Final BACM Technological and Economic Feasibility Analysis

prepared for:

San Joaquin Valley Unified Air Pollution Control District

March 21, 2003

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EXECUTIVE SUMMARY

The San Joaquin Valley is classified as a nonattainment area with respect to the National Ambient Air Quality Standards (NAAQS) for fine particulate matter (PM10). As the designated regional air quality planning agency for the San Joaquin Valley, the San Joaquin Valley Unified Air Pollution Control District (District) is charged with the responsibility for the analysis and selection of Best Available Control Measures (BACM) that will be implemented to ensure expeditious attainment of the national PM10 standards. To address this requirement, the District commissioned a study to evaluate the technological and economic feasibility of implementing the proposed BACM measures for fugitive PM10 source categories. This report presents the analyses and findings of the BACM evaluation.

Candidate BACM measures to be evaluated were selected by the District. These measures were designed to reduce emissions from fugitive PM10 sources regulated by Regulation VIII. An initial investigation of BACM technologies concluded that while none of the candidate BACM measures were technologically infeasible, the costs of implementation for selected measures could be prohibitive.

To address this concern, an estimate of the cost-effectiveness of each candidate control measure was prepared. This was computed as the ratio of implementation cost to PM10 emission reduction. Implementation costs included construction, operation, and maintenance costs borne by the source owner or operator. Emission reductions were computed as the products of baseline emissions and emission reduction, or control, efficiencies. The cost-effectiveness of each measure was calculated by dividing the cost of measure implementation by the emission reduction achieved, on the basis of the most appropriate measurement unit of source activity. Cost-effectiveness values vary over wide ranges because they are proportional to emissions reductions, which vary with both baseline emissions and control efficiency. For each candidate BACM, a worst-case scenario was evaluated to determine the upper bound of cost-effectiveness. When the computed worst-case cost-effectiveness value was less than $5,000 or more than $500,000 per ton of PM10 reduced, no further analysis was conducted. For these cases, the range of cost-effectiveness values was assumed to be either entirely feasible or entirely infeasible, respectively. When the worst-case value fell between these limits, additional scenarios were evaluated in order to present a representative range of outcomes.

The analysis methodology for determination of BACM cost-effectiveness is presented in the Introduction section of this report. The Introduction discusses the reasons that the District is undertaking an analysis of candidate BACM controls and the methodology under which candidate controls were evaluated. A review of the components of the cost-effectiveness methodology is included, together with a brief discussion of the methodology used to determine technological feasibility. The section concludes with the results of the technological feasibility analysis, which indicated that none of the measures were infeasible but that several limitations should be considered when the District considers action to adopt or modify any control measure.

Chapter 1 of the report describes the cost-effectiveness analysis conducted of measures that are designed to reduce PM10 emissions from paved roads. The measures identified by the District for consideration focus on road shoulder treatment, use of PM10-efficient street sweepers, and the cleanup of wind- or water-borne deposition on paved roads. The conclusions of these analyses indicate that use of PM10 street sweepers is very cost-effective, as is cleanup of soil deposition on paved road, and that treating shoulders on paved roads is only cost-effective on those roads carrying higher than average traffic volumes.

A review of the cost-effectiveness of various soil trackout control measures is presented in Chapter 2. Because of the small quantities of trackout that are produced by all but the muddiest construction sites, the candidate measures were generally found to have relatively high cost-effectiveness ratios. The most cost-effective measure was determined to be the construction of paved interior roads or approaches at construction and other disturbed soil sites.

Candidate measures designed to reduce emissions from unpaved roads were evaluated in Chapter 3. Because a wide variety of types of measures were considered, the cost-effectiveness results also varied widely. Generally, the measures that addressed sources with higher levels of vehicle trips were found to be more cost-effective than measures applicable to lower levels of trips, and measures that did not involve soil treatment were found to have the lowest (best) cost-effectiveness ratios. The paving of unpaved roads and parking areas was generally found to be more cost-effective than the use of watering or dust suppressant controls.

Chapter 4 presents a review of the cost-effectiveness analyses of construction project control measures. Generally, the most cost-effective measures were concluded to be those that limit vehicle speeds or rely on increased enforcement activities. Several measures that limit visible emissions could not be evaluated as no research data were found that related emission quantities to visible emission. Measures that are applicable to demolition projects were found to have higher (worse) cost-effectivess ratios, and construction site controls that focused on high emission sources, such as earthmoving, were found to be more cost-effective than measures that were applied collectively to all emission activities at a site.

Chapter 5 concluded that none of the control measures applicable to the storage or transfer of bulk materials were found to be relatively cost-effective. This was partly due to the dependence of two of the four candidate measure on reductions in visible emissions, which could not be evaluated. The other two measures were found to have very high cost-effectiveness ratios due to low uncontrolled emission levels. Uncontrolled emissions were estimated to be low because of the limited number of high wind events that occur in the majority of the Valley.

Only two control measures applicable to disturbed open areas were selected by the District and evaluated in Chapter 6. One that requires treatment of smaller parcels than are now regulated was found to have a high cost-effectiveness ratio. A measure that calls for the immediate treatment of disturbed soils instead of after 7 days of inactivity was found to be more cost-effective, but emissions reductions under both measures were found to be low because of the few number of high wind events that occur in the majority of the Valley.

Cost-effectiveness evaluations of measures applicable to windblown dust at construction sites and other areas are presented in Chapter 7. Two of the control measures could not be evaluated because they related solely to a visible opacity limitation that eluded quantification, while a third opacity-related measure for which emissions reductions could be quantified was found to be relatively expensive. One measure was found to be already required by Regulation VIII, and concluded to have a cost-effectiveness of $0 per ton of PM10 reduced. The remaining control measures that were designed to reduce windblown emissions from construction sites and bulk material storage piles during high wind events were found to be more viable.

The cost-effectiveness values for all of the candidate BACM measures that were evaluated under this study are summarized in the following table.

The list of candidate BACM measures selected for consideration did not include one that traditionally has been demonstrated to be both very effective in reducing emissions from the spectrum of regulated fugitive dust sources and affordable: increased enforcement of existing PM10 regulations. Our experience with fugitive dust control programs in other serious PM10 nonattainment areas indicates that District staffing levels devoted to enforcement of Regulation VIII are far less than those of other jurisdictions where fugitive dust sources dominate emission inventories. The current approach to enforcement of Regulation VIII requirements is on a complaint-only basis. By contrast, stationary source enforcement in the District and fugitive dust control programs in other serious PM10 nonattainment areas take a far more aggressive approach to rule enforcement. These programs assign inspectors to the exclusive enforcement of stationary source and fugitive dust rules, respectively. The 30% control factor we have estimated for the current District enforcement program is much lower than the 80% accepted by EPA in the emission reduction estimates for Clark County and Maricopa County. Given the higher emissions reductions accepted for rule enforcement under these programs, we recommend that the District consider expanding the resources devoted to the enforcement of Regulation VIII.

Candidate BACM Cost-Effectiveness		
Number	**Measure**	**Cost-Effectiveness ($ per ton of PM10 reduced)**
	Paved Roads	
1.a	Require 4 ft. paved shoulders on all new or modified paved roads	\$13,800 - \$508,000
1.b	Require construction of 4 ft. paved shoulder on 50% of highest ADT existing paved roads	\$7,290 - \$11,300
1.c	Limit purchase of new street sweepers to PM10-efficient units	\$33
1.d	Require purchase of one PM10-efficient sweeper within 3 years	\$792
1.e	Require municipalities to identify dirt-laden streets for priority sweeping	NA
1.f	Require streets to be swept by PM10-efficient units once per month	\$1,070
1.g	Require PM10-efficient sweepers to be maintained and operated within manufacturer=s specifications	NA
1.h	Require wind- or water-borne deposition to be cleaned up within 24 hours after discovery	\$2,850
	Trackout	
2.a	Impose Rule 8041 requirements on any site with more than 10 trips by vehicles of more than 2 axles	\$44,100 - \$387,000
2.b	Require trackout control devices to be 25 feet long and full road width	\$13,700 - \$322,000
2.c	Require paved interior roads to be 100 feet long and full road width	\$7,930 - \$186,000
2.d	Require gravel pads to be 3 inches deep, 50 feet long, and full road width	\$27,500 - \$322,000
	Unpaved Roads	
3.a	Limit maximum speed on unpaved roads to 25 miles per hour	\$1,080
3.b	Require all new non-temporary roads in urban areas to be paved	\$2,160 - \$5,920

Candidate BACM Cost-Effectiveness		
Number	**Measure**	**Cost-Effectiveness ($ per ton of PM10 reduced)**
3.c	Require existing public unpaved roads in urban areas to be paved	$2,160 - $5,920
3.d	Impose Rule 8071 requirements on all unpaved parking areas receiving more than 75 trips per day	$3,510
3.e	Require watering and speed controls on unpaved parking areas receiving up to 25 trips per day	$1,960,000
3.f	Limit Visible Dust Emissions (VDE) to 20% opacity on unpaved parking areas receiving up to 75 trips per day	$9,420 - $91,400
3.g	Limit VDE to 20% opacity and require stabilized surfaces on unpaved parking areas receiving up to 100 trips per day	$5,230 - $30,500
3.h	Require paving, gravel, or dust suppressants on unpaved parking area receiving more than 100 trips per day or more than 10 trips per day by vehicles with more than 2 axles	$22,800 - $207,000
3.i	Require notification to District of special event parking of more than 1,000 vehicles on unpaved surfaces	$15,800
3.j	Require paving, 4 inches of gravel, or dust suppressants to maintain stabilized surfaces at special event parking	$5,980 - $63,200
Construction		
4.a	Limit visible dust plume length to 100 yards	NA
4.b	Apply dust suppressants within 100 feet of a structure to be demolished	$129,000 - $159,000
4.c	Apply water within 1 hour within 100 feet of structure to be demolished	NA
4.d	Apply water or dust suppressants to areas where demolition equipment will operate	NA
4.e	Apply water and/or dust suppressants to disturbed soils after demolition is completed or at the end of each day of cleanup	$7,220,000
4.f	Prohibit demolition activities when wind speeds exceed 25 mph	$847,000
4.g	Require Dust Control Training Class for on-site dust control coordinator	NA

Candidate BACM Cost-Effectiveness		
Number	**Measure**	**Cost-Effectiveness ($ per ton of PM10 reduced)**
4.h	Require dust monitoring for projects with disturbed areas larger than 50 acres	$231,000 - $339,000
4.i	Require minimum soil moisture of 12% for earthmoving	$21,600 - $56,000
4.j	Limit on-site vehicle speeds to 15 mph	$850
4.k	Require posting of speed limit signs for sites larger than 10 acres	$2,490 - $74,600
4.l	Require stabilization of inactive areas immediately after disturbance	NA
4.m	Require Dust Control Plans for residential projects larger than 10 acres, and for commercial projects larger than 5 acres	$17,200 - $31,500
4.n	Require District notification of earthmoving operations at smaller project sites	$2,480 - $14,800
	Bulk Materials	
5.a	Require that VDE not exceed property line	NA
5.b	Require construction of 3-sided enclosures with 50% porosity	$659,000
5.c	Impose Rule 8031 requirements on sites storing less than 100 cubic yards of bulk materials	$659,000
5.d	Impose Rule 8031 requirements on agricultural off-field storage of non-commodity bulk materials	NA
	Disturbed Open Areas	
6.a	Impose Rule 8051 requirements on urban parcels of 0.5 acres or more in size that contain at least 1,000 square feet of disturbed surface	$67,800
6.b	Impose Rule 8051 requirements immediately after cessation of disturbance	$6,450 - $33,600
	Windblown Dust	
7.a	Require cessation of construction when wind events are declared	$7,770 - $12,700
7.b	Require cessation of construction when 20% opacity is exceeded	NA

Candidate BACM Cost-Effectiveness		
Number	**Measure**	**Cost-Effectiveness ($ per ton of PM10 reduced)**
7.c	Require continued operation of water trucks when construction ceases	$0
7.d	Require more than one stabilization method when 20% opacity exceeded on disturbed open areas	$15,000 - $65,600
7.e	Cease material handling activities when dust plumes cross property lines	NA
7.f	Water storage pile or cover when wind events are declared	$9,240 - $27,700

INTRODUCTION

Background

The San Joaquin Valley is classified as a nonattainment area with respect to the National Ambient Air Quality Standards (NAAQS) for fine particulate matter (PM10). After failing to attain the PM10 standard by the Clean Air Act deadline of December 31, 1994, the San Joaquin Valley was reclassified to serious nonattainment status effective February 8, 1993. According to the 1990 Clean Air Act Amendments (CAAA), areas that are reclassified to serious are required to submit a State Implementation Plan (SIP) revision within 18 months after the date of reclassification. The SIP revision is required to provide for the implementation of best available control measures (BACM) no later than four years from the date of reclassification. As the designated regional air quality planning agency for the San Joaquin Valley, the San Joaquin Valley Unified Air Pollution Control District (District) is charged with the responsibility for the analysis and selection of BACM that will be implemented to ensure expeditious attainment of the national PM10 standards.

Significant contributors to PM10 concentrations in the San Joaquin Valley are fugitive dust sources. To control emissions from these sources, the District adopted a set of regulations within Regulation VIII in 1993. These regulations were intended to satisfy Reasonably Available Control Measure (RACM) requirements imposed by the CAAA on moderate PM10 nonattainment areas. On April 25, 1996, the District amended Regulation VIII to improve effectiveness of the rules. The District then began a very lengthy process to further upgrade Regulation VIII to meet BACM requirements for serious areas. On March 8, 2000, EPA issued a limited approval/limited disapproval of the 1996 amendments, citing as deficiencies enforceability issues and a failure to adequately demonstrate RACM. The District during this period was developing BACM amendments that were ultimately adopted on November 15, 2001. On March 20, 2002, EPA conditionally approved the rule amendments as RACM and requested additional information demonstrating that the rules met the requirements for RACM. In its final rulemaking notice, EPA provided one year (until February 2004) to demonstrate that Regulation VIII satisfied RACM requirements. Simultaneous with the action on RACM, EPA partially approved and partially disapproved the rules as BACM and provided 18 months from the date of publication (January 22, 2003) of final action to correct BACM deficiencies.

