:	4
Hours each scraper used per workday:	9
Average travel speed of scraper:	5 mph
Number of dozers in use:	2
Hours each dozer used per workday:	9
Volume of material excavated and hauled off-site:	5,000 ton/workday
Haul truck net capacity:	20 ton
Average haul travel distance on-site (round trip):	1,700 feet
Average haul truck speed on-site:	15 mph
Number of wheels on haul truck:	18
Tare weight of haul truck:	20 ton
Daily traffic rate on Deacon Drive:	7,500 ADT

Scenario 4. This example is concerned with the demolition of a 10-story building at the site shown in Figure 4. Note that only emissions occurring after dismemberment of the structure are of concern in this example. Access to the site will entail use of an unpaved travel surface. Additional details are presented in Table 4.

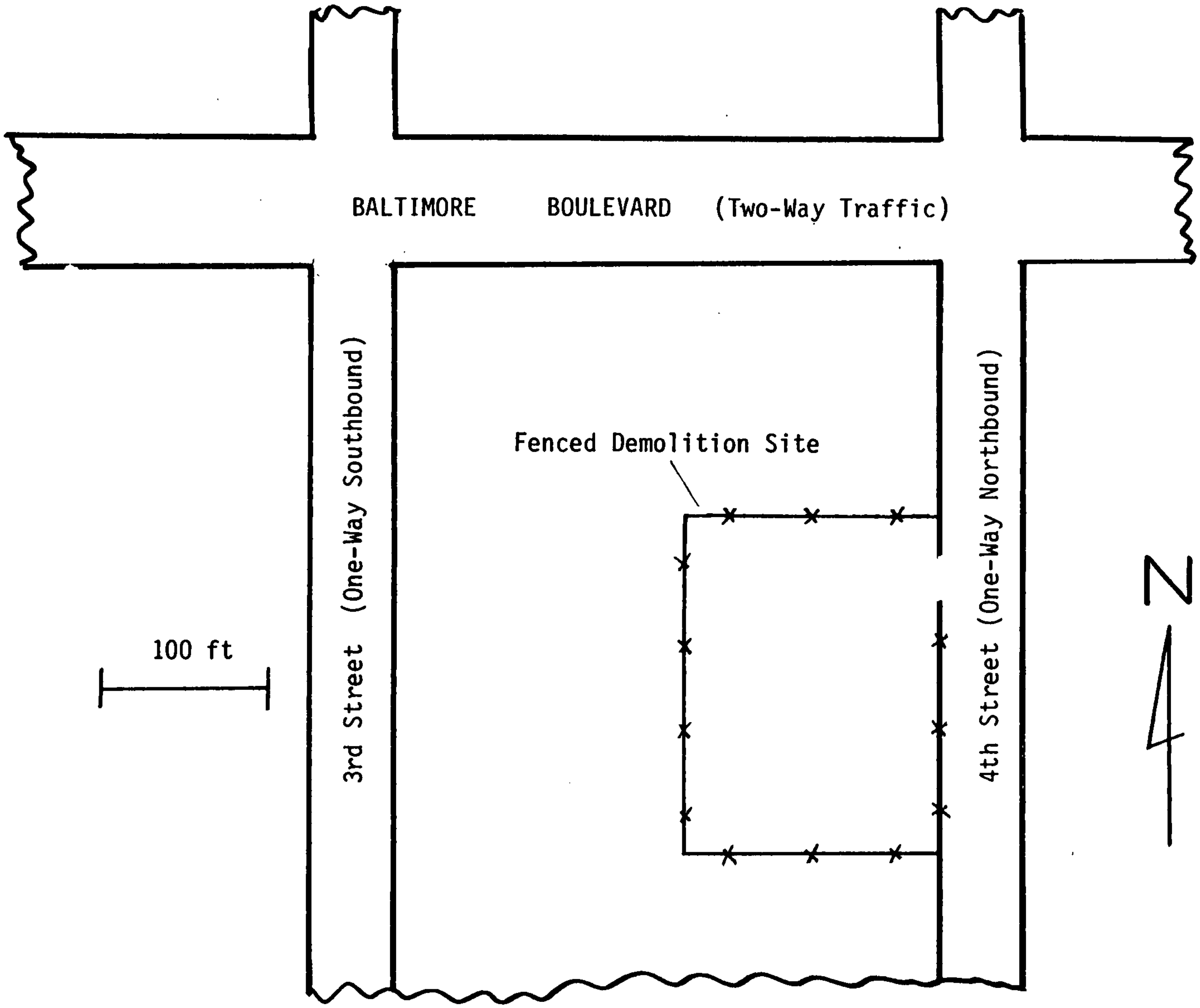

Figure 4. Hypothetical demolition site in Scenario 4.

TABLE 4. DETAILS ABOUT SCENARIO 4

Floorspace to be demolished:	50,000 sq ft
Duration:	1 week, 5 workdays
Haul truck capacity:	20 tons
Average haul travel distance on site (round trip):	250 ft
Average haul truck speed on site:	15 mph
Number of wheels on haul truck:	10
Tare weight of haul truck:	20 ton

SECTION 2

REVIEW OF AVAILABLE INFORMATION

This section provides an overview of construction and demolition (CD) processes as related to the generation of dust emissions and describes regulations used by various state and local agencies to control those emissions.

2.1 SURVEY OF EXISTING CONSTRUCTION/DEMOLITION DUST REGULATIONS

Virtually all construction and demolition emission sources could be considered as being regulated under existing nuisance or fugitive dust rules which are common throughout the country. In this way, agencies could require emission reductions from construction sites visited as a result of citizen complaints. However, given the potential magnitude of CD emissions, it is probable that agencies would find routine and systematic reductions in this source category to be effective in achieving certain air quality goals. Nevertheless, without regulations that directly address CD activities and provide an oversight role for the local agency, systematic control of emissions is unlikely.

Table 5 summarizes the major points of four recent regulations directed to construction activities (note that the San Joaquin rule is not yet final). In three, some type of plan to control dust becomes either a condition of an air regulatory permit (such as a permit to disturb topsoil) or an attachment to a separate building permit issued by another government body.

TABLE 5. SUMMARY OF EXISTING CONSTRUCTION/DEMOLITION REGULATIONS

Regulation II, Rule 200 and Regulation III, Rule 310--Maricopa County Department of Health Services, Division of Public Health, Bureau of Air Pollution Control
(both regulations revised 7/13/88)

General Description:	Rule 210 states that earthmoving for commercial purposes requires a permit from the Control Officer. Rule 310 prohibits no construction and demolition "without taking reasonable precautions to effectively prevent fugitive dust from becoming airborne."
Exceptions:	None are explicitly stated. Noncommercial (such as homeowner or public agency) activities do not require a permit, although reasonable precaution requirement in Rule 310 would still apply.
Other Points:	Rule 310 defines reasonable precautions as including the "daily removal of earth or other material that has been tracked or transported onto paved streets by trucking or earthmoving equipment." Note that this could be construed as not requiring cleaning at employee parking lots, contractor villages, or other access points not used by trucks. The "effectiveness of ... reasonable precautions" monitored by a visible opacity technique.

Section 17--District Board of Health of Clark County (Las Vegas, Nevada)
(revised 4/23/87)

General description:	Permit system to disturb topsoil, including construction activities, addition or removal of dirt or fill. (Note: clearing and grubbing included in same provision.) Permit required for the "destruction, demolition or removal" of any structure at least 1,000 sq ft in area.
Exceptions:	Size limitation of 0.1 hectare (one-quarter acre). Requirements also not intended to apply to agricultural operations or landscaping by a person at his/her residence.

(continued)

Other points:	While a term such as "dust control plan" is not specifically used, Section 17.5.1.2 requires that applicant present and agree to implement "an acceptable method to prevent particulate matter from becoming airborne." Written description of operating practices not usually required. Air pollution control officer (APCO) may require posting of a surety bond in an amount between $500 and $20,000. Applicant is responsible for ensuring contractors and/or subcontractors abide by conditions of permit. Application specifically mentions mud/dirt trackout. No explicit definitions of terms given in the regulation itself.

Section 040.030 of Amendments to Regulations of the Washoe County (Nevada) District Board of Health (adopted November 22, 1989)

General Description:	In general, any person engaged in dismantling or demolition or buildings or public or private construction "shall take all reasonable precautions to prevent the generation of dust." A dust control plan must be submitted to and approved "before topsoil is disturbed on any project where more than one (1) acre of surface area is to be altered or where the natural surface area is removed." (In practice, Board of Health usually takes lead in preparation of the plan, based on information submitted in response to a questionnaire.) Jurisdictions issuing building permits refer contractors to Board of Health offices. In addition, "any vehicle operating on a paved roadway with a load of dirt, sand, or gravel susceptible to being dropped, spilled, leaked or otherwise escaping therefrom, must be covered to prevent spillage." Covering not required if six (6) inches of freeboard is maintained or if the material contains "enough moisture to control dust emissions."
Exceptions:	Commercial agricultural operations are specifically excepted from the permit requirement. Minimum project size of one (1) acre. Also, the regulation does not prohibit a public maintenance vehicle from depositing sand to enhance traction or sprinkling water to clean and maintain the surface.

(continued)

TABLE 5. (continued)

Other points: APCO may require (a) submission of soils data; (b) specific control measures (including phased land clearing or palliatives); (c) that paved entry aprons or other means be used to control trackout. Terms used are not explicitly defined in Section 040.030.

Regulation VIII--Unified San Joaquin Valley Air Basin Authority
(draft dated May 3, 1990)

General Description: For any one of a variety of regulated activities, a written "PM10 (dust) Prevention and Control Plan" shall be submitted to the APCO within 1 or 2 years (depending on the size of operation) of the initial adoption of Regulation VIII. Plans are to be formally reviewed every three years. In addition, three years of records of control applications must be maintained, submitted upon request and be open for inspection during unscheduled audits.

Requirements specific to construction and demolition (Rule 801) include: (a) prevention or removal (at least daily) of any visible accumulation at trackout points; (b) an overall, average PM10 reduction of 25%, automatically increasing 25% every three years to a maximum of 75%; (c) stabilization of any disturbed surface within 3 days of the "cessation of surface disturbance;" and, (d) upon completion or an interruption of greater than 30 days, the disturbed surface is to be controlled "to the conditions existing prior to surface disturbance." Note the use of quantitative control efficiency goals.