As a portion of the effort to correct deficiencies, the District is conducting a new evaluation of measures proposed for adoption as BACM. Sierra Research was retained by the District to evaluate the technological and economic feasibility of implementing the proposed BACM measures. This report presents the analyses and findings of the BACM evaluation.

Methodology

Candidate BACM measures to be evaluated were selected by the District. These measures were designed to reduce emissions from fugitive PM10 sources regulated by Regulation VIII. A tabulation of the candidate BACM measures appears in Appendix A.

An initial technological feasibility analysis of BACM technologies was conducted by interviewing key contacts with public and private agencies. Telephone interviews of District staff and major source operators were used to collect information on the limitations of control technologies unique to the Valley region. This investigation concluded that none of the candidate BACM measures were technologically infeasible, but that limitations on their use should be considered by the District.

The cost-effectiveness of each candidate control measure was computed as the ratio of implementation cost to PM10 emission reduction. Implementation costs included construction, operation, and maintenance costs borne by the source owner or operator. All costs were computed in terms of 2002 dollars. The costs of acquiring or constructing an asset with a useful life greater than one year were amortized over the useful life to derive an annualized cost of acquisition or construction.

Costs of each proposed measure were determined in a consistent format to provide for a basis for comparison. For example, all costs were computed on a per-unit basis using the same source measurement units that were used in calculating emissions reductions. Costs of implementing applicable control measures to reduce PM10 emissions from unpaved roads, for example, were computed per mile of unpaved road. Basic cost data were obtained from a variety of sources, including District files, state agency publications, telephone surveys, and telephone interviews of local vendors and suppliers within the Valley.

Emission reductions were computed as the products of baseline emissions and emission reduction, or control, efficiencies. Estimates of baseline emissions were calculated from emissions factors published by EPA or in scientific research reports, and from source activity rates that were based on information obtained in telephone interviews of knowledgeable business representatives or published studies of source activities. Emission control efficiency estimates were similarly derived from emission control research reports and EPA publications. The analysis of emission control efficiency included estimates of durability, or the period over which a long-term control action would be effective. In cases where durability extended beyond one year, the cost of control was evaluated as an annualized cost.

The cost-effectiveness of each measure was calculated by dividing the cost of measure implementation by the emission reduction achieved, on the basis of the most appropriate measurement unit of source activity. Because source activity levels range over broad intervals, such as ADT levels on regulated paved roads ranging from 10 to 100,000 vehicles per day, for example, emissions and the costs of emission reduction could also vary by the same orders of magnitude. Deriving a single cost-effectiveness value to represent the application of a proposed control measure to all sources in such a source category would not have provided useful information for decisionmakers or for the general public. Instead, a sequential analysis of cost-effectiveness ratios was conducted for each measure.

In the initial analysis of each proposed measure, a worst-case cost-effectiveness ratio was computed based on the smallest or lowest-emission source impacted. Because the cost-effectiveness ratio would be highest for sources at which emissions reductions would be the smallest, the worst-case scenario evaluated was usually one that started with lowest pre-control, or baseline, emissions. For example, if a control measure called for the paving of unpaved shoulders on existing paved roads, the lowest baseline emission scenario would be a road having the lowest traffic level at which controls would be required. Typically, the lowest baseline emission scenario would also represent the lowest emission reduction scenario and, for most source categories, the worst-case cost-effectiveness ratio.

The benchmark for initial comparison of cost-effectiveness ratios was the District's definition of "cost effective control" as that term is used in the District's policy for determination of Best Available Control Technology.* Under this policy, a cost-effective control for PM10 emissions from stationary source equipment is one whose cost-effectiveness is less than $5,700 per ton of PM10 reduced. Under the sequential cost-effectiveness analysis methodology used in this study, if the initial cost-effectiveness ratio computed under the worst-case scenario exceeded $500,000 per ton of PM10 reduced, then best-case scenarios were assumed to have cost-effectiveness ratios that were also infeasible for implementation, and no further analysis was conducted. For these measures, only the worst-case cost-effectiveness ratio was reported in Table 1 of the Executive Summary and in later analyses. If the worst-case cost-effectiveness ratio was greater than $5,000 but less than $500,000 per ton of PM10 reduced, then a cost-effectiveness ratio for a typical-case scenario was usually evaluated, and the results of the two scenarios were listed in Table 1 as a range. If the worst-case cost-effectiveness was found to be less than $5,000 per ton of PM10 reduced, then the measure was assumed to be feasible under all source scenarios, and no further analysis was conducted.

Technological Feasibility

Candidate BACM measures were first evaluated to determine whether any were technologically infeasible to implement. Measures not determined to be technologically feasible were proposed to be excluded from cost and cost-effectiveness evaluations. This section summarizes the technical limitations found in researching the candidate BACMs, and the extent to which these limitations would limit use of these control measures.

Water Application: Water application is proposed as the basic dust control measure for many of the source categories regulated under Regulation VIII. The application of sufficient water to saturate surface soils results in water runoff that can be introduced to

* Best Available Control Technology (BACT) Policy, APR 1305-1, San Joaquin Valley UAPCD, November 9, 1999, http://www.valleyair.org/policies_per/Policies/APR%201305.pdf

surface waterways. Over the past few years, water quality control agencies have identified runoff flows as a significant source of fine soil particle transport to these waterways, where the particles deposit on streambeds, extinguish plant and insect life, and endanger fish viability.

Contamination of Surface Water by Chemical Dust Suppressant: The use of chemical dust suppressants is regulated by water quality control agencies on a case-by-case basis. To date, these agencies have not adopted a list of acceptable chemical dust suppressants for use anywhere in the District. Each dust suppressant use at a construction site, equipment storage area, or unpaved parking area subject to water quality control regulation must be individually reviewed and approved by the regional agency having jurisdiction. Acceptability of specific dust suppressants varies from county to county and is based on local soil, precipitation, drainage, and surface water quality conditions.

Water Pumping: On many farms and orchards in the San Joaquin Valley, water for dust control use will be pumped from on-site wells. More often than not, the motive force for such pumping will be older Diesel engines that were removed from on-road and off-road equipment when dependability became an issue. These older engines have much higher NOx and Diesel particulate emission rates than current model year systems. As a result, the pumping of large volumes of water for agricultural dust control will increase emissions of NOx and Diesel PM throughout the Valley. This technical limitation can be mitigated by either regulating emissions from agricultural pumping engines, which would require the replacement of older engines with newer ones, or the expansion of the District's Heavy Duty Engine Emission Reduction Incentive Program as it applies to agricultural pump engines.

Street Sweeping: Street sweeping, especially with PM10-efficient units, is encouraged by EPA for evaluation as a candidate BACM. Because of the slow speeds at which street sweepers operate, typically less than five miles per hour, use of these units will result in safety problems on roads having high average traffic speeds. This will especially be a problem on freeways and rural roads in flat terrain. These safety problems can be overcome if the use of street sweepers is limited to streets and roads having speed limits no greater than 45 miles per hour.

None of the technological limitations warrant the removal of any candidate BACM measure from continued consideration. The adverse impacts identified, however, should be considered and given weight in any action taken by the District to adopt or modify a proposed measure.

1. PAVED ROADS

Vehicle travel on paved roads produces PM10 emissions from the entrainment of fine particles generated by vehicle wear and by the grinding of materials deposited on roadway surfaces by vehicle tires. No effective measures have been found to reduce emissions resulting from vehicle wear. Emissions from the grinding of deposited materials, however, can be reduced by removing these materials from roadway surfaces (remediation) or by reducing their transport and deposition onto roadways (prevention). Measures considered as Best Available Control Measure (BACM) candidates for the San Joaquin Valley for the reduction of paved road emissions include both preventive and remedial approaches. These measures, together with their respective cost-effectiveness ratios, are listed in Table 1. Supporting calculations are presented in Appendix B.

Table 1
Paved Road Candidate BACM Cost-Effectiveness

Number	Measure	Cost-Effectiveness ($ per ton of PM10 reduced)
1.a	Require 4 ft. paved shoulders on all new or modified paved roads	$13,800 - $554,000
1.b	Require construction of 4 ft. paved shoulder on 50% of highest ADT existing paved roads	$7,290 - $11,300
1.c	Limit purchase of new street sweepers to PM10-efficient units	$33
1.d	Require purchase of one PM10-efficient sweeper within 3 years	$792
1.e	Require municipalities to identify dirt-laden streets for priority sweeping	NA
1.f	Require streets to be swept by PM10-efficient units once per month	$1,070
1.g	Require PM10-efficient sweepers to be maintained and operated within manufacturer's specifications	NA
1.h	Require wind- or water-borne deposition to be cleaned up within 24 hours after discovery	$2,850

1.a. <u>Require 4 foot paved shoulders on all new or modified paved roads:</u> Rule 8061 requires that all new or modified paved roads projected to carry more than 500 vehicles per day be constructed with paved shoulders that vary in width between 4 and 8 feet depending on projected traffic levels. Under this proposal, the exemption from regulation of new roads projected to have light traffic loads would be eliminated, and all new roads would be required to be constructed with paved shoulders of 4 foot minimum width.

The cost of constructing 4 foot wide paved shoulders–including traffic control, roadway excavation, aggregate base rock, and restriping the edge line–is approximately $33,000 per mile, per direction, or $66,000 per centerline-mile.[*] Paved shoulders will be maintained by receiving a chip seal coat every 10 years, costing $2,600 per centerline-mile. The amortized costs of construction and maintenance were computed to be $8,180 per year per centerline-mile.

Emissions from unpaved shoulders are generated by the pressure waves and turbulence caused by trucks with large frontal profiles (tractor-trailer units) traveling at moderate to high speeds and by the trackout of soil from shoulders onto paved surfaces. Turbulent eddies produced by the moving trucks entrain loose soil particles from unsurfaced shoulders and suspend the finer particles in the air. Research conducted by Desert Research Institute indicates emissions from this source measure approximately 0.03 pounds of PM10 per truck-mile traveled.[†]

Very few data are available to quantify the weight of soil tracked out from unpaved soil surfaces on paved public roads. One study was recently conducted by Midwest Research Institute in Missouri in which soil deposition rates were measured.[‡] In this study, a light-duty truck weighing 3.1 tons was driven over a circuit of native soil areas and paved roads to replicate trackout conditions. The moisture content of the soil was controlled between 4% and 32% to assess the relationship between soil moisture and trackout quantity. Since road shoulder trackout is caused by trips across unwatered areas in which the surface moisture content ranges between 1% and 4% during the high geological PM10 emission season, we used the data representing a soil moisture content of 4% to estimate trackout levels from road shoulders. The dry soil data we used from the MRI report indicated that the trackout rate averaged 0.0033 pounds of soil per light-duty truck exit trip.

Not all of the soil tracked out onto paved public roads becomes entrained as PM10. Observation of trackout sites indicates that larger particles are lifted from the pavement by passing vehicles and deposited at the shoulder of the road or beyond. An earlier study of trackout emissions by MRI indicated that only 25% - 30% of total suspended particulate was smaller than 10 microns.[§] On the basis of these data, we conservatively

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[*] Email from Larry Stauch, Granite Construction Company, October 28, 2002

[†] Effectiveness Demonstration of Fugitive Dust Control Methods for Public Unpaved Roads and Unpaved Shoulders on Paved Roads, prepared by Desert Research Institute for San Joaquin Valley UAPCD, December 1996

[‡] Particulate Emission Measurements from Controlled Construction Activities, EPA/600/R-01/031, prepared by Midwest Research Institute for U.S. Environmental Protection Agency, April 2001

[§] Control of Open Fugitive Dust Sources, EPA-450/3-88-008, prepared by Midwest Research Institute for U.S. Environmental Protection Agency, September 1988 assumed that 30% of the soil tracked onto public paved roads would be emitted as PM10 by passing vehicles.

The paved roads that are constructed without paved shoulders are typically found in rural areas outside of established communities. In transportation planning models, from which traffic volume data were obtained, these roads are referred to as "rural local" roads. From a survey of paved road traffic levels conducted by EarthMatters working with the county transportation planning agencies, we determined that the 10% of rural local roads carrying the fewest numbers of vehicles reported mean daily traffic counts of approximately 100 vehicles per day.[*] From truck counts collected in the San Joaquin Valley by the California Department of Transportation (Caltrans), we estimated that 3% of traffic levels on rural local roads were produced by trucks with large frontal profiles.[†] On this basis, the rural local roads that receive the least traffic will produce 32.9 pounds of PM10 per centerline-mile per year from truck traffic bow wakes under a worst-case cost-effectiveness scenario.

To compute trackout activity, we estimated that a minimum of ten light-duty vehicles and one tractor-trailer unit rolled onto paved roads from unpaved shoulders per day per centerline-mile of road. Soil deposits onto paved roads were estimated from the 2001 MRI study to be 0.0033 pounds per light duty vehicle, and 0.0378 pounds per track-trailer unit. The latter deposition factor was derived from assumptions that the quantity of soil carried by a tire was proportional to the tire's tread area and the vehicle weight supported by the tire. From these values, the soil deposited per mile of lightly traveled rural road was computed to be 0.07 pounds per day. Of this quantity, 30%, or 0.02 pounds per day, was estimated to be emitted as PM10. On an annual basis, this is equivalent to PM10 emissions of 7.72 pounds per year. Combined with truck bow wake emissions, unpaved road shoulders were estimated to produce 40.6 pounds of PM10 emissions per mile of lightly traveled road per year.

An emission analysis of a typical rural local road was also conducted. Under this typical emission/cost scenario, we used the EarthMatters survey data to determine that the average rural local road carries 2,700 vehicles per day, of which 3%, or 81, were assumed to be tractor-trailer units. Bow wake emissions from these vehicles were estimated to be 887 pounds of PM10. Correspondingly, the typical rural local road was estimated to experience unpaved shoulder trackout from 270 light duty vehicle and 8 tractor-trailer unit trips per centerline-mile per day. These trips were also estimated to produce 3.13 pounds of PM10 per day, or 1,142 pounds per year. Combined with truck bow wake emissions, unpaved road shoulders were estimated to produce 2,029 pounds of PM10 emissions per mile of typical rural local road per year.

No research data on emissions of PM10 from paved shoulders impacted by truck eddies was found in the course of this study. However, based on the reductions in road travel emissions computed for the paving of unpaved roads, we estimate that emissions should be reduced by 98%. From the 2001 MRI study, the efficiency of paved shoulders for reducing trackout was estimated to be 42%. The use of these control factors resulted in

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[*] Spreadsheets received from C. Anderson, EarthMatters, October 2002

[†] 2000 Annual Average Daily Truck Traffic on the California Highway System, California Department of Transportation, December 2001

estimated emissions reductions of 29.5 and 1,189 pounds of PM10 for lightly traveled and typical rural local roads, respectively, per year.

The use of these two road scenarios resulted in a range of cost-effectiveness values being estimated for this control measure. This range extends from $13,800 to $554,000 per ton of PM10 reduced. The high end of the range is due to emission benefits being low, as a result of low emissions being generated by a very small number of vehicles per year. These cost-effectiveness values are inversely proportional to truck traffic levels, meaning that acceptable cost-effectiveness numbers would be achieved if the measure were designed to apply only to the rural local roads with traffic levels above the mean of all such roads.

<u>1.b. Require construction of 4 foot paved or stabilized shoulders on 50% of the highest traveled existing paved roads:</u> Rule 8061 does not currently require the construction of paved or stabilized shoulders on existing paved roads with dirt shoulders. Under this candidate BACM, cities and counties would be required to survey all paved roads and treat the 50% of road mileage that carried the most traffic. To assess the impacts of this measure, we assumed that the stabilization of dirt shoulders using a chemical dust suppressant would be the compliance method of choice by public work agencies.

A study conducted in the San Joaquin Valley by Desert Research Institute (DRI) indicated that polymer emulsions provided some of the highest control efficiencies for reduction of unpaved road travel emissions of all the dust suppressant compounds tested.[*] On the basis of these data, we used the cost and control efficiency data for polymer emulsions from this study to estimate the cost-effectiveness of controlling emissions from truck eddies on untreated road shoulders through shoulder stabilization.

The cost of applying polymer emulsion to soil surfaces was estimated from vendor information and the DRI study. The polymer emulsion must be reapplied each year, and the annual cost is $0.92 per square yard. No maintenance cost is incurred provided that traffic levels on the treated shoulder do not significantly exceed 100 vehicle passes per day at any single point.

No data are available to quantify the emission reductions gained through the stabilization of unpaved road shoulders. On the basis of the 80% control efficiency measured in the DRI study from stabilizing unpaved road surfaces, we estimated that polymer emulsion treatment will achieve at least an 80% reduction in emissions from unpaved shoulders.

Under the proposed BACM, 50% of the rural local roads carrying the most traffic would be regulated. Evaluation of paved road traffic data supplied by county transportation planning agencies indicates that the average of traffic levels on rural local roads throughout the Valley was 2,700 vehicles per day in 1999. This traffic level then would become the minimum level at which this proposed BACM would be applied. Based on the Caltrans truck study, we estimate that such roads would carry 81 tractor-trailer units per day (3% of 2,700 vehicles per day). Because the highest cost-effectiveness ratio will

[*] Effectiveness Demonstration of Fugitive Dust Control Methods for Public Unpaved Roads and Unpaved Shoulders on Paved Roads, prepared by Desert Research Institute for San Joaquin Valley UAPCD, December 1996

be associated with the lowest truck traffic level regulated, emission reduction calculations were based on this truck traffic level of 81 vehicles per day. At this traffic level, the stabilization of untreated soil shoulders will reduce PM10 emissions by 764 pounds per centerline-mile per day. The corresponding cost-effectiveness of this candidate measure would be $5.67 per pound of PM10, or $11,300 per ton of PM10, reduced.

We also evaluated the cost-effectiveness of this measure using an alternate, and higher, emission factor. In 1983, MRI measured soil trackout levels from a construction project in the Midwest. In this study, soil trackout levels of 0.0287 pounds per light duty vehicle trip were measured.[*] When this factor is substituted into the analysis, uncontrolled emissions were estimated to be 2,029 pounds of PM10 per centerline-mile per year. The emission reduction calculated for this measure was 1,189 pounds, and the cost-effectiveness was estimated to be $3.65 per pound, or $7,290 per ton, of PM10 reduced.

<u>1.c. Limit the purchase of new or replacement street sweepers to PM10-efficient units:</u> Street cleaning with vacuum or regenerative sweepers is recommended by the U.S. Environmental Protection Agency (EPA) as a remediation tool in reducing PM10 emissions from paved roads.[†] The EPA report indicated that no data on control effectiveness over time were available in 1992, and that situation continues today. Data are available on the removal efficiency of fine particles (silt) from roadway surfaces, but no studies have been conducted of the rate at which roadway silt levels return to pre-sweeping levels (i.e., long-term effectiveness of street sweeping). Also, little information is available to indicate the air quality benefits of sweeping curb lanes, which is the practice in some urban areas, instead of traveled lanes. In the absence of this information, we used best engineering judgment to derive a cost-effectiveness estimate.

The purchase prices of certified PM10-efficient street sweepers are now very similar to those of non-certified units. The differences amount to a few thousand dollars, and the reason is that manufacturer's models differ by only the addition of a few brushes.[‡] The operating costs of the categories of sweepers are approximately the same. The useful life of a street sweeper is approximately eight years, and a single unit is capable of sweeping 15 centerline-miles per day in both directions. From this information, we calculated that the difference in purchase price between a certified and non-certified sweeper amounted to $3.75 per year per centerline-mile swept.

In computing emission benefits, we assumed that traveled lanes were swept, and that silt loadings on these lanes typically returned to pre-swept equilibrium conditions at a rate of 10% per day of equilibrium levels. We also assumed that unswept silt loadings on local, collector, and major streets were those recommended for use in emission inventories by the California Air Resources Board (CARB).[§] From research conducted at the University of California Riverside, street sweepers qualifying as PM10-efficient units removed an

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[*] Control of Open Fugitive Dust Sources, EPA-450/3-88-008, U.S. Environmental Protection Agency, September 1988

[†] Fugitive Dust Background Document and Technical Information Document for Best Available Control Measures, EPA-450/2-92-004, U.S. EPA, September 1992

[‡] Telecom with Sue Howard, City of Phoenix Street Transportation Department, October 16, 2002

[§] Section 7.9, Entrained Paved Road Dust, Paved Road Travel, CARB Area Source Methodologies, July 1997, http://www.arb.ca.gov/emisinv/areasrc/fullpdf/full7-9.pdf average of 86% of fine material from pavement surfaces.* Sweepers failing to qualify to certification standards removed an average of 55% of fine material. On the basis of these data and the assumptions stated above, we computed the average silt loadings of local, collector, and major streets under sweeping schedules that varied between once every day to once every 30 days. From surveys conducted by EarthMatters of sweeping frequencies used by the most populous city in each county, we computed the average silt loadings resulting from sweeping with certified and non-certified units on each of the three categories of streets in each of eight counties in the Valley. To do this, we assumed that sweeping frequencies reported by the largest city in each county were representative of the frequencies within all of the other cities in that county. We then computed an average silt loading Valley-wide for each street category by weighting the individual county values by the average daily traffic volume per street category in each county. The daily traffic volumes were obtained from a survey of county transportation planning agencies conducted by EarthMatters.† Based on these calculations, the emission reduction achieved by using certified PM10-efficient sweepers instead of non-certified units, averaged over the three street categories and reported travel volumes in the eight Valley counties, was calculated to be 227 pounds of PM10 per year per centerline-mile. Due to the small purchase differential between a certified PM10-efficient sweeper and a non-certified unit, the cost-effectiveness of purchasing and operating a certified unit instead of a non-certified unit was computed to be $33 per ton of PM10 reduced.

<u>1.d. Require purchase of one PM10-efficient sweeper within three years:</u> Under this candidate BACM, municipalities that conducted street sweeping programs would be required to purchase and operate a PM10-efficient sweeper within three years regardless of any pre-existing sweeper replacement schedule. The highest financial burden to be incurred under this proposal would fall on municipalities that owned new non-certified sweepers that had to be replaced with new certified units after three years of operation.

The cost of this proposal was estimated to be the difference between the purchase price of a new certified sweeper in three years and the salvage value of a non-certified unit at that time. For a new non-certified sweeper costing $149,000,‡ we estimated that the salvage value would be $80,000 at the end of the three-year period (ignoring inflation). A new sweeper will cost $152,000 in three years (also ignoring inflation), resulting in an increase in asset value of $72,000. That increase in asset value, amortized over the eight-year life of the certified sweeper, is equal to an annualized cost of $13,500.

From the analysis conducted for Measure 1.c., we estimated that emission reductions from use of a certified PM10-efficient sweeper average 227 pounds per year per centerline-mile. On the basis of these values, the cost-effectiveness of this proposal would be $792 per ton of PM10 reduced.

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* PM_{10}-Efficient Street Sweeper Evaluations, Phase II Draft Final Report, prepared by UC Riverside Center for Environmental Research and Technology for South Coast AQMD, June 1999

† Spreadsheets emailed by C. Anderson, EarthMatters, October 2002, representing VMT and road mileage totals by ADT range for each of eight Valley counties in 1999

‡ Maricopa Association of Governments PM-10 Efficient Street Sweeper Study, MAG, December 2001

1.e. Require municipalities to identify dirt-laden streets for priority sweeping by PM10-efficient units: The cost-effectiveness of this proposed measure is zero if municipalities are required to purchase and operate PM10-efficient street sweepers. There is no difference in annualized cost between using PM10-efficient sweepers to sweep dirty streets versus clean streets. Thus, although there will be a reduction in emissions, the absence of a cost differential will result in a cost-effectiveness of zero. In other words, this proposed measure would cost nothing to implement.

1.f. Require streets to be swept by PM10-efficient sweepers at least once per month: The highest cost-effectiveness ratio imposed by this candidate BACM would fall on a municipality that swept streets on the least allowable schedule, once per month, with non-certified units. Under the scenario analyzed, the municipality would be required to replace non-certified units with certified units and continue sweeping on a once-per-month basis.

We estimated the increase in annualized cost of retiring existing non-certified units and immediately purchasing certified PM10-efficient sweepers by assuming that the average age of non-certified units was four years, in the middle of their useful life. For a non-certified sweeper purchased at a cost of $149,000, we estimated that the salvage value at four years would be $60,000. This return, offset by the purchase of a $152,000 certified sweeper, would result in an increase in asset value of $92,000. This value, amortized over the eight-year useful life of the new sweeper, would produce an annualized capital cost of $17,200.

We computed emission benefits from VMT data reported by Fresno County. Within Fresno County's largest city, the City of Fresno, all streets are currently swept once per month. Replacing each of the city's non-certified sweepers with certified PM10-efficient units would reduce PM10 emissions by 72 pounds per year per centerline-mile.[*] On a cost-effectiveness basis, this replacement program would cost $1,070 per ton of PM10 reduced.

1.g. Require PM10-efficient street sweepers to be operated and maintained according to manufacturer's specifications: The cost-effectiveness of this candidate BACM cannot be determined because of the lack of emission data representative of operations within the manufacturer's specification versus operation outside these specifications.

1.h. Require wind- or water-borne deposition to be cleaned up within 24 hours after discovery: Under this candidate BACM, counties and cities would be required to respond within 24 hours to any deposition of soil onto public paved roads carried by wind or water erosion. Currently, such events are uncommon, and typically limited to small landslide events during periods of extended precipitation in foothill areas with moderate to substantial road cut sections. Based on information provided by Merced County Department of Public Works, we estimated that the typical incident involved a 3-ton landslide deposition of soil onto a county road that would require a crew of three, a grader, and water truck for four hours of travel and clean up.[†]

[*] Note that this value is lower than the Valley-wide average of emission reductions because the Valley-wide average sweeping frequency is lower than 30 days, which results in higher emissions reductions.
[†] Telecom with Steve Hamilton, Merced County Department of Public Works, November 7, 2002

The cost of this typical response was computed from cost data supplied by the Merced County Department of Public Works. A response by a crew of two Road Maintenance Workers II and an Assistant Road Supervisor, together with equipment, would cost approximately $640 per cleanup operation.

The calculation of emissions resulting from cleanup within 24 hours, and from failure to provide this service, was challenging in the absence of any research focusing on this question. As a result, we used best engineering judgment and assumptions to quantify emissions under the alternative scenarios. In the absence of cleanup, we assumed that 25% of the deposited material would be located in the traveled lane adjacent to the cutbank, and that 30% of the soil in the traveled lane would be entrained as PM10 over time. This latter assumption is supported by research of trackout emissions conducted by Midwest Research Institute.[*] On the basis of these assumptions, the uncontrolled emissions from a typical water erosion event were computed to be 450 pounds of PM10.

For liability reasons, public works staff are usually quick to flag erosion deposition onto paved roads so that motorists slow down and drive around areas of deposition. For this reason, we assumed that emissions from vehicles driving over deposited material would be zero prior to cleanup, and because the material would be water saturated, we also assumed that no PM10 emissions would be generated by the removal and transfer of erosion-deposited material. Thus, the emission reduction from implementation of this proposed measure was estimated to be 450 pounds of PM10 per cleanup incident. On this basis, the cost-effectiveness of this measure would be approximately $2,840 per ton of PM10 reduced.

[*] Control of Open Fugitive Dust Sources, EPA-450/3-88-008, prepared by Midwest Research Institute for U.S. EPA, September 1988

2. CARRYOUT AND TRACKOUT

Carryout and trackout refer to the transport and deposition of soil onto paved public roads from areas of unpaved soil surfaces, such as construction sites, unpaved parking areas, and areas of bulk material storage. Once deposited onto paved roads, trackout soil (trackout) is pulverized and entrained into the air by the tires of passing vehicles. These emissions can be reduced through either remedial activities, such as frequent sweeping of paved roads on which trackout is visible, or preventive activities, such as the operation of devices at the exits of unpaved soil areas that removed encrusted soil from the tires of exiting vehicles. All of the candidate BACMs that impact trackout are preventive measures. These measures, together with their respective cost-effectiveness ratios, are listed in Table 2. Supporting calculations are presented in Appendix B.