Exemptions: Activities exempted from provisions of the regulation are: (a) disturbed areas (other than roads) of less than one (1) acre; (b) construction or demolition activity with a floor plan of less than 10,000 sq ft; (c) any construction or demolition activity that meets the following:

i. occurs entirely within an enclosed structure with no visible emissions

ii. modifications to residential dwellings

iii. movement of less than 250 cubic yards of dirt

(continued)

TABLE 5. (continued)

Other Points:	In addition to Rule 801 for construction and demolition, draft regulation contains five other rules directed at bulk material handling, landfilling operations, open or staging areas, paved and unpaved roads. Regulation defines 30 terms used.

While all three are written as requiring the applicant to prepare some type of dust control plan, there may be substantial differences in practice. For example, Clark County generally requires only that the general type of control (e.g., water truck, sprinklers, or chemical sealants) be described in the permit application. No formal written plan is usually required, although applicants with relatively large projects may be asked (on a case-by-case basis) to submit additional information.

Washoe County takes a much more active role in preparation of control plans. Applicants complete a "generic" questionnaire from which a Health Department employee develops the control plan. The Health Department outlines any "special conditions" in the transmittal letter for the permit. These special conditions usually deal with how many pieces of equipment are required rather than frequency of application or other operating practices.

On the other hand, the draft San Joaquin regulation's approach to control plans is quite different. First, the draft defines the PM10 prevention and control plan to be a written document identifying measures or strategies to "prevent, reduce, or control" emissions. Plans are to include schedules as well as provisions to monitor the performance of the controls. Furthermore, the setting of quantitative goals for control efficiency is tantamount to requiring controlled and uncontrolled emission inventories. Finally, the regulation gives recordkeeping requirements and establishes the interval for formal review for the plan.

It is impossible to know how provisions in the draft regulation will be implemented in practice. Nevertheless, it is important to discern the trends in rulemaking and to incorporate desirable features of both existing and draft rules. The example given in Section 3.0 (a) requires a written control plan; (b) establishes a schedule for formal periodic review of the plan; and (c) specific recordkeeping requirements on the part of the permittee as evidence of control application.

The three agencies requiring some form of control plan in Table 5 exempt certain operations on the basis of a minimum area of interest. Exceptions are also made for enclosed CD activities, small floor plans, and certain homeowner activities, such as landscaping or remodeling. Example exemptions are given in the rule format presented in Section 3.0. Also, for greater clarity, a set of definitions are included in the example regulation.

It is believed that decisions such as

- Drafting a regulation specific to CD as opposed to incorporating rules in an overall fugitive dust regulation

- Having the air regulatory agency issue a permit versus attaching a control plan to a building permit

- Requiring the applicant to prepare the control plan rather than using agency personnel

are best left to the discretion of the local agency. The Section 3.0 example regulation has been written in general terms to provide agencies that flexibility.

Features not found in Table 5 have been incorporated into the example regulation. For example, the use of agency-supplied forms is required for recordkeeping; it is believed that this would simplify agency inspection procedures. In addition, at least one on-site inspection conducted by the APCO or his/her designee is required to encourage a more structured inspection process than may be common in certain jurisdictions.

2.2 DUST EMISSION SOURCES AT CONSTRUCTION AND DEMOLITION SITES

Prior to discussing generic dust emitting activities, it is necessary to identify the following three "phases" in the construction/demolition process:

Phase I. Demolition Debris Removal, during which the debris of any existing man-made structures or natural obstructions is removed from the site. Thus, this phase includes the removal of debris from implosion or mechanical dismemberment of a building as well as from blasting of rock formations.

Phase II. Site Preparation, during which the ground surface at the site is brought to final or near-final grade. Thus, this phase includes on-site cut and fill operations as well as the transport of cut material off-site and the receipt of "foreign" fill materials.

Phase III. Construction, which includes the other major construction activities, such as flatwork, structural and reinforcing steel operations, interior finishing, and landscaping.

Three points should be noted. First, the division of the construction process into three phases is certainly arbitrary in that arguments can be made to include other phases or to move certain operations from one phase to another. For example, one could easily argue that rock blasting is better characterized as "site preparation" rather than "demolition." Here, the intention is to define a series of sequential phases, involving "unit operations" with similar equipment and, hence, relatively similar emission estimation procedures. Second, all three phases need not occur at a single construction site. Finally, only emissions due to debris removal operations, rather than the actual demolition process, will be considered in the following sections.

2.2.1 Dust-Generating Activities During the Demolition Phase

As mentioned above, only the emissions associated with the removal of debris during the demolition phase were considered as part of the scope of this report. Note that a recommendation is made in Section 3.0 that a special permit or a variance be issued for dust emissions during the actual demolition.

Two sources of dust emissions are associated with debris removal: (a) handling of the debris, with eventual placement into trucks, and (b) transport of the material from the site.

Phase I, Unit Operation A (debris loading): Both AP-42[1] and the recent EPA guidance manual[2] present the following equation by which emissions from debris loading could be estimated:

$$E = 0.0011\ (U/5)^{1.3} / (M/2)^{1.4} \qquad (2\text{-}1)$$

where: E = PM10 emission factor expressed as pounds of emissions per ton of debris handled (lb/ton),

U = mean wind speed (mph) at 4-meter height, and

M = moisture content (%) of the debris being loaded.

The following default values are suggested for use when site-specific information is unavailable:

Default wind speed (U) = 10 mph
Default debris moisture content (M) = 0.5 %

These values have been chosen to yield conservatively high emission estimates, in the absence of site-specific data. Finally, the mass of debris resulting from building demolition may be estimated by assuming that 1 sq ft of floor space results in 0.046 ton of debris.

Phase I, Unit Operation B (Transport of Debris): The following equations may be used to estimate emissions due to truck transport of debris:[1,2]

$$E = 2.1\ (s/12)\ (S/30)\ (W/3)^{0.7}\ (w/4)^{0.5}\ (365-p)/365 \qquad (2\text{-}2)$$

where: E = PM10 emission factor expressed as pounds of emissions per vehicle mile traveled (lb/vmt);

s = surface silt content (%); portion of road surface material less than 200 mesh;

S = mean vehicle speed (mph);

W = mean vehicle weight (ton);

w = mean number of wheels per vehicle; and

p = mean number of days with at least 0.01 inch of precipitation (see Figure 5).

for travel on an unpaved surface, and

$$E = 0.77\ (sL/0.35)^{0.3} \qquad (2\text{-}3)$$

where: E = PM10 emission factor expressed as pounds of emissions per vehicle mile traveled (lb/vmt); and

sL = surface silt loading (oz/sq yd); mass of material less than 200 mesh per unit area of road surface

for travel on a paved surface. The following default values are suggested for truck transport of debris:

Default unpaved surface silt content = 12%

Default haul truck speed = 20 mph

Default haul truck weight = 1.5 x truck capacity (ton), or, tare weight (ton) plus one-half of capacity (ton)

Default number of wheels per haul truck = 10

Default number of days with precipitation = 0 for short term projects, or, value taken from Figure 5

Default paved surface silt loading = 0.35 oz/sq yd

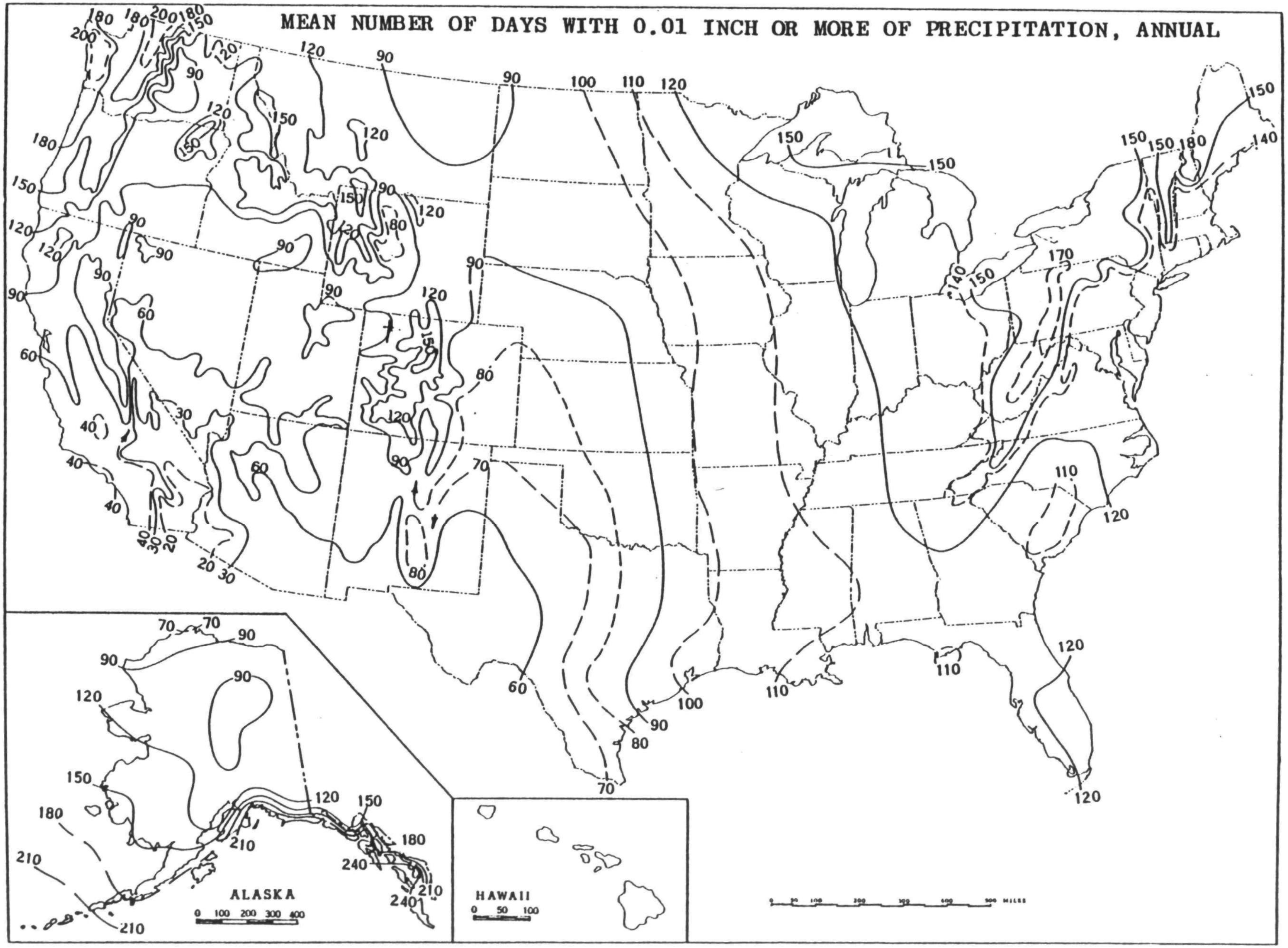

Figure 5. Mean annual number of days with at least 0.01 in of precipitation. Patterns are too complex in Hawaii for inclusion on map. (Means for Hilo, Honolulu, and Lihue are 148, 204, and 90 days per year, respectively).[3]

As before, these values have been chosen to yield relatively conservative emission estimates in the absence of site- specific data.