Table 2
Trackout Candidate BACM Cost-Effectiveness

Number	Measure	Cost-Effectiveness ($ per ton of PM10 reduced)
2.a	Impose Rule 8041 requirements on any site with more than 10 trips by vehicles of more than 2 axles	$44,100 - $387,000
2.b	Require trackout control devices to be 25 feet long and full road width	$13,700 - $322,000
2.c	Require paved interior roads to be 100 feet long and full road width	$7,930 - $186,000
2.d	Require gravel pads to be 3 inches deep, 50 feet long, and full road width	$27,500 - $322,000

2.a. Impose Rule 8041 requirements on any site with 10 or more trips by vehicles of more than two axles: Rule 8041 currently requires that any construction site is required to (1) install and maintain a trackout control device, (2) maintain sufficient length of paved interior roads to remove mud and dirt from exiting vehicles, or (3) remove deposits of mud and dirt accumulated on paved interior roads with sufficient frequency to prevent trackout. Under this proposed BACM, the Rule 8041 requirement would be imposed on any site experiencing 10 or more trips per day by vehicles of more than two axles. To evaluate this proposal, we selected the first compliance option, to operate a trackout control device, and based emissions reductions on trackout from a typical 3-axle dump truck.

The newest trackout control device in use in serious PM10 nonattainment areas is a pipe grid system that shakes the accumulated dirt and mud from trucks leaving construction sites.[*] The device consists of 2 inch diameter steel pipe welded in a ladder grid of 8-foot lengths. Three sections of grid are linked together in each of two lanes and appropriately spaced over a 2 inch thick bed of 1 inch aggregate with dimensions of 100 feet by 18 feet at the exit of an unpaved area. The cost of purchasing, shipping, and installing the control device is approximately $5,100. The pipe grid has a useful life of eight years, which means that the annualized purchase and installation cost of the system is $958 per year. Periodically, the device needs to be removed and the aggregate screened and relaid to remove accumulated dirt. The total of this maintenance cost and the annualized purchase and installation cost is $1,820 per year.

Very few data are available to quantify the weight of soil tracked out from unpaved soil surfaces on paved public roads. One study was recently conducted by Midwest Research Institute in Missouri in which soil deposition rates were measured.[†] In this study, a light-duty truck weighing 3.1 tons was driven over a circuit of native soil areas and paved roads to replicate trackout conditions. The moisture content of the soil was controlled between 4% and 32% to assess the relationship between soil moisture and trackout quantity. Since most trackout in the San Joaquin Valley is caused by trips across unwatered areas in which the surface moisture content ranges between 1% and 4% during the high geological PM10 emission season, we used the data representing a soil moisture content of 4% to estimate trackout levels in the San Joaquin Valley. Also, the trend at construction sites is to use less water for dust control because of the increasingly stringent requirements of regional water quality control agencies to control runoff and sediment transport to open waterways from these sites. The dry soil data we used from the MRI report indicated that the trackout rate averaged 0.0033 pounds of soil per light-duty truck exit trip. In an alternate emission analysis, we used the deposition factor of 0.0287 pounds of soil per light-duty truck reported in a 1983 MRI study of construction site trackout.[‡]

Not all of the soil tracked out onto paved public roads becomes entrained as PM10. Observation of trackout sites indicates that larger particles are lifted from the pavement by passing vehicles and deposited at the shoulder of the road or beyond. An earlier study of trackout emissions by MRI indicated that only 25% - 30% of total suspended particulate was smaller than 10 microns.[‡] On the basis of these data, we conservatively assumed that 30% of the soil tracked onto public paved roads would be emitted as PM10 by passing vehicles.

The minimum activity level to be regulated under this proposal is ten 3-axle vehicle trips (five exiting trips) per day per unpaved area. The typical 3-axle, 10-cubic-yard capacity dump truck was estimated to weigh 22.8 tons (the average of empty and full weights) and be equipped with 10 wheels. Because all of the trackout data collected by MRI were

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[*] Telecom and email from Jeff Lane, Trackout Control, September 23, 2002; http://www.trackoutcontrol.com

[†] Particulate Emission Measurements from Controlled Construction Activities, EPA/600/R-01/031, prepared by Midwest Research Institute for U.S. Environmental Protection Agency, April 2001

[‡] Control of Open Fugitive Dust Sources, EPA-450/3-88-008, prepared by Midwest Research Institute for U.S. Environmental Protection Agency, September 1988

based on trips by light-duty trucks weighing 3.1 tons and equipped with four wheels, we used several assumptions in adjusting the test data to estimate the trackout quantity produced by vehicles of different weights and numbers of wheels. We assumed that the quantity of trackout was proportional to the surface area of each tire tread and to the vehicle weight supported by each tire. In other words, the quantity of soil clinging to each tire was assumed to be proportional to the tire tread surface area to which soil could cling, and that the quantity of soil wedged into the tire tread grooves per unit surface area is proportional to the weight on each tire. On this basis of these assumptions, the quantity of soil tracked out in a single exit trip by a 10-yard dump truck was estimated to be 0.0313 pounds per trip. Of this quantity, 30% was assumed to be emitted as PM10, resulting in emissions of 0.05 pounds of PM10 generated by five 3-axle trucks exiting an unpaved area per day. When substituting the higher 1983 MRI soil deposition factor in this analysis, the emissions generated by five 3-axle trucks were estimated to be 0.41 pounds of PM10 per day.

The pipe grid trackout control device was estimated to reduce trackout by 80%. This estimate is based on the data reported in the 2001 MRI report for gravel and paved interior road control devices, and an estimate provided by a construction inspector for the Maricopa County (Arizona) Small Business Assistance program.* The use of this control efficiency estimate results in estimated emissions reductions of 9.4 and 82.5 pounds of PM10 per year per unpaved area using the 2001 and 1983 MRI deposition factors, respectively. Applied to the annualized cost of installing and maintaining a pipe grid trackout control device, this proposed measure has a cost-effectiveness ranging from $22.04 to $194 per pound of PM10 reduced, or $44,100 to $387,000 per ton of PM10 reduced, depending upon the emission factor used. These values will be lower (improved) at construction sites where significant quantities of water are applied for general dust control because, at these sites, uncontrolled trackout will be higher and the use of a trackout control device will provide larger emission benefits.

<u>2.b. Require trackout control devices to be 25 feet long and extend over the full width of the access road:</u> Rule 8041, Section 5.8.1, requires the installation and maintenance of a trackout control device at all access points to paved public roads as an acceptable option for controlling trackout from construction sites, unpaved parking areas, or bulk material storage areas experiencing 150 vehicle trips per day (equivalent to 75 vehicle exits per day). However, Rule 8041 does not specify the dimensions of such trackout control devices. In the absence of such information, and in the absence of research data that would allow us to compute trackout emissions as a function of control device size, we can only assume the device would be de minimis. This assumption is not unrealistic as, currently, the requirements of Rule 8041 are enforced only in response to complaints. Under this approach, we assumed the benefits of a de minimis compliance strategy are limited and approach zero. A de minimis compliance strategy also is feasible provided that no trackout is visible on adjacent paved public roads. Under this assumption, the cost differential and the emission differential between the current regulation and the proposed measure would be maximized. The cost-effectiveness of the proposed measure computed under this scenario then probably represents an average value within the range possible for this measure.

* Telecom with R. Polita, Maricopa County Small Business Assistance program, September 24, 2002

The trackout control device we evaluated in this analysis was a gravel bed system similar to those used by a majority of construction site managers in Clark County (Nevada), where such trackout requirements have been in place for the past two years.[*] The dimensions of the device specified in this candidate measure are smaller than the typical unit in Clark County, which measures 60 feet long by 30 feet wide. The number of exiting vehicle trips over this device that we evaluated ranged from 75 light-duty trucks per day, the minimum traffic level regulated under Rule 8041, and 100 light-duty trucks. The activity rates were selected to produce a range of cost-effectiveness ratios, indicative of the range of cost impacts applicable to regulated sources.

The cost of a gravel bed trackout control device has been estimated by Clark County construction site enforcement staff as $500 to construct and $860 per year to maintain.[†] Maintenance includes the periodic removal, screening, and replacement of the gravel to remove accumulated soil. The cleaning frequency depends on the ability of construction site water truck operators to keep disturbed soils moist enough to prevent visible dust plumes, but dry enough to prevent mud from adhering to the wheels of on-highway vehicles leaving the site. For the typical emission/cost scenario, we assumed that the size of a gravel bed trackout control device would be 50% of the size customarily used in Clark County, and that installation and maintenance costs would be 50% of the Clark County estimates.

Baseline emissions under this scenario were computed using the uncontrolled trackout data reported in the 2001 and 1983 MRI studies. These data indicate that 75 light-duty exiting trucks would generate 0.24 pounds of soil trackout per day per facility under the worst-case scenario, and that 100 exiting trucks would generate 2.87 pounds under the typical scenario. Assuming that 30% of this material would become airborne as PM10 emissions, as discussed in Measure 2.a, these trackout quantities would produce emissions ranging from 18 to 215 pounds of PM10 per year per facility on a 250 day per year construction schedule.

The control efficiency of a gravel bed trackout control device has been shown in the 2001 MRI study to average 46%. Using this value, the emission reductions achievable under this scenario range from 8.5 to 99 pounds of PM10 per year per facility. Coupled with the estimated costs of constructing and maintaining a gravel bed device, the cost-effectiveness of this proposed measure was computed to range from $6.87 to $161 per pound, or $13,700 to $322,000 per ton, of PM10 reduced. These values will be lower at construction sites where significant quantities of water are applied for general dust control because of the greater levels of uncontrolled emissions, and emissions reductions, attributable to heavily watered sites.

<u>2.c. Require paved interior roads to be 100 feet long and full road width:</u> As mentioned above, Rule 8041 does not specify any dimensions for paved interior roads used to prevent trackout. As discussed in Measure 2.b, in the absence of such information we evaluated this proposed measure under the assumption that the minimum length of an interior paved road was de minimis, and the benefits would be limited and approach zero.

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[*] Section 94, Air Quality Regulations, Clark County Air Quality Management Board, November 2000

[†] Telecom with A. Bashor, Clark County Department of Air Quality Management, November 18, 2002

Under this assumption, the cost differential and the emission differential between the current regulation and the proposed measure would be maximized. A range of cost-effectiveness values of the proposed measure was computed under this scenario based on a range of costs and uncontrolled emissions rates.

The cost of paving an interior road adjacent to a facility exit was estimated from information provided by a Valley construction contractor. According to this source, the paving on a 30 foot wide, 100 foot long section of access road with 3 inches of asphalt would be $6,500.[*] Assuming that this section would become a permanent feature of the constructed project, the useful life of this pavement would be 25 years.[†] Amortized over the useful life, the annualized capital cost of this improvement would be $716 per year. In a second scenario, we assumed that a 50 foot long section of paved access road was in existence, and that improvements were limited to a 50 foot extension of an existing paved access road. The improvement cost under this scenario would be $358 per year.

The emissions from trackout were computed using the same range of traffic levels (75 to 100 light-duty truck exit trips per day) as anticipated in the Measure 2.b. analysis. From that analysis, the uncontrolled emission were reported to range from 18.4 to 215 pounds of PM10 per day per facility. The average control efficiency of interior paved roads in reducing trackout was 42% as reported in the 2001 MRI study. Emission reductions were calculated from these data to range from 7.7 to 90 pounds of PM10 per day per facility.

The cost-effectiveness of this proposed measure was calculated to range from $3.97 to $93 per pound of PM10 reduced, or $7,930 to $186,000 per ton. These values will be lower at construction sites where significant quantities of water are applied for general dust control.

<u>2.d. Require gravel pads to be 3 inches deep, 50 feet long, and the full width of the access road:</u> As discussed in Measure 2.b, Rule 8041 does not currently specify the dimensions of trackout control devices. Again, we evaluated this proposed measure under the assumption that the minimum size of a control device allowed under Rule 8041 would be de minimis, and the benefits would be limited and approach zero. Under this assumption, the cost differential and the emission differential between the current regulation and the proposed measure would be maximized. The cost-effectiveness of the proposed measure computed under this scenario then probably represents an average value within the range possible for this measure.

The costs of installing and maintaining a gravel bed trackout control device are estimated in the analysis of Measure 2.b. These annual costs are $1,360 per year per facility.

Uncontrolled emission rates, controlled emission rates, and emission reductions for this technology were also calculated in Measure 2.b. The emission reductions range from 8.45 to 98.9 pounds of PM10 per day per facility. On the basis of these data, the cost-effectiveness of a gravel bed trackout control device of the specified dimensions will range from $13.74 to $161 per pound, or $27,500 to $322,000 per ton, of PM10 reduced.

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[*] Telecom with Larry Stauch, Granite Construction Company, Fresno, CA, September 26, 2002

[†] PM_{10} BACM Plan, South Coast AQMD, September 1994

These values will be lower at construction sites where significant quantities of water are applied for general dust control.

3. UNPAVED ROADS

Vehicle travel on unpaved roads produce PM10 emissions from the abrasion and entrainment of fine particles from the roadway soil surface by vehicle tires. Emissions from unpaved road travel can be reduced by treating the road surface with water, chemical dust suppressants, or gravel, or by paving the roadway surface with asphalt concrete or Portland cement concrete. Measures considered as BACM candidates for the San Joaquin Valley for the reduction of unpaved road emissions include most of these treatment approaches. These measures, together with their respective cost-effectiveness ratios, are listed in Table 3. Supporting calculations are presented in Appendix B.

Table 3
Unpaved Road Candidate BACM Cost-Effectiveness

Number	Measure	Cost-Effectiveness ($ per ton of PM10 reduced)
3.a	Limit maximum speed on unpaved roads to 25 miles per hour	$1,080
3.b	Require all new non-temporary roads in urban areas to be paved	$2,160 - $5,930
3.c	Require existing public unpaved roads in urban areas to be paved	$2,160 - $5,930
3.d	Impose Rule 8071 requirements on all unpaved parking areas receiving more than 75 trips per day	$3,510
3.e	Require watering and speed controls on unpaved parking areas receiving up to 25 trips per day	$1,960,000
3.f	Limit VDE to 20% opacity on unpaved parking areas receiving up to 75 trips per day	$9,420 - $91,400
3.g	Limit VDE to 20% opacity and require stabilized surfaces on unpaved parking areas receiving up to 100 trips per day	$5,230 - $30,500
3.h	Require paving, gravel, or dust suppressants on unpaved parking area receiving more than 100 trips per day or more than 10 trips per day by vehicles with more than 2 axles	$22,800 - $207,000
3.i	Require notification to District of special event parking of more than 1,000 vehicles on unpaved surfaces	$15,800
3.j	Require paving, 4 inches of gravel, or dust suppressants to maintain stabilized surfaces at special event parking	$5,980 - $59,800

<u>3.a. Limit maximum speed on unpaved roads to 25 mph:</u> Under this proposed measure, a maximum speed limit would be set for unpaved roads of 25 miles per hour.

Implementation of this measure would require signing of unpaved roads and enforcement of the limit. In this analysis, we evaluated the costs of these program components and the emission benefits generated by a speed limit on unpaved roads in Merced County.

Merced County has 219 miles of unpaved roads.[*] The cost of installing one speed limit sign in each direction on each mile of road would cost $87,600 and, over a 15-year useful life, would equate to an annualized cost of $53 per year per centerline-mile.

Baseline emissions were computed using the statewide California Air Resources Board (CARB) emission factor for unpaved road travel (2.00 pounds of PM10 per vehicle-mile traveled).[†] From traffic count data collected by VRPA in 2002 and UC Davis in 2001, we estimated that the average unpaved road in Merced County carried 15.4 vehicles per day.[‡,§] On this basis, annual average uncontrolled emissions on these roads are 11,200 pounds of PM10 per year per centerline-mile.

No data on average travel speeds on unpaved roads in the San Joaquin Valley were found in the research literature or in the files of county transportation agencies. As a result, we assumed that the speeds driven by test vehicles in the studies of unpaved road dust suppressant control efficiencies represented typical travel speeds on these roads. The average speed recorded in the 1994 UCD and 1996 DRI test programs was 25.9 miles per hour.[**,††] Since the CARB statewide emission factor is based on these two studies, we assumed that the uncontrolled emission factor for unpaved road travel in the Valley was 2.00 pounds of PM10 per vehicle-mile traveled and that this factor did not need to be adjusted to represent local average travel speed.

Under the proposed measure, unpaved road travel speed would be limited to 25 miles per hour. Because the emission factor equation proposed for adoption by the U.S. Environmental Protection Agency assumes that unpaved road travel emissions are linearly proportional to vehicle speed,[‡‡] we adjusted the CARB emission factor by the ratio of regulated speed to uncontrolled speed (e.g., 25.0 mph/25.9 mph) to derive an emission factor representative of compliance with the proposed measure. This adjusted emission factor was found to be 1.93 pounds of PM10 per vehicle-mile traveled. When multiplied by the average traffic level on Valley unpaved roads, this factor produced an average emission rate of 10,900 pounds of PM10 per year per centerline-mile.

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[*] 1999-2000 Rule 8060 Questionnaire Response spreadsheet, developed by San Joaquin Valley UAPCD, July 2002

[†] Unpaved1999Nov29Final spreadsheet, developed by P. Gaffney, California Air Resources Board, October 2002

[‡] Unpaved road traffic count spreadsheets, developed by VRPA, November 2002

[§] Using GIS to Estimate Vehicle Activity and Roadway Mileage for Unpaved Roads in California, prepared by U.C. Davis for the California Air Resources Board, July 2002

[**] Evaluation of the Emission of PM-10 Particulates from Unpaved roads in the San Joaquin Valley, prepared by U.C. Davis for the San Joaquin Valley UAPCD, April 1994

[††] Effectiveness Demonstration of Fugitive Dust Control Measures for Public Unpaved Roads and Unpaved Shoulders on Paved Road, prepared by Desert Research Institute for San Joaquin Valley UAPCD, December 1996

[‡‡] Section 13.2.2 Unpaved Roads (draft), Compilation of Air Pollutant Emission Factors, AP-42, U.S. Environmental Protection Agency, http://www.epa.gov/ttn/chief/ap42/ch13/draft/d13s02-2_oct2001.pdf

We do not believe that compliance with a speed control on unpaved roads will be met with 100% compliance by the general public, based on the history of compliance in California with posted speed limits on paved roads. Based on the county resources that we estimate will be devoted to enforcement of this proposed measure, we estimate that compliance will be no greater than 25%. Assuming this is correct, the emission reduction achieved by this proposed measure is estimated to be 98 pounds of PM10 per year per centerline-mile. On this basis, the cost-effectiveness of this measure is estimated to be $1,080 per ton of PM10 reduced.

<u>3.b. Require all new non-temporary roads in urban areas to be paved:</u> Rule 8061 currently imposes dust mitigation requirements on unpaved roads carrying more than 75 vehicle trips per day, but does not prohibit the construction of new unpaved roads in urban areas. Under this proposed measure, no new unpaved roads would be constructed except for those that would function temporarily at construction sites or in support of other similar transitory activities. Under Rule 8071, unpaved roads can be treated by watering, gravel, dust suppressants, vegetation, or paving to reduce PM10 emissions. For the purpose of this analysis, we selected paving as the most typically used long-term control approach.

The cost of paving an unpaved road is approximately $400,000 per mile, inclusive of roadway excavation, aggregate base, striping, and traffic control.[*] Amortized over a 25-year useful life, the annualized cost of paving is $44,100 per year per centerline mile.

Baseline emissions and controlled emissions were computed using the CARB statewide emission factors for unpaved and paved roads of 2.00 and 0.0035 pounds of PM10 per vehicle-mile traveled, respectively. The minimum traffic levels expected to use a new road in an urban area were estimated to be the trips generated by a range of two to eight residences, the minimum number of homes to be served by a public road. The number of trips generated by these residences was estimated to range from 28.4 to 77.9 one-way trips per day, of which 72%, or 20.4 to 56.1 trips per day, would be home-based.[†] Using these values, emission reductions attributable to this proposed measure were estimated to range from 14,900 to 40,900 pounds of PM10 per year per centerline mile.

The cost-effectiveness of this proposed measure was estimated to range from $1.08 to $2.96 per pound, or $2,160 to $5,930 per ton, of PM10 reduced.

<u>3.c. Require existing public unpaved roads in urban areas to be paved:</u> The cost-effectiveness of this proposed measure is same as that of Measure 3.b, because the costs and benefits of reconstructing existing unpaved roads carrying low traffic volumes will be same as the costs and benefits of creating new paved roads in place of unpaved roads. This cost-effectiveness ratio was estimated to range from $1.08 to $2.96 per pound, or $2,160 to $5,930 per ton, of PM10 reduced.

<u>3.d. Impose Rule 8071 requirements on all unpaved parking areas receiving more than 75 vehicle trips per day:</u> Rule 8071 regulates fugitive PM10 emissions from unpaved

[*] Email from L. Stauch, Granite Construction Company/Fresno, November 11, 2002
[†] URBMIS7G for Windows, Computer Program User's Guide, Version 5.1.0, prepared by Jones & Stokes for San Joaquin Valley UAPCD, October 2000

parking lots of 1 acre or larger in size that experience 75 or more vehicle trips per day. Under this proposed BACM, the size exemption would be eliminated, and any unpaved lot experiencing 75 or more vehicle trips per day would be regulated, regardless of size. In this analysis, we determined the smallest parking lot size that would be regulated and the corresponding cost-effectiveness of controlling PM10 emissions by paving it.

We computed the smallest size unpaved parking lot regulated under this proposal by estimating the minimum number of parking slots needed to serve 75 vehicle trips per day. From a traffic engineering reference, we concluded that the minimum duration of parking for any trip purpose was 0.4 hours per parking cycle for personal business.[*] During an 8-hour business day, a single parking space would serve 22.5 parking cycles of this duration, or 45 one-way vehicle trips per day. In order to serve 75 one-way vehicle trips per day, a total of two parking spaces would be needed. The cost of paving this area was estimated to be $1,160 which, over a 25-year useful life, would equal an annualized capital cost of $128 per year.

Baseline and controlled PM10 emissions for vehicle travel on these lots were computed using the CARB statewide emissions factor for unpaved and paved roads. Baseline emissions, over an unpaved parking area at 5 miles per hour, were estimated to be 73.6 pounds of PM10 per year. Controlled emissions, representing travel over a paved parking area, were estimated to be 0.66 pounds of PM10 per year. The emission reduction resulting from paving was 72.9 pounds of PM10 per year.

The cost-effectiveness of this proposed measure, on the smallest of parking lots regulated, would be $3,510 per ton of PM10 reduced. This value will be greater for parking lots accommodating longer duration parking cycles or less-than-capacity use.

<u>3.e. Require watering and speed controls on unpaved parking areas receiving up to 25 vehicle trips per day:</u> Rule 8071 regulates fugitive PM10 emissions from unpaved parking lots of 1 acre or larger in size that experience 75 or more vehicle trips per day. Under this proposed measure, unpaved parking lots of 1 acre or larger in size would be regulated regardless of the number of vehicle trips experienced. In evaluating this measure, we assumed a parking lot size of 1 acre, the smallest regulated, and a traffic volume of 25 vehicle trips per day, the largest number of vehicle trips to be regulated under watering requirements. Due to the small size of the lot evaluated, we concluded that speed controls would not be needed as vehicle speeds would probably not exceed 10 miles per hour. The result of choosing these lot size and traffic volume parameters is to effectively compute the minimum cost-effectiveness of this measure. This is a different tack than was assumed for the analysis of most proposed measures, and the reasoning is explained below.

Under this scenario, 25 vehicle trips (12.5 parking cycles) are conducted daily on a 1-acre parking lot. The cost of watering this lot once per day, immediately prior to the

[*] Transportation and Traffic Engineering Handbook, Institute of Traffic Engineers, Prentice-Hall, 1976

commencement of parking activity, is estimated to be $68 per day, based on water truck rental and driver labor rates provided to us by Valley construction sources.[*]

We used the CARB emission factor for unpaved road travel, adjusted for a vehicle speed of 5 miles per hour, to compute baseline emissions. Assuming that parking trips are evenly distributed over the 1-acre lot, uncontrolled emissions were estimated to be 0.38 pounds of PM10 per day.

The control efficiency of a single daily water application was estimated from the 2001 MRI report of construction emission controls.[†] This research indicated that watering traveled unpaved roads at the levels proposed in our cost analysis reduced emissions by 85% in the first hour, and that the efficiency declined to zero by the fourth hour after watering. We integrated the information from this study to conclude that daily watering would effectively reduce PM10 emissions by 18% over the 8-hour period subsequent to watering. The emission reduction achieved through this control would be 0.07 pounds of PM10 per day.

The cost-effectiveness of this proposed measure, evaluated under the scenario described, would be $981 per pound, or $1,960,000 per ton, of PM10 reduced. These values will be greater if fewer vehicle trips were used in the scenario described. If only one vehicle trip occurred during each day, and if that trip occurred at the end of each day when the control effectiveness of morning watering was zero, the cost-effectiveness of this measure would be infinite, as cost would be incurred for no emission benefit.

<u>3.f. Limit Visible Dust Emissions (VDE) to 20% opacity on unpaved parking areas receiving up to 75 vehicle trips per day:</u> In evaluating this proposed measure, we assumed that the use of a chemical dust suppressant (polymer emulsion) would be the least expensive method for assuring compliance with a 20% opacity standard. In the evaluation scenario, we also assumed that the parking lot under consideration was 1 acre in size, the largest that would escape regulation under the current Rule 8071, and that the parking lot experienced the minimum number of vehicle trips (25 per day) contemplated for regulation under this proposed measure. These assumptions are intended to maximize costs and minimize emission reductions, resulting in the highest cost-effectiveness ratio to be imposed on any regulated parking area. In a second scenario, we assumed twice as many vehicles, of greater weight and driving at slightly higher speed, used the unpaved parking area.

The cost of applying chemical dust suppressant to an unpaved parking area was derived from data reported in an unpaved road emission study[‡] and from vendor data.[§] From these sources, we computed the cost of surface preparation and emulsion purchase and

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[*] Telecom with D Harrald, Kaweah River Rock Co., September 23, 2002, and email from L. Stauch, Granite Construction Company/Fresno, November 14, 2002

[†] Particulate Emission Measurements from Controlled Construction Activities, prepared by Midwest Research Institute for U.S. Environmental Protection Agency, April 2001

[‡] Effectiveness Demonstration of Fugitive Dust Control Methods for Public Unpaved Roads and Unpaved Shoulders on Paved Roads, prepared by Desert Research Institute for San Joaquin Valley UAPCD, December 1996

[§] Evaluation of the Air Quality Performance Claims for the Midwest Industrial Supply, Inc. Soil Sement Dust Suppressant, California Air Resource Board, April 2002 application to be $5,340 per acre. Since this dust suppressant has a useful life of one year, this cost would be incurred each year in order to satisfy the 20% opacity requirement. In the second scenario, we assumed that only 75% of the 1-acre parking area required treatment at a cost of $4,010.

Baseline emissions were computed from the CARB statewide emission factor for unpaved road travel adjusted to account for a range of travel speeds of 5 and 7 miles per hour assumed for parking activities in a small lot. Vehicles were assumed to range in weight from 1.8 to 15 tons each. Twenty-five to 50 vehicle trips (12.5 to 25 parking cycles) were estimated to produce 0.99 to 1.98 vehicle miles traveled per day, resulting in PM10 emissions ranging from 0.38 to 2.78 pounds per day.

The efficiency of polymer emulsion for reducing PM10 emissions was stated to be 84% at the application rate specified in the CARB documentation. This level of control would result in emission reductions ranging from 117 to 851 pounds of PM10 per year under the scenario evaluated.

The cost-effectiveness of the proposed measure, under the condition evaluated, was estimated to range from $4.71 to $46 per pound, or $9,420 to $91,400 per ton, of PM10 reduced. These values will decline (improve) if traffic volumes are greater at any unpaved parking area than the minimum levels evaluated in this scenario.