2.2.2 Dust-Generating Activities During Site Preparation

Dust emissions can occur during the following portions of the site preparation phase: (a) bulldozing of earth; (b) pan scraper operations, such as topsoil removal and general earthmoving; (c) truck haulage of cut or fill materials, and (d) material handling of cut or fill materials. The following sections discuss applicable emission estimation procedures.

Phase II, Unit Operation A (bulldozing): The following equation is recommended for bulldozing emission estimates:[1,2]

$$E = 0.74\ (s)^{1.5} / (M)^{1.4} \quad (2\text{-}4)$$

where: E = PM10 emission factor expressed as pounds per hour of dozer operation (lb/hr);

s = surface silt content (%); and

M =surface moisture content (%);

In the absence of site-specific data, the following default values are suggested to yield conservative emission estimates:

Default surface silt content = 12%

Default surface moisture content = 5%

Phase II, Unit Operation B (pan scrapers): The following emission factor is recommended for scraping operations:[2]

$$E = 4.2\ \text{lb/mile} \quad (2\text{-}5)$$

where: E = PM10 emission factor expressed as pounds per scraper mile traveled (lb/mile).

Phase II, Unit Operation C (Truck Haulage): Equations (2-2) and (2-3) may be used to estimate emissions due to truck transport of cut and fill material on paved and unpaved roads, respectively. The following default values are suggested for truck transport involving travel off-site (i.e., hauling cut material away from the site or "importing" fill material).

Default silt content = 12%

Default haul truck speed = 20 mph

Default haul truck weight = 30 tons

Default number of wheels per haul truck = 10

Default surface silt loading = 0.35 oz/sq yd

For transport entirely on-site (i.e., using "off highway" trucks, such as Euclids or model 769 Caterpillars), the following default values are suggested:

Default silt content (U) = 12%

Default haul truck speed = 20 mph

Default haul truck weight = 45 tons

Default number of wheels per haul truck = 6

Default surface silt loading = 0.35 oz/sq yd

These values have been chosen to yield conservative emission estimates in the absence of site specific data.

Phase II, Unit Operation D (Cut/Fill Material Handling): Equation (2-1) is the recommended means by which emissions from material handling is estimated:[1,2]

$$E = 0.0011 \, (U/5)^{1.3} \, / \, (M/2)^{1.4}$$

where: E = PM10 emission factor expressed as pounds of emissions per ton of material handled (lb/ton);

U = mean wind speed (mph) at 4-meter height; and

M = moisture content (%) of the material being handled.

The following default values are suggested to yield conservative emission estimates for earthmoving, in the absence of site-specific data:

Default wind speed (U) = 10 mph

Default moisture content (M) = 5%

2.2.3 Dust Emissions During Construction

The following emission factor has been recommended to estimate emissions from remaining construction activities (Phase III):[4]

$$E = 3.6 \text{ lb/acre/work hour} \qquad (2\text{-}6)$$

where: E = PM10 emission factor expressing mass of emissions per unit area disturbed per working hour.

No default values are considered necessary because the size and duration of construction project should be known at the time a permit is sought.

Note that no "unit operations" (such as material handling or travel on unpaved surfaces) have been included in this discussion of construction phase dust emissions. This is primarily due to the form of the available emission factor (Equation [2-6]). The factor was developed from perimeter monitoring of many sources, rather than near-field source testing of an individual "unit" source.

In many respects, however, this is not a limitation. For example, the two previous phases can be relatively accurately estimated and scheduled. This phase usually involves the receipt of many deliveries (such as concrete, structural steel, and other building materials as well as landscaping items later in the process); many of these arrival times are difficult to accurately forecast. Equation (2-6) thus provides a method to estimate construction phase estimates in spite of this uncertainty. Should applicants believe that they can accurately predict average daily traffic levels and route lengths together with activity levels for other unit operations during Phase III, then they may use Equations (2-2) and (2-3) as well as the other emission factors presented above to estimate emissions.

2.2.4 Mud/Dirt Trackout

In addition to on-site activities discussed above, substantial emissions are possible because of material tracked out from the site and deposited onto adjacent paved streets. Because all traffic (and not just that related to construction) on the paved road can suspend the deposited material, this "secondary" source of emissions may be far more important than all the dust sources located within the construction area. Furthermore, this secondary source is present during all phases of construction.

If N represents the daily number of vehicles entering or leaving an unpaved access point to a paved road, then the quantity E in the following[2]

$$E = \begin{cases} 0.012 & \text{for } N \leq 25 \\ 0.029 & \text{for } N > 25 \end{cases} \qquad (2\text{-}7)$$

represents the unit PM10 increase in lb/vehicle due to trackout. If M represents the daily traffic volume on the paved road, then E x M represents the PM10 emission rate (in pounds per day) for trackout.

2.2.5 Wind Erosion

In addition to mechanically generated dust emissions, emissions may occur from cleared land and material stockpiles during high wind events. Section 11.2.7 of the EPA document AP-42 presents an estimation methodology for PM10 wind erosion sources. In its simplest form, the estimation technique can be written as[1]

$$E = p1 + p2 + p3 + \ldots + pN \tag{2-8}$$

where:
- E = annual PM10 emission rate due to wind erosion;
- N = number of disturbances in a year; and
- pi = erosion potential (mass per unit area) corresponding to the observed (or probable) fastest mile of wind for the i-th period between disturbances.

The erosion potential for a dry surface is found by the expression

$$p = \begin{cases} 29(u^* - u^*t)^2 + 12(u^* - u^*t) & \text{for } u^* > u^*t \\ 0 & \text{for } u^* \leq u^*t \end{cases} \tag{2-9}$$

where:
- p = PM10 erosion potential (g/m^2);
- u^* = wind friction velocity (m/s); and
- u^*t = threshold friction velocity (m/s).

Additional details on the method can be found in Section 11.2.7 of AP-42. Because the method can prove to be cumbersome when long-term (i.e., seasonal, annual) emission estimates are desired, the algorithm has been included in the computer model package described in EPA-450/3-90-010.[4] Readers are encouraged to use this computer package when wind erosion estimates are needed.

It is important to recognize that wind erosion emissions are much less "certain" than emissions from, say, material handling or vehicle travel. That is, while one can be reasonably confident that dust will be generated from the mechanical activities, erosion only occurs when the windspeed exceeds a threshold value. It is possible that the threshold may not be exceeded during the sometimes short time periods of interest in construction and demolition. The implications of this uncertainty on determining control efficiency and emission reductions are discussed in Section 2.3.6.

2.3 CONTROL OF OPEN DUST SOURCE EMISSIONS AT CONSTRUCTION AND DEMOLITION SITES

The previous section described dust generating activities at CD sites; this section discusses the control techniques applicable to those activities. Table 6 presents a summary of recommended controls for CD activities. In keeping with general EPA guidelines, the use of preventive rather than mitigative controls is emphasized in the following discussion.

2.3.1 Control Methods for Material Handling Operations

There are two fundamental dust control measures for material handling operations: (a) sheltering from the wind and (b) wet suppression. These options act to either reduce the numerator or increase the denominator in Equation (2-1). In either case, the predictive equation may be used to determine the control efficiency as

$$CE = 100 \times (Eu - Ec)/Eu \qquad (2\text{-}10)$$

where: CE = average control efficiency in percent;

Eu = "uncontrolled" emission factor from Equation (2-1); and

Ec = "controlled" emission factor from Equation (2-1).

The wind speed near a material handling operation may be reduced by portable screens, fences, or any other type of flow obstruction (either natural or man-made). Because barriers could be easily built with labor and materials on

TABLE 6. CONTROL OPTIONS FOR CONSTRUCTION/DEMOLITION OPEN SOURCES OF PM10

Phase/Unit operation[a]	Emission source	Recommended control methods
I/A	Loading of Debris	Windspeed reduction, wet suppression (Section 2.3.1)
I/B	Transport of Debris[b]	Wet suppression, paving, chemical stabilization[c] (Section 2.3.2)
II/A	Bulldozing	Wet suppression[d] (Section 2.3.3)
II/B	Pan Scrapers	Wet suppression (Section 2.3.3)
II/C	Cut/Fill Haulage	Wet suppression, paving, chemical stabilization (Section 2.3.2)
II/D	Cut/Fill Handling	Wind speed reduction, wet suppression (Section 2.3.1)
III	General Construction	Wind speed reduction, wet suppression, early paving of permanent roads (Section 2.3.4)
All phases	Mud/Dirt Trackout	Early paving of permanent roads, cleaning of aprons, truck cleaning devices, covered loads (Section 2.3.5)
All phases	Wind Erosion	Chemical stabilization, vegetative cover, wind speed reduction (Section 2.3.6)

[a] Operations and phases as described in Section 2.2 of this report.

[b] Loads should be covered to avoid loss of material in transport.

[c] Chemical stabilization usually cost-effective for relatively long-term or semipermanent unpaved roads.

[d] Excavated materials may already be moist and not require additional wetting.

site, it is clear that this control measure is feasible at virtually all sites of interest in this report.

Similarly, wet suppression is a generally feasible control measure for CD sites, because most sites have access to some source of water. For projects that do not have an abundant source of water (such as road construction in rural parts of the west), the feasibility of wet suppression must be determined on a case-by-case basis.

For sites with water, a variety of mechanisms may be used to add to the moisture content of materials being handled at construction sites. (While additives such as surfactants might be added to plain water, the use of foam is not recommended in most CD situations because materials are not repeatedly transferred.) Water cannons are easily added to water trucks that may already be used to control roadway dust at the site. Spray systems with varying geometries could be readily fabricated, assuming that pressurized water is available.

Finally, it is imperative that dust control plans contain some precautions to be taken against compounding effects of watering programs on trackout problems. For example, loadout emissions can be virtually eliminated by soaking the material being transferred. However, it is clear that overly wet material may leak from endloaders or transfer trucks, thus providing yet another means for trackout beyond the site boundary.

2.3.2 Control of Vehicle-Related Dust

Unpaved Surfaces: The often short time periods of interest for CD sites may require that unpaved roadway dust control be viewed differently than in other industries. In general, the most cost-effective means of reducing unpaved road dust is either to pave or to chemically stabilize the road surface. Clearly, the high costs for paving or chemical treatment would not be warranted for temporary construction roads and travel surfaces. While temporary travel areas could be improved with a material with a lower silt content, it is possible that future landscaping plans would preclude that option. In that instance, wet suppression (either by watering or applying materials such as hygroscopic salts) would represent the preferred control option for temporary roads.

Once again, it is imperative that dust control plans contain provisions to protect against enhanced trackout as an undesired consequence of a roadway watering program.

When projects involve the construction of permanent roads (industrial parks or subdivisions, for example), paving at the earliest possible time represents an effective means of controlling unpaved road dust. Early paving also provides a buffer (which may be cleaned as needed) to control trackout onto more heavily traveled public streets. In addition, this can be a very economical control measure, as the permanent roads would be an already budgeted item.

The control efficiency afforded by paving may be calculated using

$$CE = 100 \times (Eu - Ec)/Eu \qquad (2\text{-}11)$$

where: CE = average control efficiency in percent;

Eu = "uncontrolled" emission factor for the unpaved road from Equation (2-2); and

Ec = "controlled" emission factor for the paved road from Equation (2-3)

It is recommended that the default silt loading (sL) value given earlier be used to determine the "controlled" emission factor. Regulatory agencies may choose to provide their own sL values for applicants to use.

Two methods are available to assess the effectiveness of wet suppression of unpaved road emissions. The first is an empirical model for watering, as described in EPA-450/3-88-08:

$$CE = 100 - (K)(P)(D)(T)/(I) \qquad (2\text{-}12)$$

where: CE = average control efficiency in percent;

K = constant equal to 0.00087 for annual conditions or equal to 0.0012 for worst-case (summer) conditions;

P = evaporation value (inches) taken from Figure 6;

D = average hourly daytime traffic rate (vehicles/h);

I =water application intensity (gal/sq yd); and

T = time (h) between applications.

While this model should be used only for plain water (i.e., no additives), the second estimation method may be used for any type of wet suppression. Figure 7 shows that, between average uncontrolled moisture content and a value twice that, a small increase in moisture content results in a large increase in the control efficiency. Beyond this, however, control efficiency increases very slowly with additional moisture. Note that the ordinate in Figure 7 is <u>instantaneous</u> rather than average control efficiency. This point, as well as the general use of both methods, is illustrated in the example control plans.

In the event that a site involves semipermanent unpaved roads (as might be the case for roadway construction), then chemical stabilization becomes much more cost-effective. Figure 8 presents a method that may be used to estimate the time-averaged control efficiency due to repeated applications of chemical dust suppressants. Several points should be noted about this figure and its use:

1. The term "ground inventory" used as the ordinate for the figure is a measure of residual effects from earlier applications. Ground inventory is found by adding together the total volume (per unit area) of concentrate (not solution) applied since the start of the control program.

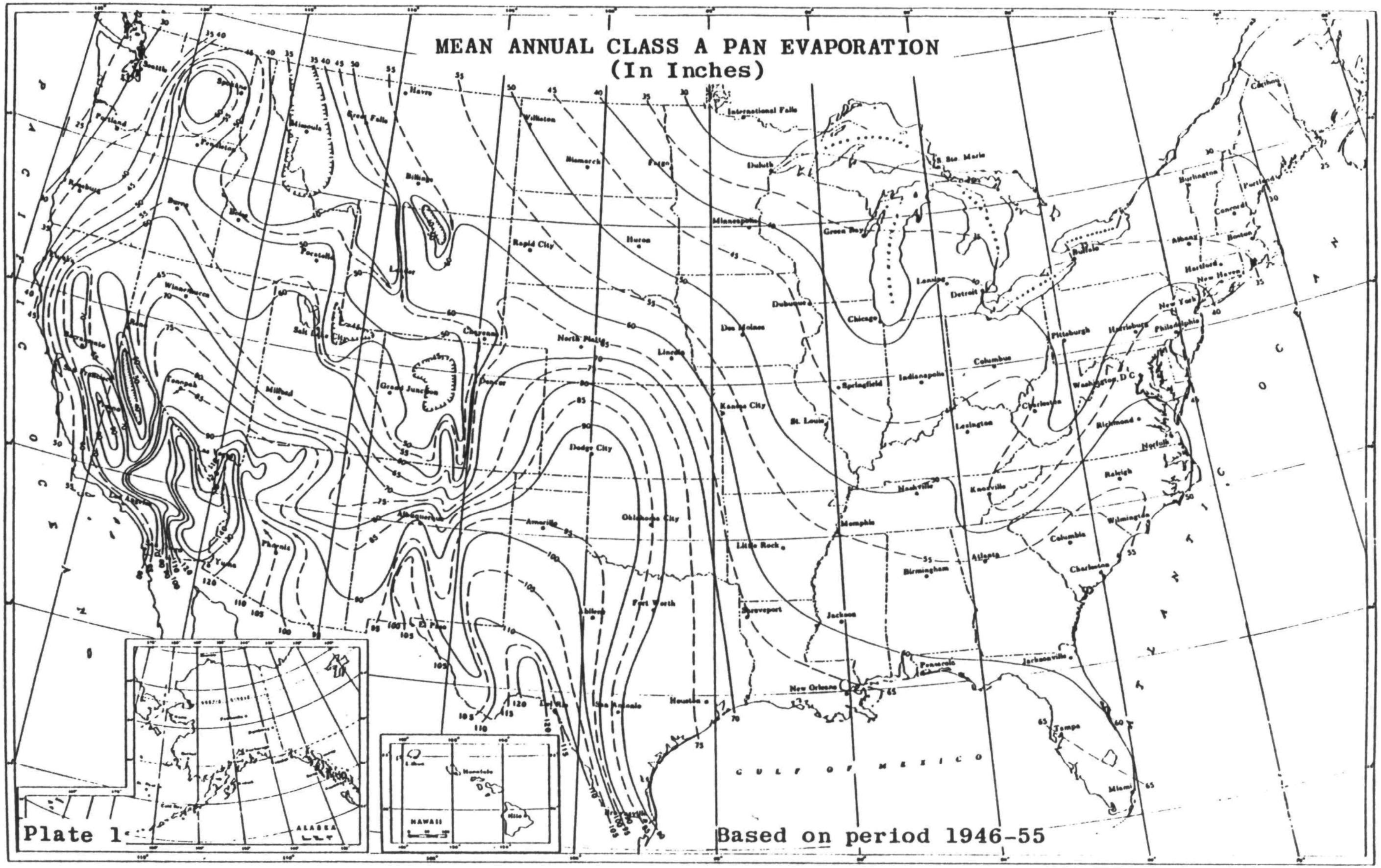

Figure 6. Annual evaporation data for the contiguous United States.[3]

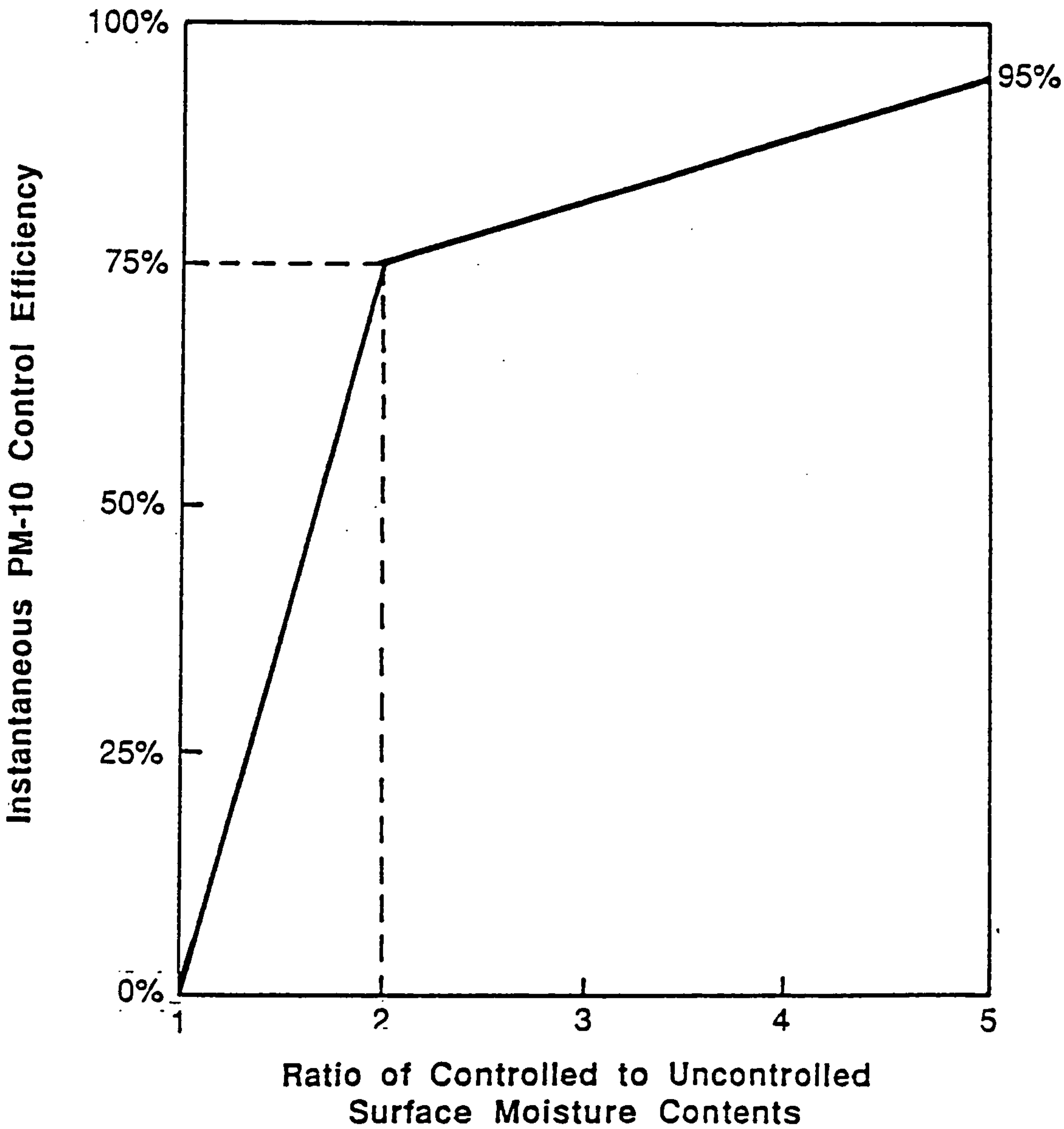

Figure 7. Watering control effectiveness for unpaved travel surfaces.