3.g. Limit VDE to 20% opacity and require stabilized surfaces on unpaved parking areas receiving up to 100 vehicle trips per day: Under this proposed BACM, unpaved parking areas would have to be sufficiently treated to prevent visible emissions greater than 20% opacity and to establish a surface that would comply with stability requirements specified in Rule 8011. As in the analysis of Measure 3.f, we assumed that the application of polymer emulsion dust suppressant on an annual basis would satisfy these requirements. In evaluating this proposed measure, we again assumed that the parking lot under consideration was 1 acre in size, the largest that would escape regulation under the current Rule 8071; that the parking lot experienced a range of vehicle trips from 75 to 90 per day; that vehicle weights ranged from 1.8 to 15 tons per day; and that vehicle travel speeds ranged from 5 to 7 miles per hour. These assumptions are intended to provide a range of costs and emission reductions, resulting in a range of cost-effectiveness ratios expected from regulation of affected parking areas.

The cost of annually applying polymer emulsion to a 1-acre parking area was estimated to range from $4,010 to $5,340 per year. The parking of 37.5 vehicles per day (equivalent to 75 vehicle trips), weighing 1.8 tons each, would produce 1.14 pound of PM10 per day, using the CARB emission factor adjusted for a travel speed of 5 miles per hour. The parking of 45 vehicles per day (equivalent to 90 vehicle trips), weighing 15 tons each, would produce 5.00 pounds of PM10 per day, using the CARB emission factor adjusted for a travel speed of 7 miles per hour. The control efficiency of polymer emulsion has been certified by CARB to be 85% at the application rate used in the cost analysis. The corresponding emission reductions achieved under this scenario would range from 351 to 1,530 pounds of PM10 per year, assuming that parking activities occurred every day of the year.

The cost-effectiveness of the proposed measure, under the condition evaluated, was estimated to range from $2.62 to $15 per pound, or $5,230 to $30,500 per ton, of PM10 reduced. These values will decline (improve) if traffic volumes are greater at any unpaved parking area than the minimum levels evaluated in this scenario.

3.h. Require paving, gravel, or dust suppressants on unpaved parking areas receiving more than 100 trips per day or more than 10 trips per day by vehicles with more than 2 axles: Under this proposal, unpaved parking areas would be required to be treated if traffic volumes equaled or exceeded 10 vehicle trips (5 parking cycles) by vehicles having more than 2 axles. In evaluating this proposed measure, we again used a 1-acre parking area for ease in comparing results with Measures 3.f and 3.g, and computed emissions for both the minimum number of 2-axle and 3-axle vehicles regulated under this proposal. To determine the maximum cost-effectiveness ratio for the regulation of 3-axle vehicles, we computed emissions on the basis of the lightest 3-axle vehicle available on the market, which is a one-ton-capacity light truck with a dual axle rear end. These trucks weigh 2.30 tons each.

The cost of annually treating a 1-acre unpaved parking area with polymer emulsion dust suppressant is $5,340 per year, as calculated in the analysis of Measure 3.f.

The emission factors for 2- and 3-axles vehicles were computed by adjusting the CARB unpaved road factor for vehicle speed and weight. For 2-axle vehicles, no weight adjustment was made, but the adjustment to a 5-mile-per-hour travel speed produced an emission factor of 0.39 pounds of PM10 per vehicle-mile traveled, as reported in the analysis of Measure 3.f. This factor was further adjusted for vehicle weight to derive an emission factor of 0.43 pounds of PM10 per vehicle-mile traveled by a light 3-axle vehicle traveling 5 miles per hour. Total baseline emissions under the two operating scenarios (e.g., 100 light-duty 2-axle vehicle trips and 10 light-duty 3-axle vehicle trips) were 1.53 and 0.17 pounds of PM10 per day, respectively.

As discussed in the analysis of Measure 3.f, the control efficiency of polymer emulsion dust suppressant was estimated to be 84%. The emissions reductions achieved through use of this control approach were computed to be 468 and 52 pounds of PM10 per year for activity rates of 100 2-axle and 10 3-axle vehicle trips per year, respectively, assuming that parking activities occurred every day of the year.

The cost-effectiveness of this proposed measure was estimated to be $11 per pound, or $22,800 per ton, of PM10 reduced for 1-acre lots handling 100 2-axle vehicle trips per day, and $103 per pound, or $207,000 per ton, or PM10 reduced for lots handling 10 3-axle vehicle trips per day.

3.i. Require notification to District of special event parking of more than 1,000 vehicles on unpaved surfaces: Under this proposed measure, District enforcement staff would receive notification in advance of any event parking involving more than 1,000 vehicles on unpaved parking areas. The intent of the measure is to increase rates of compliance with the requirements of Rule 8071. In evaluating this proposal, we computed the minimum area needed to park 1,000 vehicles, and assumed that watering would be the preferred control option selected to comply with Rule 8071.

The minimum area needed to park 1,000 vehicles was derived from parking requirement data contained in a traffic engineering reference.* These data, adjusted to account for the lack of striped lines on an unpaved lot, suggested that 400 square feet are needed per parking space, inclusive of aisles. On this basis, we estimated that 400,000 square feet, or 9.2 acres, were needed to park 1,000 vehicles. Because of the propensity to use wide aisles in unpaved event parking lots, we estimate that travel speeds will approach 10 miles per hour in these lots.

The cost of this measure is limited to surface treatment activity. Watering of the unpaved parking area once per day is estimated to cost $264 per day. Note that because enforcement of Rule 8041 is currently done on a complaint basis only, we can only assume that current control practices are de minimis and, in some cases, close to nonexistent. For this reason, we have assumed in this analysis that baseline emissions represent uncontrolled conditions, and no accounting of the costs of current control efforts is included.

Baseline emissions were computed on the basis of the CARB emission factor for unpaved road travel adjusted for a vehicle speed of 10 miles per hour. This adjustment resulted in an emission factor of 0.77 pounds of PM10 per vehicle-mile traveled, and daily emissions of 185 pounds of PM10 per event day of 1,000 parking cycles.

As computed in the analysis of Measure 3.e, the control efficiency of daily watering immediately prior to the commencement of parking activities is 18% averaged over an 8-hour period. This control approach would reduce emissions by 34 pounds of PM10 per day.

The cost-effectiveness of this proposed measure is estimated to be $7.88 per pound, or $15,800 per ton, of PM10 reduced. These values will be higher if compliance with Rule 8071 requirements is currently being achieved at unpaved event parking areas, thereby reducing the emission benefits computed in this worst-case analysis.

<u>3.j. Require paving, 4 inches of gravel, or dust suppressants to maintain stabilized surfaces at special event parking areas:</u> Under this proposed measure, watering of special event unpaved parking areas would not be deemed an acceptable control option, and one of several alternatives (paving, 4 inches of gravel, or dust suppressants) would be required. For the purposes of this analysis, we chose the use of polymer emulsion dust suppressants as one of more likely alternatives of choice. Polymer emulsion must be applied annually to remain effective.

The cost of applying polymer emulsion was computed in the analysis of Measure 3.f to be $5,340 per acre. For a 9.2-acre area capable of parking 1,000 vehicles, the annual cost of this control option would be $49,100 per year.

Baseline emissions for the parking of 1,000 vehicles were computed in the analysis of Measure 3.i to be 185 pounds of PM10 per event day. We computed the annual

* Transportation and Traffic Engineering Handbook, Institute of Traffic Engineers, Prentice-Hall, 1976

emissions of parking activities on this lot to range from 1,850 to 18,500 pounds of PM10 per year, based on an assumed range of 10 to 100 special event days with parking activity per year. The control efficiency of polymer emulsion was reported by CARB to be 84% at the application rates used in our cost analysis. Combining these factors, and given the activity rates assumed, emission reductions from the use of this control approach would range from 1,550 to 15,500 pounds of PM10 per year.

The cost-effectiveness of annual polymer emulsion application to a special event parking lot handling 1,000 vehicles per day for 10 to 100 days per year was estimated to range from $2.99 to $29.90 per pound, or $5,980 to $59,800 per ton, of PM10 reduced. These values vary depending on the number of days in a year that special event parking occurs.

4. CONSTRUCTION

Construction activities embody several different sources of fugitive PM10 emissions. The excavation, transfer, and storage of soil during earthmoving activities produce handling and wind entrainment emissions. The travel of heavy construction equipment, on-highway haul trucks, and light-duty trucks over unpaved soil surfaces produce emissions through the grinding and entrainment of soil particles under vehicle wheels. The trackout of loose soil from construction-disturbed areas to public paved roads significantly adds to silt loadings on paved surfaces, the source of emissions from a similar form of vehicle tire grinding and entrainment of fine soil particles. Disturbed soil surfaces provide reservoirs of fine soil particles for entrainment by gusting winds. Emissions from these sources can be reduced through methods that stabilize soil surfaces, bind soil particles together, or remove soil from vehicles. All of the candidate BACMs that impact construction activities act in one or more of these ways. These measures, together with their respective cost-effectiveness ratios, are listed in Table 4. Supporting calculations are presented in Appendix B.

Table 4
Construction Activity Candidate BACM Cost-Effectiveness

Number	Measure	Cost-Effectiveness ($ per ton of PM10 reduced)
4.a	Limit visible dust plume length to 100 yards	NA
4.b	Apply dust suppressants within 100 feet of a structure to be demolished	$129,000 - $159,000
4.c	Apply water within 1 hour within 100 feet of structure to be demolished	NA
4.d	Apply water or dust suppressants to areas where demolition equipment will operate	NA
4.e	Apply water and/or dust suppressants to disturbed soils after demolition is completed or at the end of each day of cleanup	$7,220,000
4.f	Prohibit demolition activities when wind speeds exceed 25 mph	$847,000
4.g	Require Dust Control Training Class for on-site dust control coordinator	NA
4.h	Require dust monitoring for projects with disturbed areas larger than 50 acres	$231,000 - $339,000
4.i	Require minimum soil moisture of 12% for earthmoving	$21,600 - $56,000
4.j	Limit on-site vehicle speeds to 15 mph	$850

Table 4 Construction Activity Candidate BACM Cost-Effectiveness		
Number	**Measure**	**Cost-Effectiveness ($ per ton of PM10 reduced)**
4.k	Require posting of speed limit signs for sites larger than 10 acres	$2,490 - $74,600
4.l	Require stabilization of inactive areas immediately after disturbance	NA
4.m	Require Dust Control Plans for residential project larger than 10 acres, and for commercial projects larger than 5 acres	$17,200 - $31,500
4.n	Require District notification of earthmoving operations at smaller project sites	$2,480 - $14,800

4.a. Limit visible dust plume length to 100 yards: Rule 8021 currently requires that construction activities be sufficiently controlled so as to prevent the generation of visible dust plumes having an opacity greater than 20%. Under this proposed BACM, the length of visible dust plumes would additionally be limited to no more than 100 yards. Because no research data could be found that relate emission strength with the density or length of visible dust plumes, the cost-effectiveness of this measure could not be evaluated.

4.b. Apply dust suppressants within 100 feet of a structure to be demolished: Currently under Rule 8021, the exterior surfaces of buildings and razed building materials must be watered sufficiently to prevent the generation of visible dust plumes with an opacity greater than 20% during demolition activities. Under this proposed measure, the ground surface within 100 feet of the exterior of a building to be demolished would be treated with dust suppressants to additionally prevent the generation of visible dust plumes during demolition and cleanup activities. Because dust suppressants will be effective for a year or more in controlling windblown PM10 emissions from the vacant lot after demolition is completed, assuming limited vehicle use of the property, we also accounted for this air quality benefit. In evaluating this measure, we assumed that the highest cost-effectiveness ratio would be incurred by the smallest project regulated: a single family residential structure. Under this scenario, we assumed that the structure to be demolished would have a footprint area of 1,000 square feet. On this basis, the area to be treated would equal 5,820 square yards, or 1.21 acres. We also assumed that the dust suppressant to be used would be a polymer emulsion that has been certified by the California Air Resources Board (CARB) for control of fugitive dust.[*] Under an alternate scenario, we assumed that the structure to be demolished would have a footprint of 5,000 square feet and be two stories in height. We also assumed that 50% of the area adjacent to the building would not require stabilization.

[*] Evaluation of the Air Quality Performance Claims for the Midwest Industrial Supply, Inc. Soil Cement Dust Suppressant, California Air Resources Board, April 2002

The cost of applying polymer emulsion dust suppressant to a disturbed open area was derived from data reported in an unpaved road emission study[*] and from vendor data [†] From these sources, we computed the cost of surface preparation and emulsion purchase and application to be $5,340 per acre. Under the scenarios evaluated, the cost of pretreating the demolition site would range from $4,200 to $6,460.

In the calculation of baseline emissions, we assumed that the current 20% opacity limit could be achieved by watering the area targeted for dust suppressants twice per day during demolition activities. Uncontrolled emissions were evaluated for front-end loader travel and haul truck travel using an unpaved road emission factor developed by CARB (2.00 pounds of PM10 per vehicle-mile traveled).[‡] This emission factor was adjusted to account for the heavier weights and slower speeds of construction vehicles engaged in demolition activities. The adjustments were computed using the weight-to-emission relationship incorporated into the current AP-42 emission factor for unpaved road travel,[§] and the speed-to-emission relationship included in the proposed AP-42 emission factor.[**] The control efficiency of watering this site twice per day was estimated to be 36.3%[††] based on a study of construction dust controls conducted by Midwest Research Institute Emissions for vehicle travel over watered soil surfaces under these scenarios were estimated to range from 2.77 to 16.4 pounds of PM10 per demolition project.

We also computed emissions from windblown dust emissions that would occur at the site for a six-month period subsequent to demolition. Baseline emissions were computed from the CARB emission factors for windblown dust from unpaved roads.[‡‡] The emission factors are reported on a county-specific basis, and a Valley-average factor was computed by weighting each county-specific factor by the county land area. The resulting factor, converted from units of pounds of PM10 emitted per mile of 20-foot-wide unpaved road to pounds of PM10 emitted per acre of disturbed soil, was calculated to be 156 pounds of PM10 per acre per year. For the two emission scenarios, windblown PM10 emissions over a six month period were computed to range from 61.1 to 94.2 pounds. The total baseline emissions from demolition activities and wind entrainment for a six-month period were computed to range from 77.5 to 97.0 pounds of PM10.