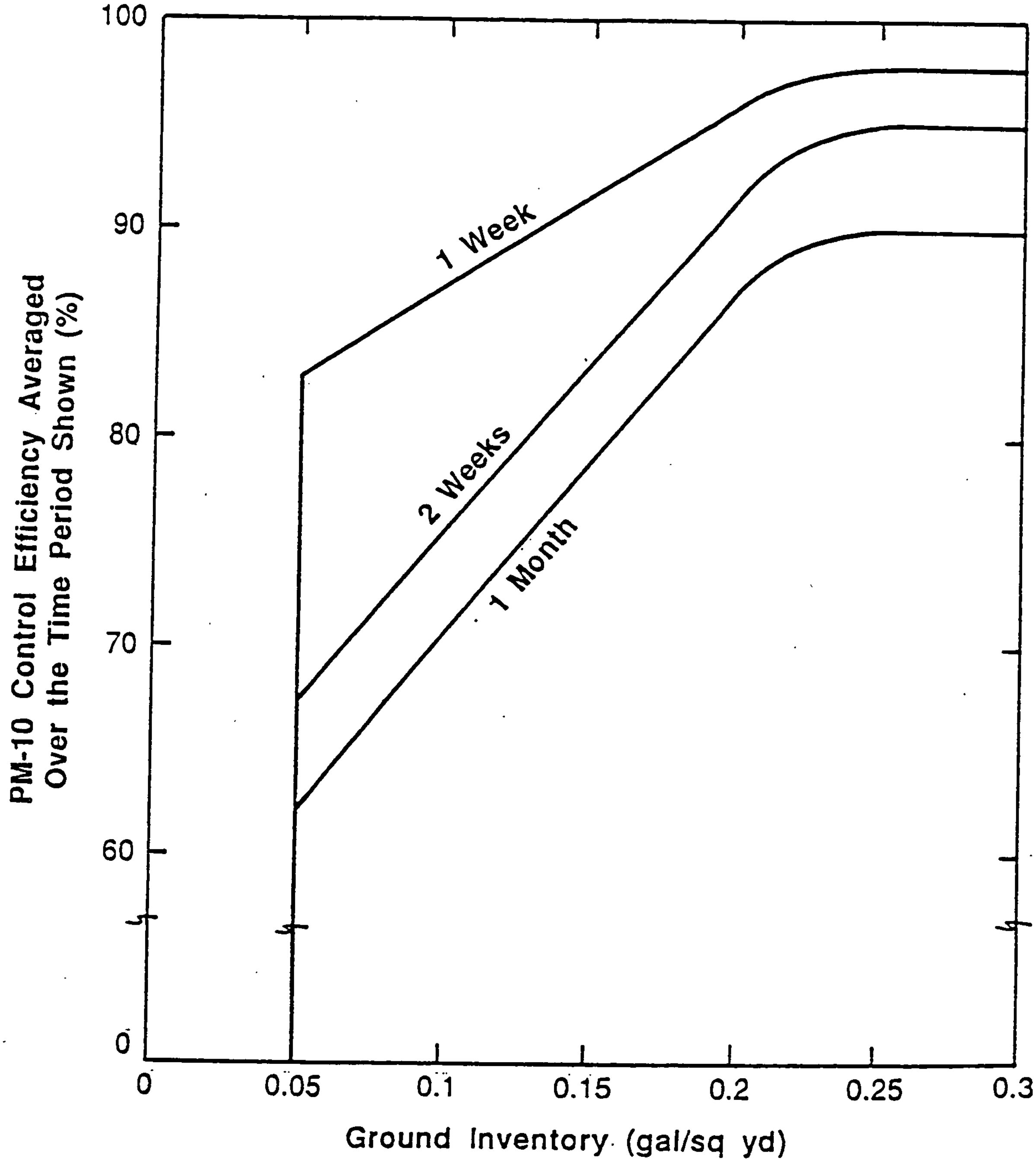

Figure 8. Average PM10 control efficiency for chemical suppressants.

2. No credit is given for ground inventory values less than 0.05 gal/sq yd.

3. The figure is based on an average of four suppressants considered in an earlier field study. The basis of the methodology lies in a similar model developed for petroleum resins only.

The use of this figure is illustrated in the roadway construction example given in Section 4.3.

Paved Surfaces: Paved travel surfaces represent a more difficult dust source to control than do unpaved surfaces. Because the emission factor depends on silt loading, available control measures attempt to decrease the amount of material present on the surface. It is very important to note that, because the exponent in Equation (2-3) is less than unity, a reduction in silt loading is not accompanied by as large a reduction in the emission factor. That is, a control that is 90% effective in reducing silt loadings a paved surface is only 50% effective in reducing the PM10 emissions.

Paved road controls may be viewed either as "preventive," in that the control seeks to prevent material from being deposited onto a surface, or as "mitigative," with the purpose of removing material that has already been deposited. While the current EPA policy emphasizes prevention, because CD sites are localized and intensive sources of road loading, both preventive and mitigative measures are considered feasible. As discussed in EPA 450/3-88-008, there are no generally available methods by which the efficiency of preventive controls can be estimated. Methods to estimate the efficiency of common mitigative measures are summarized in Table 7.

2.3.3 Control of Site Preparation (Phase II) Emissions

For two of the four dust-generating operations under Phase II--namely, material handling and truck haulage--the control techniques described in Sections 2.3.1 and 2.3.2 apply. The other two operations deal with the

TABLE 7. ESTIMATED METHODS FOR AVERAGE EFFICIENCY VALUES FOR PAVED ROAD CONTROLS[a]

Control	Average efficiency, C (%)[b]	Comments
Vacuum sweeping	$C = \begin{cases} 34, & D \le 2 \\ 68/D, & D > 2 \end{cases}$	340 m^3/min (12,000 cfm) blower tested
Water flushing	$C = \begin{cases} 69\text{-}0116\ V, & V \le 299 \\ 10{,}300/V, & V > 299 \end{cases}$	Water applied at 2.2 L/m^2 (0.48 gal/yd^2)
Water flushing followed by broom sweeping	$C = \begin{cases} 96\text{-}0.132\ V, & V \le 365 \\ 17{,}500/V, & V > 365 \end{cases}$	Water applied at 2.2 L/m^2 (0.48 gal/yd^2)

[a] Based on PM15 field emission measurements as given in Reference 2. PM10 efficiency may be assumed equal to that for PM15.

[b] In the expressions, D and V represent the number of days or vehicle passes, respectively, since application.

movement of recently disturbed earth, which may have a relatively high moisture content.

With the exception of watering particularly dusty materials, no additional controls are recommended for bulldozers and pan scrapers. The control efficiency of watering bulldozer operations may be estimated by comparing emission factors resulting from different moisture contents in Equation (2-4). For scraping operations, it is recommended that one of the two (i.e., either Equation [2-12] or Figure 7) methods described for unpaved road watering under Section 2.3.2 be used to estimate the control efficiency.

2.3.4 Control of Emissions During Construction (Phase III)

Recall from the earlier discussion of this phase that the generally available emission factor does not make use of "unit operations" and that it is usually not possible to accurately forecast daily operating conditions. Consequently, it is generally not possible to prepare detailed control plans for this phase. It is recommended, however, that at a minimum plans contain provisions for the control of unpaved travel surfaces and staging areas as well as for trackout (see below).

2.3.5 Control of Mud/Dirt Trackout

Because this dust source occurs outside the site perimeter, the choice of control measures may be highly dependent upon the physical setting of the CD site. For example, construction within a busy urban corridor may preclude not only the use of paved "buffer zones" but also routine cleaning of public streets adjacent to the site. In that situation, then, prevention of trackout by early paving and subsequent routine cleaning of access areas may be the only viable control option. For construction in other areas, on the other hand, a mitigative approach may be more successfully used to clean up material that has already reached the street. As a rule of thumb, it is recommended that local and state agencies strongly encourage the use of preventive (i.e., controls applied on the construction site) techniques rather than mitigative measures that remove material which has already left the site boundaries.

As noted in EPA guideline documents, quantification of the control efficiency for preventive measures is impossible using the standard before/after approach. EPA-450/3-88-008 presents a method of estimating upper bounds of emission reductions that is essentially identical to Equation (2-7) and then suggests that regulatory agencies assign some effective level of control. For example, daily manual cleaning of an access area could be associated with, say, 25% control while the use of paved aprons or buffers together with routine cleaning of those paved areas might be given an efficiency of, say, 90%. It is recommended here that local agencies (1) establish nominal efficiency values for preventive trackout controls and (2) focus on visual measures of trackout control performance during site inspections.

2.3.6 Control of Open Area Wind Erosion

Earlier it was noted that, compared to other emission sources, (a) applicants will find wind erosion emissions substantially more difficult to estimate and (b) reductions in this source are far less "certain." For these reasons, it is recommended that wind erosion emissions not be included in determining CD site emission reductions and overall average control efficiency. However, it is strongly recommended that local agencies require that disturbed earthen surfaces be stabilized against air and water erosion within a fixed period of time after the disturbance. This recommendation is included in the example regulation of Section 3.

Suitable surface stabilization may be accomplished with water chemical suppressants, by the addition of larger aggregate ("momentum partitioning"), or through the establishment of vegetative cover. Ground cover is usually cost-effective at construction sites, and its general use is recommended.

SECTION 3

EXAMPLE REGULATION

This section presents an example CD regulation that state and local air regulatory agencies may use as a model. The example (as presented in Table 8) is largely based on features found during the review of existing and draft regulations (see Section 2.1).

Several points should be noted about the example:

1. First, the example presents only a skeleton of a regulation which must be "fleshed out" for use. For example, agencies will need to decide if dust control plans are to be attached to building permits or if a separate air regulatory permit is to be issued.

   Similarly, it is important that regulators have legal counsel rephrase the example for consistency with state and local laws. Table 8, for example, only prohibits persons from "allowing" certain situations; many agencies will need to supplement this with verbs such as "cause" or "permit." Also, no specific mention of fees or penalties is made.

2. The example regulation contains several blank lines for items such as the minimum size of areas to be considered or time periods within which control must be applied. Agencies need to determine an appropriate value for each blank.

TABLE 8. EXAMPLE REGULATION

Section 100--General

101 Purpose--To reasonably regulate construction and demolition activities that release particulate matter emissions to the ambient atmosphere

102 Applicability--This regulation applies to all construction and demolition activities within the ________'s jurisdiction unless specifically exempted below.