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[*] Effectiveness Demonstration of Fugitive Dust Control Methods for Public Unpaved Roads and Unpaved Shoulders on Paved Roads, prepared by Desert Research Institute for San Joaquin Valley UAPCD, December 1996

[†] Evaluation of the Air Quality Performance Claims for the Midwest Industrial Supply, Inc. Soil Cement Dust Suppressant, California Air Resources Board, April 2002

[‡] Unpaved1999Nov29Final spreadsheet, developed by P. Gaffney, California Air Resources Board, October 2002

[§] Section 13.2.2, Unpaved Roads, Compilation of Air Pollutant Emission Factors, AP-42, U.S. Environmental Protection Agency, September 1998, http://www.epa.gov/ttn/chief/ap42/ch13/final/c13s02-2.pdf

[**] Section 13.2.2 Unpaved Roads (draft), Compilation of Air Pollutant Emission Factors, AP-42, U.S. Environmental Protection Agency,

[††] Particulate Emission Measurements from Controlled Construction Activities, prepared by Midwest Research Institute for U.S. Environmental Protection Agency, April 2001

[‡‡] Section 7.13, Windblown Dust - Unpaved Roads, CARB Area Source Methodologies, August 1997, http://www.arb.ca.gov/emisinv/areasrc/fullpdf/full7-13.pdf

The control efficiency of polymer emulsion dust suppressant was found to be 84% in a study conducted by Desert Research Institute (DRI).* This study evaluated the control efficiency of dust suppressant applied to actively traveled unpaved roads. Since no data were reported for the control efficiency of dust suppressants applied to inactive disturbed areas, we assumed conservatively that this control efficiency would also be no less than 84%. This efficiency was applied to the uncontrolled emission estimates to compute emission reductions attributable to this proposed measure ranging from 65.1 to 81.5 pounds of PM10 per demolition under these scenarios.

The cost-effectiveness of this proposed measure was estimated on the basis of this information to range from $64.30 to $79.30 per pound, or $129,000 to $159,000 per ton, of PM10 reduced.

<u>4.c. Apply water within one hour within 100 feet of a structure to be demolished:</u> Rule 8021 currently requires that the exterior surfaces of buildings and razed building materials be watered sufficiently to prevent the generation of visible dust plumes with an opacity greater than 20% during demolition activities. Under this proposed measure, the ground surface within 100 feet of the exterior of a building to be demolished would also be watered within one hour prior to commencement of demolition. Because a dust control measure such as watering of the area on which haul vehicles will travel is needed to satisfy the 20% opacity requirement, this proposed measure is already required by Rule 8021. As a result, no analysis of the cost-effectiveness of this measure was conducted.

<u>4.d. Apply water or dust suppressants to areas where demolition equipment will operate:</u> Rule 8021 currently requires that the exterior surfaces of buildings and razed building materials be watered sufficiently to prevent the generation of visible dust plumes with an opacity greater than 20% during demolition activities. Under this proposed measure, the ground surface over which demolition equipment would operate must be treated with water or dust suppressant. Because a dust control measure such as watering or the application of dust suppressant to the area on which haul vehicles will travel is needed to satisfy the 20% opacity requirement, this proposed measure is already required by Rule 8021. As a result, no analysis of the cost-effectiveness of this measure was conducted.

<u>4.e. Apply water and/or dust suppressants to disturbed soils after demolition is completed or at the end of each day of cleanup:</u> Currently under Rule 8021, the exterior surfaces of buildings and razed building materials must be watered sufficiently to prevent the generation of visible dust plumes with an opacity greater than 20% during demolition activities. Under this proposed measure, the ground surface disturbed during demolition activities must be treated with water and/or dust suppressants to reduce windblown dust emissions after demolition has ceased. In evaluating this proposed measure, we assumed that the highest cost-effectiveness ratio would be incurred by the smallest project regulated: a 1.21 acre disturbed area surrounding a single family residential structure with a footprint area of 1,000 square feet. We also assumed that watering would be used to prevent windblown emissions during the night until demolition and dust control operations recommenced the next day.

* Effectiveness Demonstration of Fugitive Dust Control Methods for Public Unpaved Roads and Unpaved Shoulders on Paved Roads, prepared by Desert Research Institute for San Joaquin Valley UAPCD, December 1996

The cost of watering was derived from a survey of water purveyor rates in the San Joaquin Valley[*] and data on construction watering practices collected by the District[†] and by Sierra Research.[‡] The water purveyor survey was conducted by Sierra Research using a telephone interview approach. The average price of water sold in the Valley was computed by weighing the price of water in the largest city in each county by the population of that county. For the purpose of this analysis, we assumed that 629 gallons of water were applied to an acre of land in each watering pass (0.023 in.), and that the hourly cost of renting a water truck with driver was $50.00 per hour. On this basis, we estimated that one watering pass at the end of each demolition day would cost $97 for the scenario being evaluated.

Baseline emissions were computed from the CARB emission factors for windblown dust from unpaved roads.[§] The emission factors are reported on a county-specific basis, and a Valley-average factor was computed by weighting each county-specific factor by the county land area. The resulting factor, converted from units of pounds of PM10 emitted per mile of 20-foot-wide unpaved road to pounds of PM10 emitted per acre of disturbed soil, was calculated to be 156 pounds of PM10 per acre per year. For a 1.2 acre site, windblown PM10 emissions were computed to be 0.26 pounds per night.

No data were found that related the reduction in windblown emissions to the application of water to disturbed soils. We were able to locate data on the effectiveness of water application to unpaved roads under use at construction sites, and these data were used to estimate a minimum control effectiveness. These data indicate the control effectiveness of a single water application of 0.025 inches of water to be 10%, averaged over the succeeding 14 hours of road travel. At this minimum control efficiency, emissions reductions were calculated to be 0.03 pounds of PM10 per night.

The cost-effectiveness of this measure, for the scenario evaluated, was estimated to be $3,610 per pound, or $7,220,000 per ton, of PM10 reduced. If the control efficiency of watering were assumed to be 100%, at a maximum, the cost-effectiveness would decline (improve) to $374 per pound, or $748,000 per ton, of PM10 reduced.

4.f. Prohibit demolition activities when wind speeds exceed 25 mph: Rule 8021 requires the control of fugitive PM10 sources at demolition sites to the extent necessary to limit the opacity of visible dust plumes to 20%. Under this proposed measure, demolition activities must cease when wind speeds exceed 25 miles per hour (mph), a speed at which an opacity limit of 20% is very difficult to sustain using almost any control approach. To evaluate this measure, we again used the demolition of a single story, 1,000-square-foot residential structure as the calculation example, and based the cost of implementation on the daily cost of borrowed capital incurred when completion of a demolition project of this size is delayed for a day, plus the costs of additional watering and of idled labor and equipment on the high-wind day.

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[*] Unpublished survey of San Joaquin Valley water purveyors, Sierra Research, August 2002
[†] Draft Regulation VIII Staff Report, San Joaquin Valley UAPCD, September 2001
[‡] Email from L. Stauch, Granite Construction Company, November 14, 2002
[§] Section 7.13, Windblown Dust - Unpaved Roads, CARB Area Source Methodologies, August 1997, http://www.arb.ca.gov/emisinv/areasrc/fullpdf/full7-13.pdf

The cost of demolition was computed from data published by the California Department of Transportation.[*] The cost factor for demolition of miscellaneous structures ($150 per cubic meter) was applied to an estimated volume of demolition waste generated by a single-story residential structure of 1,000-square-foot floor area to produce an estimated cost of $17,000 for demolishing among the smallest of structures to be affected by this proposal. At the current construction loan interest rate of 5.15%, a 24-hour delay in demolition would cost $2.40 in additional capital interest charges under this scenario.

To evaluate the cost of additional watering, we assumed that a 4,000-gallon water truck would spray two truckloads of water continuously over the site for over 6 hours on the day that high winds were predicted. In the absence of this measure, continuous watering would be conducted during the two hours on a high-wind day that wind speeds exceeded 25 mph. A wind database recorded in 1968 at the Lemoore Naval Air Station, which was used in an earlier Sierra Research study[†] to model windblown emissions in the San Joaquin Valley, indicated that wind speeds exceeding 25 mph occur for periods no longer than two hours per day on any one day. In the baseline case, a water truck would operate for 2.2 hours spreading one truckload of water over the demolition during high winds. In the controlled emission case, a water truck would operate for 6.6 hours pre-wetting the site and continuing operation during high winds. On the basis of these data, we estimated that the additional application of water for 4.4 hours to pre-wet the surface soil and maintain surface soil moisture content during the wind event would cost an additional $327 for the high wind day under this scenario.

The cost of idled labor and equipment was computed on the basis of charge rate information received from construction managers. These costs were estimated to total $170 per hour total for two operators, one front-end loader, and one debris haul truck, or $1,360 per eight hour day idled. The total cost of this proposed measure was calculated to be $1,690 per high wind day under this scenario.

Baseline emissions for this scenario were computed from emission factors developed by University of Nevada Las Vegas (UNLV) research of windblown soil emissions in the Las Vegas area.[‡] From these portable wind tunnel studies, the highest emission factor computed for a wind speed of 25 mph, (the highest hourly average wind speed recorded in a Lemoore Naval Air Station data base used in the modeling of windblown emissions in an earlier Sierra Research study[§]) was used to compute a maximum 24-hour emission rate for this scenario. We estimated that the area disturbed around the residential structure would equal 1.2 acres, the same area evaluated in Measures 4.b and 4.e. The uncontrolled emissions for this site were estimated to be 99.7 pounds per high wind day. Continuous watering of this site during the two hours that winds exceed 25 mph, at a rate of 0.055 gallons per square foot per hour, was estimated to produce a control efficiency

[*] 2001 Contract Cost Data, A Summary of Cost by Items for Highway Construction Projects, California Department of Transportation, January 2002

[†] Analysis of Source Significance Levels Through Dispersion Modeling, prepared by Sierra Research for the San Joaquin Valley UAPCD, October 2002

[‡] Development of Vacant Land PM-10 Emission Factors in the Las Vegas Valley, D. James/UNLV et al, November 2001

[§] Analysis of Source Significance Levels Through Dispersion Modeling, prepared by Sierra Research for the San Joaquin Valley UAPCD, October 2002 during demolition activities of 94%, based on research conducted by Midwest Research Institute in 2001.* The baseline emission rate resulting from continuous watering for a 2.2 hour period during a high-wind event was calculated to be 6.0 pounds of PM10 per demolition day.

For the controlled emission scenario, we assumed that continuous watering would be performed prior to and during high winds with demolition activities suspended. No research data were found that reported the control efficiency of watering during high wind events in the absence of soil disturbing activities. On the basis of the MRI data, however, we estimated that watering over a 6.6 hour period prior to and during high winds, with demolition activities suspended for the day, would produce a control efficiency of 98% in windblown PM10 emissions. From this estimated control efficiency, we computed controlled emissions from extended watering and suspension of demolition activities during a high-wind event would be 2.0 pounds of PM10 per demolition day.

The cost-effectiveness of this measure was calculated to be $424 per pound, or $847,000 per ton, of PM10 reduced.

<u>4.g. Require Dust Control Training Class for on-site dust control coordinator:</u> Rule 8021 requires that the owners of projects involving 40 acres or more of disturbed area must submit a Dust Control Plan to the District. This plan must identify all fugitive dust sources and control measures. Under this proposed BACM, the on-site dust control coordinator for a construction project must receive training in dust control measures at a District-conducted or District-sanctioned class. To evaluate this proposed measure, we were required to assume that each construction site employing a trained dust control coordinator would also be managed under an approved Dust Control Plan. While we were able to identify the emission reduction benefits accruing to the implementation of a Dust Control Plan by a trained coordinator, we were not able to separate these benefits into separate fractions attributable to the implementation of a Plan versus implementation by a trained coordinator. As a result, we evaluated the cost-effectiveness of combined Dust Control Plan and trained coordinator requirements in the analysis of Measure 4.m below.

<u>4.h. Require dust monitoring for projects with disturbed areas of 50 acres or more:</u> Rule 8021 currently requires the development and implementation of Dust Control Plans for construction projects that would disturb 40 acres or more of soil. Under the proposed BACM, projects that would disturb 50 acres or more would be required to conduct dust monitoring activities as a method of certifying the effectiveness of dust control measures. To evaluate this proposed measure, we assumed that the highest cost-effectiveness ratio would result from application of this requirement to a 50-acre construction site, the smallest area to be regulated. We also assumed that monitoring would demonstrate the need for additional dust control effectiveness, which would be satisfied by the operation of an additional water truck on a continuous basis to reduce emissions from all fugitive PM10 sources. Under an alternate scenario, we assumed that dust monitoring would be

* Particulate Emission Measurements from Controlled Construction Activities, EPA/600/R-01/031, prepared by Midwest Research Institute for U.S. Environmental Protection Agency, April 2001

conducted visually by a trained onsite coordinator who would direct dust control activities to maintain compliance with a 20% opacity limit.

The cost of air quality monitoring was derived from actual costs incurred at a construction site in the Bay Area AQMD. Under a dust control requirement imposed by the California Energy Commission (CEC), a power plant project was required to conduct PM10 monitoring during construction at upwind and downwind project property line locations. This cost was estimated by the project sponsor to be $7,500 per month.[*] Over the course of a six-month construction period, monitoring would cost $45,000.

The cost of an onsite dust control coordinator was derived from salary and benefits information provided by a Valley construction manager.[†] The hourly cost of employing an onsite coordinator was estimated to be $50.00 per hour, and we assumed that dust control responsibilities would require 2 hours per day. On this basis, an onsite dust control coordinator would cost $13,300 per 50-acre construction project.

At the Bay Area construction site, reduction of high PM10 concentrations was achieved through additional water application. We estimate that additional water application will also be the preferred method of source control at San Joaquin Valley construction sites, and have assumed that the practical impact of PM10 monitoring will be the continuous operation of one additional water truck at each monitored construction site of 50 acres in size. The cost of this activity is estimated to be $409 per day, or $54,400 for a six-month construction period. The total cost of this proposed measure is estimated to range from $67,600 to $99,400 for a 50-acre project under these scenarios.