Section 200--Definitions

For the purpose of this regulation, the following definitions apply

201 APCO (Air Pollution Control Officer)--The person heading the (agency) or any of his/her designees.

202 Applicant--The individual, public and/or private corporation, or any other legal entity preparing the dust control plan described in Section 301.

203 Chemical Stabilization/Suppression--A means of dust control implemented by any person to mitigate PM10 emissions by applying petroleum resins, asphaltic emulsion, acrylics, adhesives, or any other APCO-approved materials.

204 Construction/Demolition Related Activities--Any on-site mechanical activities preparatory to or related to the building, alteration, rehabilitation, or demolition of an improvement on real property, including but not limited to: grading, excavation, loading, crushing, cutting, planing, shaping, or breaking.

205 Disturbed Surface Area--A portion of earth's surface, or materials placed thereon, which has been physically moved, uncovered, destabilized, or otherwise modified, thereby increasing the potential for emission of fugitive dust.

206 Dust Suppressants--Water, hygroscopic materials, chemical stabilization/suppression materials (see definition 203), and other materials not prohibited for use by the Environmental Protection Agency or any other applicable law, rule, or regulation, as a treatment material to reduce PM10 emissions.

207 Fugitive Dust--The particulate matter entrained in the ambient air which is caused from man-made and natural activities such as, but not limited to, movement of soil, vehicles, equipment, blasting, and wind. This excludes particulate matter emitted directly in the exhaust of motor vehicles, other fuel combustion devices, from portable brazing, soldering, or welding equipment, and from pile drivers.

(continued)

208 Lot--A designated parcel, tract, or area of land established by plat, subdivision, or as otherwise permitted by law, to be used, developed, or built upon as a unit.

209 Open Area--An unsealed or unpaved motor vehicle parking area, truck stop, vacant lot, or any other disturbed surface area located on public or private property which is subject to wind erosion, and is a source of PM10 emissions.

210 Paved Surface--An improved street, highway, alley, public way, easement, or other area that is covered by concrete, asphaltic concrete, asphalt, or other materials specified by the APCO.

211 PM10--Particulate matter with an aerodynamic diameter smaller than or equal to a nominal 10 microns as measured by the applicable Federal reference method.

212 (PM10 Dust Prevention and) Control Plan--A written document that describes dust emission sources present at the site and identifies the means and strategies used to reduce the emissions.

213 Site--The real property upon which construction/demolition activities occur.

214 (Surface, Soil) Stabilization--The process used to mitigate PM10 emissions for an extended period of time by applying petroleum resins, asphaltic emulsion, acrylics, adhesives, or any other APCO-approved material or physical stabilization by vegetation or the addition of aggregate material to the surface.

215 Traffic Volume (ADT)--The average daily traffic (ADT) is the number of vehicle trips on a paved or unpaved surface during a 24-h period. The ADT value for a publicly owned road shall be determined according to the regulations of the public agency responsible for that road.

216 Unpaved Surface--Any surface not defined as paved in definition 210 above.

Section 300--Prohibitions/Requirements

301 No person shall engage in any construction/demolition related activity (as defined above) without having an APCO-approved PM10 dust prevention and control plan, unless exempted below. This control plan will be in writing and, at a minimum, will

(continued)

TABLE 8. (continued)

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1. briefly describe construction/demolition activities to be performed at the site that will produce PM10 dust emissions. These dust-generating activities shall include, but not be limited to

   I. Removal of Obstructions (Natural/Man-made)

      a. Transfer of the debris into vehicles for haulage
      b. Transportation of the debris on-site
      c. Additional transfers of the debris (if on-site, as for fill material)

   II. Preparation of the Site

      a. Bulldozing and scraping operations
      b. Truck transportation of materials (such as "imported" fill) on-site
      c. Transfers of materials

   III. Construction Operations

      a. Traffic on paved surfaces and staging areas
      b. Traffic on unpaved surfaces and staging areas

2. present estimated uncontrolled PM10 emission rates for each activity and summarize the total uncontrolled PM10 emissions expected.

3. describe the control measures (if any) to be applied to each activity and estimate the corresponding controlled emission rate for each activity

4. estimate the overall efficiency of the control plan by comparing the total controlled emissions to total uncontrolled emissions. **(Note that the APCO may choose to prescribe a minimum target overall efficiency for the control plan.)**

The applicant is responsible for ensuring that each contractor or subcontractor working at the site adhere to the provisions of the dust control plan.

The APCO shall make available for inspection examples of approved dust control plans at the offices of _______.

301 Unless specifically exempted below, no person shall allow any visible accumulation of mud, dirt, dust, or other material from the paved roads including paved shoulders adjacent to the site where construction/demolition activity occurs. The methods used to prevent accumulation as well as the scheduled frequency must be addressed in the dust control plan.

(continued)

302 Unless specifically exempted below, disturbed surfaces may not be allowed to remain in an unstabilized state. Disturbed surfaces must be stabilized against wind and water erosion within ___ calendar days after the disturbing activity ceases. In no event shall a disturbed area be allowed to remain unstabilized for a period greater than ___ calendar days. The method(s) used to stabilize the surface shall be described in the dust control plan.

303 As evidence of control application, the applicant shall keep dust control records on agency-supplied forms. These forms will be included with the APCO's written approval of the applicant's dust control plan. Records are to be kept current, be submitted upon the request of the APCO, and be open for inspection during unscheduled inspections.

304 For construction projects with a duration of at least ____ calendar days, the APCO shall perform at least one on-site inspection. Prior to this scheduled inspection, the APCO may require the applicant to furnish information or other records.

305 For construction projects with a duration of at least ____ calendar days, the APCO will formally review the dust control plan within ____ calendar days of the on-site inspection.

Section 400--Exemptions

The following are specifically exempted from the provisions of this regulation:

401 Construction/demolition activity involving a floor plan of less than _____ sq ft

402 Any construction/demolition meeting the following activity levels or requirements:

1. occurring entirely within an enclosed structure from which no visible airborne particulate matter escapes;
2. modifications to residential dwellings by the owner/occupant that do not require building permits;
3. movement of less than _____ cubic yards of dirt;

403 Disturbed surface areas of less than ______ acre.

(continued)

TABLE 8. (continued)

404	The implosion or mechanical dismemberment of any structure. (Note, however, that this activity may be subject to regulation ________, which requires a permit or variance to be granted.)
405	Blasting of rock or other earthen materials in conjunction with construction/demolition activities. (Note, however, that this activity may be subject to regulation ________, which requires a permit or variance to be granted.)

3. As noted in the example, dust emissions resulting from mechanical dismemberment or implosion of an existing structure or from blasting of rock are not covered by the regulation. However, it is recommended that agencies provide additional phrasing referring to a separate permit or variance to cover this type of emission source.

4. Readers are reminded that the regulation given in Table 8 is meant solely as an example and is intended only to provide a general framework around which regulations may be developed. Agencies should freely add or delete material as appropriate for their jurisdictions.

SECTION 4

EXAMPLE DUST CONTROL PLANS

This section presents example dust control plans based on the four "scenarios" introduced in Section 1 of this report. Refer again to Tables 1 through 4 and Figures 1 through 4 for more details.

4.1 SCENARIO 1

This example deals with the construction of a 20-story building in a busy downtown area. The site is fenced off and only one access point is used by vehicles entering or leaving the site. The access road is scheduled to be paved near the end of the construction.

4.1.1. Uncontrolled Emissions

Phase I, Debris Loadout. Five thousand (5,000) tons of excavated material are removed each day. Geologic site investigations have estimated the soil moisture to be 6%. That value, together with the default wind speed for Equation (2-1), results in a daily PM10 estimate rate of

0.0011 (10/5)^1.3 / (6/2)^1.4 lb/ton x 5000 ton/work day = 2.9 lb/day

Phase I, Truck Transport. Because the trucks in Table 1 have a net capacity of 15 tons, 330 (= 5000/15) truck loads will be required each day. Using the values in Table 1 together with the defaults suggested for Equation (2-2), it follows that emissions associated with truck transport of excavated material can be estimated as

$$2.1\ (12/12)\ (15/30)\ ([20 + 15/2]/3)^{.7}\ (10/4)^{.5}\ \text{lb/VMT} \times 330\ \text{load/day} \times 150\ \text{ft (round trip)/load} \times 1\ \text{mile}/5{,}280\ \text{ft} = 73\ \text{lb/work day}$$

Phase I, Trackout. Because 330 truck loads are required per day, the appropriate value from Equation (2-7) is 0.029 lb/vehicle. Over the 1-month (30-day) excavation period, the 5,000 vehicle/day traffic on 4th Street accounts for

$$0.029\ \text{lb/vehicle} \times 5000\ \text{vehicle/day} \times 30\ \text{day} = 4400\ \text{lb}$$

The daily emission rate of 4400/30 = 140 lb/day occur on both working and nonworking days.

Phase II, Site Preparation. Because this site had been previously developed, no additional site preparation is required in this example. Consequently, there are no emissions associated with site preparation.

Phase III, Construction. PM10 emissions associated with general construction activities at the site may be estimated using Equation (2-6) and the information given in Table 1. Assuming 8 working hours during each of the 160 work days, then the 1.2 acre site is estimated to emit

$$3.6\ \text{lb/work hour/acre} \times 1.2\ \text{acre} \times 8\ \text{work hour/workday} = 34\ \text{lb/workday}$$

Phase III, Trackout. Because more than 25 vehicles enter and leave the site each work day, the appropriate value from Equation (2-7) is 0.029 lb/vehicle. Over the 8-month (240-day) construction period, then,

$$0.029\ \text{lb/vehicle} \times 5000\ \text{vehicle/day} \times 240\ \text{day} = 35{,}000\ \text{lb}$$

Again, this emission rate applies to both working and nonworking days.

Summary. Over the two phases (Phases I and III), the following PM10 emissions are estimated to occur:

Phase I - 20 work days at (2.9 + 73) lb/workday or 1,500 lb, plus 4,400 lb of trackout, for a grand total of 5,900 lb of PM10 emissions over 1 month

Phase III - 160 workdays at 34 lb/workday or 5,400 lb, plus, 35,000 lb from trackout, resulting in a total of 40,000 of estimated PM10 emissions over 8 months

Both phases -- 46,000 lb of PM10 estimated over a 9-month period

4.1.2 Example Control Plan

Phase I, Debris Loadout. As indicated by the summary above, this activity results in only a very small fraction of the emissions. For that reason, no additional controls are contemplated for this source.

Phase I, Truck Transport. To reduce both truck transport and trackout emissions, the first 25 ft of the entrance will be paved to provide a buffer before exiting to 4th Street. This portion of the entrance was scheduled to be paved later but will be paved now as a control measure. The remaining 50 ft of temporary roadway will be constructed of 6-in deep crushed stone, with no more than 2% passing a 200-mesh screen (i.e., silt content less than 2%).

Using Equations (2-2) and (2-3) together with default values as necessary, controlled emissions are estimated as

```
2.1 (2/12) (15/30) ([20 + 15/2]/3)^.7 (10/4)^.5 lb/VMT
  x 330 load/day x 100 ft (round trip)/load
  x 1 mile/5,280 ft = 8.1 lb/day
```

for the unpaved portion of the road and as

```
0.77 (.35/.35)^0.3 lb/VMT  x 330 load/day x 50 ft
  x 1 mile/5,280 ft = 2.4 lb/day
```

for the paved portion. Total daily emissions would be 10.5 lb/day for a control efficiency of 86% (i.e., 10.5 compared to 73 lb/day).

Phase I, Trackout. Emissions of trackout will be controlled by manually cleaning (using a hose and a push broom) the paved 25-ft portion of the road twice a day (e.g., at noon and at quitting time) and the paved curb cut at 4th Street when the cut shows visible accumulation. In addition, loads will be covered with tarps prior to leaving the site. Furthermore, all travel operations in the area will cease in the event of a spill or large amount of trackout until the access area has been cleaned. These control measures have been estimated to result in approximately 75% control. The controlled emissions from this phase are 36 lb/day compared to the uncontrolled emissions of 145 lb/day or 1,080 lb for 30 days.

Phase III, Construction. PM10 emissions from general construction activities include miscellaneous sources such as traffic from delivery (e.g., cement mixers, structural steel, and other materials) vehicles and forklift in staging areas, or traffic from workers arriving and leaving the site. The summary above showed that this is a minor source of PM10 emissions when compared to trackout. Consequently, no specific additional controls are planned. Note, however, that improved access road will result in reduced emissions during the construction phase.

Phase III, Trackout. Phase III will control trackout in much the same manner as Phase I. The 25-ft paved road will be cleaned (using a hose and a broom) at least once daily (e.g., at quitting time). The reduced cleaning schedule (from twice per day during Phase I) is believed to be sufficient because (a) fewer vehicles should enter/leave the site each day and (b) the vehicles are not carrying loose material (as they did in Phase I). If this schedule is found not to be sufficient, the Phase I schedule will be reinstituted. Furthermore, should a spill occur, no vehicles will be allowed to leave the site until the spill has been cleared. Again, the control efficiency is approximately 75%; 36 lb/day over the 8-month construction period is the estimated controlled PM10 emission rate.

In summary, the total controlled PM10 emissions are:

Phase I--20 workdays at 13.4 lb/workday (2.9 + 10.5) or 268 lb, plus 1,080 lb of trackout, for a grand total of **1,350 lb** of PM10 emissions over 1 month. Compared to the uncontrolled total, this represents an overall control efficiency of **77%.**

Phase III--160 workdays at 34 lb/workday or 5,400 lb, plus, 8,600 lb from trackout, resulting in a total of **14,000 lb** estimated PM10 emissions over 8 months. Thus, an overall efficiency of **65%** is estimated for this phase.

Both Phases--A total of **15,000 lb** of controlled PM10 is estimated, compared to an uncontrolled estimate of 55,000; thus, overall average control efficiency is found to be **72%.**

4.2 SCENARIO 2

In this example, site preparation was planned for the entire 20-acre site, followed by construction of 20 homes on one-half of the site. A second construction phase of 20 other homes is scheduled to begin one year from now. In the following, only site preparation and construction of the first 20 houses are considered.

4.2.1 Uncontrolled Emissions

Phase II, Bulldozing. Employing Equation (2-4) along with the default values of 12% silt and 5% moisture contents, the uncontrolled PM10 emission factor is estimated as

$$0.74\ (12)^{1.5}/(5)^{1.4} = 3.23\ \text{lb/hr}$$

From Table 2, it is known that three bulldozers will each operate 8 h/workday, resulting in 24 dozer hours per workday. In that case, the estimated emission rate is 78 lb/workday.

Phase II, Pan Scrapers. Section 2.2 presented a PM10 emission of 4.2 lb/mile for scrapers. Because two scrapers will each operate 8 h/workday at 5 mph (see Table 2), there will be 2 x 8 x 5 = 80 scraper miles traveled each workday. Applying the emission factor of 4.2 lb/mile to that value results in an estimated PM10 emission rate of 340 lb/workday.

Phase III, Construction. The dust emissions associated with the construction of the first 20 homes is estimated using the 3.6 lb/work hour/acre value given in Section 2.3. From Table 2, it is known that the project will require 150 workdays of 8 work hours each. In that case, the 10-acre site is estimated to emit

3.6 lb/work hour/acre x 10 acres x 8 work hours/workday = 290 lb/workday

Phase III, Mud/Dirt Trackout. From Table 2, there are 40 vehicles entering/leaving the work site during each workday. Using Equation (2-7) and the 6,000 ADT value for Summit Drive, it is seen that

0.029 lb/vehicle x 6000 vehicles/day = 170 lb/day

are estimated to result from trackout. As before, this value applies to the entire 7-month period (i.e., working and nonworking days).

In summary, the PM10 emissions would be:

Phase II--78 lb/workday for bulldozing and 340 lb/work day for scrapers for a total of 420 lb/workday. Over the 40 workdays, this results in 17,000 lb of estimated PM10 emissions.

Phase III--290 lb/workday due to construction and 170 lb/day from mud/dirt trackout. This yields an estimated 80,000 lb of PM10 emissions over the 7-month period:

150 workdays x 290 lb/workday + 7 months x 365 day/12 months x 170 lb/day = 80,000 lb

In addition, during the first construction period, there are 10 acres to the east of Suburban Drive are subject to wind erosion. In keeping with the recommendations made in Section 2.2.5, no attempt to estimate erosion emissions has been made here. (In general, one could expect that wind erosion will represent a very minor source compared to the 80,000 lb total estimated above.) The following dust control plan does, however, include provisions for this potential source of PM10.

4.2.2 Example Dust Control Plan

Because of the need to stabilize the area left undeveloped, the applicant has decided that staggering site preparation (i.e., 10 acres this year and 10 acres next year) would be more cost-effective. This will not only eliminate the potential 10-acre wind erosion source but also cut total uncontrolled emissions during Phase II in half, from 17,000 lb to 8,500 lb.

Phase II, Bulldozing. This represents a relatively minor source when compared to the total emissions during Phase II; consequently, no additional controls are proposed. Recall, however, that only 20 workdays will be required for the staggered site preparation.

Phase II, Scrapers. The scraper route will be watered at the start of each 8-h workday to decrease emissions. Assuming

- Because the site is located in Kansas City, Missouri, the appropriate value for P is 60 (see Figure 6).
- The estimate is for annual rather than summer conditions (i.e., the appropriate value for K is 0.00087).
- 0.25 gal/sq yd of water is applied to the route at the start of every 8-h workday.
- Each of the two scrapers makes 12 complete loops per hour (thus, 24 scrapers pass a point every hour).

then Equation (2-12) results in a control efficiency estimate of

$$100 - (0.00087)(60)(24)(8)/(0.25) = 60\%$$

This corresponds to a controlled emission estimate of

(1-0.60) x 4.2 x 80 scraper miles/workday = 130 lb/workday

The above rate occurs only 20 workdays because site preparation will be divided between two years.

Phase III, Construction. Because a major portion of the emissions during construction is due to traffic on unpaved Suburban Drive, the applicant proposes to pave this road as soon as site preparation has been completed. By comparing the leading terms of Equations (2-2) and (2-3), a control efficiency of 63% is estimated:

(2.1 - 0.77)/2.1 x 100% = 63%

This efficiency results in an estimated controlled emission rate of (1-0.63) x 290 = 110 lb/workday.

Phase III, Mud/Dirt Trackout. Paving Suburban Drive will also help to control the mud/dirt trackout onto Summit Drive. It is estimated that this will result in 80% control. Controlled mud/dirt trackout PM10 emissions are estimated as (1-0.80) x 170 = 34 lb/day. In addition, travel operations in the area will cease in the event of a spill or large amount of trackout until the access area has been cleaned.

In summary, controlled emissions for the completion of the first 20 homes are as follows:

Phase II--Twenty workdays at 78 lb/workday (bulldozer) plus 130 lb/workday (scraper), thus totaling **4,200 lb** of emissions. This represents a

[(78+340) - (78+130)] / (78+340) = 0.50

or, 50% reduction in emission rate and a

(17,000 - 4200) / (17,000) = 0.75

or, **75%** reduction in the total emissions during the current year.

Phase III--Total controlled PM10 emissions for Phase III activities associated with the first 20 homes are estimated as

150 workdays x 110 lb/workday +
7 months x 365 day/12 months x 34 lb/day = 24,000 lb

This represents a **70%** decrease from the uncontrolled total of 80,000 lb.

Overall efficiency for this control plan is **71%.**

4.3 SCENARIO 3

As shown in Figure 3, operations in all three phases are occurring simultaneously at this road construction site:

Phase I. Excavation--The roadway is being built below existing grade with cut material loaded into haul trucks for transport and disposal off-site.

Phase II. Site Preparation--A previously excavated area is being brought to final grade with pan scrapers and bulldozers.

Phase III. Construction--Pavement operations are being performed at the far righthand area in the figure.

For illustration purposes, assume that each active area occupies 5 acres of the total 15-acre site.

4.3.1 Uncontrolled Emissions

Phase I, Material Loading. From Table 3, 5,000 tons of material are hauled off-site each workday. Using Equation (2-1) together with the recommended default values of 10 mph and 0.5% moisture and the information in Table 3, the estimated PM10 emissions can be found as

$$0.0011\ (10/5)^{1.3} / (0.5/2)^{1.4}\ \text{lb/ton} \times 5000\ \text{ton/day} = 94\ \text{lb/workday}$$

Phase I, Transport of Debris. Equation (2-2) may be used to estimate emissions due to truck transport of material over unpaved roads. From the information provided in Table 3, the truck capacity is 20 tons and 5,000 tons of material is hauled per day, therefore 250 loads (round trips) will be required to remove the material per workday (= 5000 tons per workday / 20 ton per load). Assuming that the site is in Kansas City, Missouri, it follows from Figure 5 that the mean annual number of days with precipitation is 100 days. Assume further that the default silt content of 12% is applicable; in that case, daily PM10 emissions are estimated as

$$\begin{aligned} E = {} & 2.1\ (12/12)\ (15/30)\ [(1.5\times20)/3]^{0.7}\ (18/4)^{0.5} \\ & \times [(365-100)/365]\ \text{lb/VMT} \\ & \times 250\ \text{loads/workday} \times 1{,}700\ \text{ft} \times 1\ \text{mile}/5{,}280\ \text{ft} \\ & = 640\ \text{lb/workday} \end{aligned}$$

for truck haulage.

Phase II, Bulldozing. Estimated uncontrolled PM10 emissions from bulldozing activities are determined from Equation 2-4. Assuming the default values of 12% silt and 5% moisture, this equation yields:

$$0.75\ (12)^{1.5} / (5)^{1.4} = 3.3\ \text{lb/hr of dozer operation.}$$

From Table 3, it is seen that there are 18 h of dozer operation every workday (2 dozers x 9 h/workday); thus, E = 18 h/workday x 3.3 lb/h = 59 lb/workday

is the estimated emission rate.

Phase II, Pan Scrapers. The emission factor for pan scrapers is 4.2 lb/mile (Equation 2-5). From Table 3, an emission rate of

E = 4.2 lb/mile x 4 scrapers x 5 miles/h x 9 h/day = 760 lb/workday

can be determined.

Phase III, Construction. The particulate emissions from paving the roadway is estimated using the construction phase emission factor of 3.6 lb/acre/work hour (Equation [2-6]) and the information in Table 3. Therefore, the emission rate for these activities is 160 lb/workday , which is equal to the product of the emission factor, the 5-acre site, and the 9 work hours per workday.

Mud/Dirt Trackout. With 250 loads/day being hauled off-site from excavation operations, more than 25 vehicles enter/leave the site per day and the emission factor of 0.029 lb/vehicle (Equation [2-7]) is applicable. Total traffic on Deacon Drive is 7,500 vehicles per day, giving a total emission rate of 220 lb/day. Note that this includes working as well as nonworking days.

In summary, total emissions from this project include:

- Phase I Cut Operations--730 lb/workday (94 lb/workday loading and 640 lb/workday transport)
- Phase II Site Preparation--820 lb/workday (59 lb/workday bulldozing and 760 lb/workday pan scrapers)
- Paving--160 lb/workday for construction
- Trackout--220 lb/day

With 21 workdays during the 30 day base month, the total PM10 emissions for the base month are estimated as

21 workdays x (730 +820 +160) lb/workday
+ 30 days x 220 lb/day = **42,000 lb** = 21 tons

4.3.2 Example Control Plan

In the following example control plan, it is assumed that the APCO has set an overall control of at least 65% control. This will require reducing the 21 tons of PM10 emissions to no more than 7.4 tons during the base month.

Phase I, Debris Loading. Because this is a relatively minor source, no additional control measures are contemplated. Emissions are unchanged at 94 lb/workday.

Phase I, Transport of Debris. This source accounts for almost half of the total emissions and needs to be well controlled. In addition, as this site involves an unpaved ramp to Deacon Drive and a haul route that will be in use for a fairly long period, chemical stabilization is cost-effective. The main haul route and the entrance/exit ramp will be treated with 0.25 gal/sq yd of a 1 part chemical to 5 part water solution on the first of each week. Thus, the "ground inventory" increases by

1/(1+5) x 0.25 gal/sq yd = 0.042 gal/sq yd

each week. From Figure 8, the following control efficiency estimates are obtained:

Period	Ground inventory (gal/yd^2)	Average control efficiency (%)
Week 1	0.042	0
Week 2	0.083	85
Week 3	0.12	89
Week 4	0.17	92

The controlled emission rate for the base month may be estimated by applying the mean average control efficiency of (0 + 85 + 89 + 92)/4 = 66% to the uncontrolled emission rate of 640 lb/workday. Thus, controlled emissions are estimated as (1-.66) x 640 = 210 lb/workday. (If this dust control program continues, estimated emissions will be even lower in later months as the ground inventory increases.)

Phase II, Bulldozing. This is also a relatively minor source. No additional controls are planned and the emission rate is unchanged at 59 lb/workday.

Phase II, Scrapers. The control efficiency for watering the site can be determined with Equation (2-12) together with a few assumptions. Assuming that

- Because the site is located in Kansas City, Missouri, the appropriate value for P is 60 (see Figure 6)
- The estimate is for summer (worst-case) conditions (i.e., the appropriate value for K is 0.0012)
- 1.0 gal/sq yd of water is applied at the start of every 9-h workday
- Each of the 4 scrapers makes 5 complete loops per hour (thus, 20 scrapers pass a point every hour)

then the control efficiency would be estimated as

$$[100 - (0.0012)(60)(20)(9)/(1.0)] = 87\%$$

The estimated controlled emission rate is thus (1-.87) x 760 = 98.3 lb/workday. Note that, because scrapers operate only on-site, this watering program will not compound mud/dirt trackout onto Deacon Drive.

Phase III, Construction. Unpaved travel surfaces and staging areas will be kept at twice the uncontrolled surface moisture value. According to

Figure 7, this will result in approximately 75% instantaneous control for travel emissions. Because instantaneous control efficiency is greater than than average control efficiency, it is assumed that the 75% value applies to the entire emission rate of 160 lb/workday. Therefore, estimated controlled PM10 emissions will be (1-.75) x 150 = 40 lb/workday.

Phase III, Mud/Dirt Trackout. To control mud/dirt trackout, the temporary ramp used to enter and exit the site which is chemically treated to control truck transport emissions will also control the mud trackout. Also, the paved access point at Deacon Drive will be manually cleaned (using a hose and push broom) of rock and dirt at least twice per workday (e.g., at noon and at quitting time). Furthermore, the haul trucks carrying excavated material will be covered with tarps prior to leaving the site. Finally, operations in the area will cease in the event of a spill or large amount of trackout until the area has been cleaned. This combination of controls is estimated to have a control efficiency of approximately 70% which corresponds to an emission rate of (1-0.7) x 220 = 66 lb/day.

In summary, then, controlled emissions during the 30-day period of interest are estimated to be

21 workdays x (94 + 210 + 59 + 98 + 40) lb/workday
+ 30 days x 66 lb/day = 12,000 lb = 6.2 tons

This represents a 70% overall reduction from the uncontrolled total of 21 tons.

4.4 SCENARIO 4

This example deals with the demolition of a building within a busy downtown area. Only emissions after the building is dismembered are considered.

4.4.1 Uncontrolled Emissions

Debris Loading. Based on information given in Table 4 and the default values given in connection with Equation (2-1), it follows that the debris loading PM10 emissions equal

0.0011 (10/5)^1.4 (0.5/2)^1.4 lb/ton x 50000 sq ft x 0.046 [ton/sq ft]
= 43 lb

Note that the 43 lb of emissions is spread over 5 days, so the emission rate is 8.7 lb/day.

Truck Transport. Because the demolition results in 0.046 ton/sq ft x 50,000 sq ft = 2,300 tons of debris and because the haul truck capacity is 20 tons, it is clear that 115 loads (round trips) will be required to remove all the debris. Using the values in Table 4 together with the defaults suggested for Equation (2-2), it follows that the truck transport emissions are estimated as

2.1 (12/12) (15/30) ([20 + 20/2]/3)^.7 (10/4)^.5 lb/VMT x 115 loads
x 250 ft (round trip)/load x 1 mile/5,280 ft = 45 lb

This 45 lb is also spread over the 5-day period, resulting in a rate of 9.0 lb/day.

Trackout Emissions. Because the 115 trips required to remove the debris result in a daily total of at least 46 vehicles entering and leaving the site, the appropriate value for trackout emissions from Equation (2-7) is 0.029 lb/vehicle. When applied to the traffic rate on 4th Street, it is seen that trackout emissions equal 0.029 lb/vehicle x 5,000 vehicle/day = 140 lb/day. Note that trackout emissions may continue to occur for a period after debris removal.

In summary, the uncontrolled PM10 emission rate in this example is 8.7 + 9.0 + 140 = **160 lb/day** over the removal period. Of this total, trackout emissions account for approximately 90%.

4.4.2 Example Control Plan

Suppose that each of the three sources described above are to be controlled. The following presents a possible control plan.

Debris Loading. The demolition contractor proposes to build 10-ft high sections of approximately 50% porous fence from wood lath or latticework before any loadout is performed. Each section will be skid-mounted to allow easy relocation. Prior to starting loadout each workday, the sections will be aligned to reduce winds from a sector of approximately 180 degrees.

Assuming a 50% reduction in wind speed from the 10 mph default value used above, then Equation (2-1) yields

0.0011 (5/5)^1.3 / (0.5/2)^1.4 lb/ton x 50000 sq ft x 0.046 ton/sq ft
= 18 lb

This represents (43-18)/43 x 100% = 58% control of debris loading emissions. Recall that this total emission rate is spread over 5 workdays, with a daily PM10 emission rate of 3.6 lb/workday.

Truck Transport. Rather than watering the short stretch of unpaved travel route involved in this example, the contractor prefers to construct a temporary road of crushed stone, with no more than 2% passing a 200-mesh screen (i.e., silt content less than 2%). The contractor also believes that this control option will help in controlling trackout emissions.

This road will be 125 ft long by 15 ft wide and 6 in deep, thus requiring roughly 40 cu yd of stone. This represents a (12-2)/12 x 100% = 83% reduction in silt content used earlier in Equation (2-2); because the emission factor is a linear function of silt content, this also corresponds to an 83% reduction in the daily emission rate (i.e., from 9.0 lb/day to 1.5 lb/day).

Trackout Emissions. In order to reduce trackout emissions, the demolition contractor proposes the following preventive measures. First, traffic will be restricted to the temporary crushed stone road; plastic pennants or streamers will be used to mark the sides of the road to facilitate compliance. Second, the paved curb cut at 4th Street will be manually cleaned (using a hose and push broom) of rock and dirt at least twice per work day (e.g., at noon and at quitting time). Furthermore, operations will cease in the event of a spill or large amount of trackout until access area has been cleaned. This combination of controls is estimated as having an efficiency of 70% compared to uncontrolled trackout from an unimproved travel surface. Seventy percent efficiency corresponds to a controlled emission rate of 44 lb/day.

In summary, the controlled PM10 emission rate for this example is 3.6 + 1.5 + 44 = **49 lb/day.** When compared to the 160 lb/day uncontrolled value, it is seen that the overall efficiency of the proposed control plan is estimated to be **69%.**

Finally, it should be noted that, because new construction activities will take place at this site, no provisions to stabilize the exposed area have been included in this dust control plan.

SECTION 5

REFERENCES

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