The data reported by the Bay Area construction monitoring effort were used to determine the air quality benefits of this approach. Because the project was constructed under the requirements of a dust control plan, which were enforced by an independent contractor, the monitoring data showed small differences between upwind and downwind PM10 concentrations. The dust control plan was designed to prevent downwind PM10 concentrations from exceeding upwind concentrations by an increment exceeding 50 $\Phi g/m^3$ - 24 hour average.[‡] However, early in the construction schedule a short-term exceedance of this increment (54 $\Phi g/m^3$ - 10 hour average) was recorded, and additional dust control measures were undertaken that kept the increment below the target limit during the subsequent two months. Analysis of the monitoring data subsequent to this event indicated that the increment would have been exceeded on two other days among the other 40 days of monitored construction if the additional dust control measures had not been implemented. Thus, the air quality benefit of monitoring in this case was to assure compliance on 5% of construction days by reducing emissions on those days.

[*] Telecom with S. DeYoung, Calpine C*Power, November 21, 2002
[†] Email from Larry Stauch, Granite Construction Company, November 19, 2002
[‡] This increment between upwind and downwind monitors was “borrowed” from South Coast AQMD Rule 403, which imposes this requirement on construction projects not implementing Best Available Control Measures.

Baseline emissions for a 50-acre residential construction project were computed from emission factors published by CARB.* For a 50-acre project, based on the similar calculations performed in the analysis of Measure 4.g, uncontrolled project emissions would total 44.6 tons of PM10. The control efficiency of construction dust control measures implemented under an approved dust control plan were estimated from data reported by the Bay Area power plant construction inspectors† and data collected by MRI.‡ Based on the data provided in the Bay Area construction reports, we estimated that a 50-acre residential construction project would use two 4,000 gallon water trucks operating continuously to water 30% of the construction site (15 acres) that would be actively disturbed due to earthmoving operations on any one day. Operating continuously, these water trucks would cover the 15 acres every 3.2 hours. The MRI study indicates that the average control efficiency provided by watering actively disturbed areas on this frequency would be 60.6%. Applying this control efficiency to the uncontrolled emission rate allowed us to estimate that baseline emissions under this scenario would be 17.6 tons of PM10 over the duration of construction on a 50-acre site.

Controlled emissions were computed by estimating the control efficiency of a higher frequency of watering and applying this result to the uncontrolled emission rate. At the Bay Area construction site, a 119-acre site, the recording of an exceedance of the PM10 concentration increment resulted in the use of two more water trucks to dampen disturbed areas more frequently. For the 50-acre parcel in this example, the comparable increase in watering would involve one additional water truck operating continuously over 30% of the site being actively disturbed, as discussed in the analysis of cost for this proposed measure. The use of one additional water truck would reduce the watering frequency to every 2.1 hours. At this frequency, the MRI report indicates that the average control efficiency would be 73.7%. Applying this control efficiency to the uncontrolled emission rate results in controlled emissions under this scenario of 11.7 tons of PM10 over the duration of construction.

Emission reductions from increased watering were estimated to be 5.86 tons of PM10 over the duration of construction. Construction was estimated to occur over six months, or 133 days. The emission reduction that would occur on 5% of the days on which the monitoring system would record exceedances of the PM10 concentration increment would be 0.29 tons, or 586 pounds, of PM10. These latter values, then, represent the emission reduction benefits of conducting monitoring at a 50-acre residential construction site.

The cost-effectiveness of this proposed measure was estimated to range from $115 to $170 per pound, or $231,000 to $339,000 per ton, of PM10 reduced.

<u>4.i. Require minimum soil moisture of 12% for earthmoving:</u> Under the current version of Rule 8021, emissions from earthmoving activities are to be controlled through the

* Section 7.7, Building Construction Dust, CARB Area Source Methodologies, August 1997, http://www.arb.ca.gov/emisinv/areasrc/fullpdf/full7-7.pdf

† Dust Monitoring Summary, Los Esteros Critical Energy Faciliity, San Jose, California, Lowney Associates, August and September 2002

‡ Particulate Emission Measurements from Controlled Construction Activities, EPA/60/R-01-031, prepared by Midwest Research Institute for U.S. Environmental Protection Agency, April 2001

application of water or dust suppressants to the extent that visible dust plumes do not exceed 20% opacity. Under this proposed BACM, areas to be excavated would be pre-watered to the extent that the moisture content of any soil to be excavated would have to be no less than 12% by weight. To evaluate this scenario, we assumed that pre-watering would be conducted by either portable sprinkler systems or by water trucks. In pervious soils, sprinklers would be moved into place during the night preceding excavation and run for a sufficient time to increase the moisture content of the soil to be excavated to the 12% target. In soils that did not drain well, water trucks would be used to wet the soil surfaces shortly before excavation by scrapers. For the purpose of analysis, we also assumed that the minimum project size that would be impacted by this regulation would be 40 acres, which is the current minimum size for requiring a Dust Control Plan under Rule 8021.

Costs of operation of a sprinkler system were estimated from vendor information[*] and Bureau of Labor Statistics.[†] The rental cost of aluminum irrigation pipe for the three weeks that earthmoving occurred would be $282, or $7.07 per acre under this scenario. Assuming that two laborers earning $18 per hour (including benefits) would work 1.5 hours each day setting up the "pipelay," the labor cost for watering would be $886, or $22.14 per acre. Information obtained through interviews of construction managers indicated that for residential construction projects, excavation depths for earthmoving average about one foot across the surface area of the project.[‡] From this information, the quantity of water needed to increase soil moisture content from 4%, the estimated annual average natural moisture content for San Joaquin Valley soils, to 12% would cost an additional $1.24 per acre. The total cost of implementation was estimated to be $30.45 per acre under this scenario, or $1,220 for a 40-acre project.

Under the water truck scenario, we assumed that water trucks would be onsite already, and that the only additional costs would be for the purchase of additional water and for the labor to operate the water trucks. Labor costs were included as water truck drivers would be otherwise operating other equipment when water trucks were onsite but not in use. The cost of water needed to attain a soil moisture content was estimated to be $1.24 per acre, or $49.60 for a 40 acre project. The cost of labor was estimated to be $3,100 for a 40-acre project based on rates provided by a Valley construction manager.[§]

Baseline emissions were computed from EPA emissions factors.[**] Based on the use of a Caterpillar 651E scraper hauling soil with an average 6.5% silt content[††] over an assumed circuit 0.25 miles in length, we computed scraper loading, travel, and unloading emissions to be 4.11 pounds of PM10 per acre.

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[*] Telecom with Rain-for-Rent, November 25, 2002

[†] State and County Employment and Wages from Covered Employment and Wages, U.S. Bureau of Labor Statistics, September 2002, http://data.bls.gov/cgi-bin/dsrv?en

[‡] Telecom with L. Stauch, Granite Construction Company, October 15, 2002

[§] Email from L. Stauch, Granite Construction Company, November 14, 2002

[**] Sections 11.9 (July 1998) and 13.2.2 (September 1998), Compilation of Air Pollutant Emission Factors, AP-42, U.S. Environmental Protection Agency, September 1995

[††] Evaluation of the Emission of PM-10 Particulates From Unpaved Roads in the San Joaquin Valley, prepared by U.C. Davis for the San Joaquin Valley UAPCD, April 1994

Controlled emissions were computed in the same manner as baseline emissions, except that the moisture content in each of the emission factor equations was assumed to be 12%. To adjust the scraper loading and unloading emission factors, which do not include a moisture adjustment factor, to the higher moisture content of 12%, we assumed that the published emission factor represented a natural moisture content, which we also assumed was 4%, and that the relationship of emissions to moisture content was the same as that forecasted in the AP-42 emission factor equation for material handling. In this equation, emissions are proportional to the soil moisture content raised to the negative 1.4 power. By substituting a moisture content of 12% into the scraper travel emission equation, and adjusting the scraper loading and unloading emission factors by the factor of $(4\%/12\%)^{1.4}$, we estimated that controlled emissions would be 1.29 pounds of PM10 per acre under this scenario. The emission reduction computed under this scenario was 2.81 pounds of PM10 per acre.

The cost-effectiveness of this proposed BACM was estimated to range from $10.80 to $28.01 per pound, or $21,600 to $56,000 per ton, of PM10 reduced.

<u>4.j. Limit on-site vehicle speeds to 15 mph:</u> Rule 8021 requires that vehicle travel over unpaved surfaces at construction sites not produce visible dust plumes with opacities greater than 20%. Under this proposed measure, vehicle speeds on unpaved surfaces would be limited to 15 miles per hour (mph) in order to guarantee low emission rates. We evaluated this measure by assuming that it would be selectively enforced by District inspectors using portable radar guns checking the speeds of light-duty vehicles. Our review of construction emission research studies indicated that no construction equipment are operated at speeds higher than 15 mph. For our calculation example, we assumed a minimum project size of 40 acres, the smallest project required to develop a Dust Control Plan under Rule 8021.

The cost of implementing this measure includes the acquisition of equipment and the allocation of District inspection time to enforcement of this measure. A least expensive handheld radar gun costs approximately $700, according to vendor information.[*] With an estimated useful life of eight years, and a use rate of 50 days per year, we estimated that the daily cost of this unit would be $2.62. We also estimated that a District inspector would spend about 0.5 hours performing speed checks during a monthly inspection at any single construction site, costing about $19.25 per visit. We assumed that speed checks would not require a separate trip to a construction site, but these checks would be performed during a routine inspection. On this basis, the cost would be $21.87 per inspection for a single construction site, or $131 for monthly inspections at a six-month construction project.

Baseline emissions for light-duty truck travel at a 40-acre construction site were estimated from the CARB emission factor for unpaved road travel[†] and travel estimates were derived from an emission inventory study.[‡] A residential construction site is

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[*] Phantom Handheld Police Radar Gun, Astro Products, http://www.radar-gun.com

[†] Section 7.10, Unpaved Road Dust (Non-Farm Roads), CARB Area Source Methodologies, August 1997, http://www.arb.ca.gov/emisinv/areasrc/fullpdf/full7-10.pdf

[‡] PM_{10} Emissions Inventory Data For The Maricopa Planning Area, prepared by Engineering-Science for U.S. Environmental Protection Agency Region IX, October 1987

estimated to generate 40 vehicles-miles traveled (VMT) per acre by light-duty trucks on unpaved surfaces. At a 40-acre site, this travel level will equate to 1,600 VMT per project. These vehicles are estimated to travel at speeds averaging 20 mph on unpaved surfaces. As the CARB emission factor is based on an average travel speed of 25.9 mph, this factor was adjusted to a 20 mph travel speed by assuming that emissions are linearly proportional to speed, which is the relationship published by EPA in an draft revision to AP-42.[*] Using this relationship, the adjusted emission factor was estimated to be 1.54 pounds of PM10 per VMT. The resulting emissions of unpaved road travel by light-duty vehicles were estimated to be 2,470 pounds of PM10 per project.

We assumed that the use of a radar gun on an unannounced inspection basis would produce 50% compliance with the proposed measure. Controlled emissions were then calculated by adjusting the CARB unpaved road emissions to a vehicle speed of 17.5 mph and then applying the activity rates estimated in the baseline calculations. The adjusted emission factor was estimated to be 1.35 pounds of PM10 per VMT, and the controlled emission rate was computed to be 2,160 pounds of PM10 per project. The resulting emission reduction estimated for this measure was 309 pounds of PM10 per project.

The cost-effectiveness of this proposed measure was estimated to be $0.42 per pound, or $850 per ton, of PM10 reduced. These values will be greater if compliance with the required speed limit is less than 50% as estimated.

<u>4.k. Require posting of speed limit signs at construction sites greater than 10 acres:</u> Rule 8021 currently requires that vehicle travel over unpaved surfaces at construction sites not produce visible dust plumes with opacities greater than 20%. Under this proposed measure, signs advising of a 15 mph speed limit would be posted at all construction sites greater than 10 acres in size in order to guarantee low emission rates. We assumed that each acre of construction would have one unpaved road crossing it, and that speed limit signs would be posted every 500 feet in both directions on such roads. We also assumed that the posting of signs alone would produce 25% compliance with the target speed limit. Under an alternate scenario, we assumed that a 50-acre construction site would be posted with four signs at project entrances, and that the compliance factor would be 75%.

The cost of installing speed limit signs was collected through an interview of local county public work staff.[†] For a 10-acre construction site, we estimated that unpaved roads would extend 2,090 feet, and that eight speed limit signs installed on these roads would cost $1,600. Because the signs would be removed at the completion of construction, all of the installation cost would be lost except for the salvage value of the signs, which we estimated to be $20 per sign. On this basis, the net cost of sign installation would be $1,440 under this scenario. Under the second scenario, 4 signs costing $720 would be installed at a 50-acre construction site.

As in the analysis of Measure 4.i, we assumed that uncontrolled light-duty truck travel speeds were 20 mph, and that baseline emission would be 18.72 pounds of PM10 per

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[*] Section 13.2.2 Unpaved Roads (draft), Compilation of Air Pollutant Emission Factors, AP-42, U.S. Environmental Protection Agency, http://www.epa.gov/ttn/chief/ap42/ch13/draft/d13s02-2_oct2001.pdf
[†] Telecom with S. Hamilton, Merced County Department of Public Works, November 7, 2002

acre, or 618 pounds per project. At a compliance rate of 25% with a 15 mph speed limit, the controlled emission factor would be 1.45 pounds of PM10 per VMT, and controlled emissions would be 579 pounds of PM10 per project. At a compliance rate of 75%, the controlled emission factor would be 1.25 pounds per VMT, and controlled emissions would be 2,510 pounds per project. The emission reductions were estimated to range from 38.6 to 579 pounds of PM10 per project under these scenarios.

The cost-effectiveness of this proposal was estimated to range from $1.24 to $37.30 per pound, or $2,490 to $74,600 per ton, of PM10 reduced. These values will vary depending on the level of compliance with the specified speed limit achieved in practice.

<u>4.l. Require stabilization of inactive areas immediately after disturbance:</u> Rule 8021 requires that vehicle access be restricted and water or dust suppressants be applied to inactive areas within seven days after the cessation of surface disturbance activities. Under this proposed measure, these requirements would be imposed immediately after surface disturbance activities have stopped. We could not identify an increase in cost resulting from the early stabilization of inactive areas. Because emission reductions would occur through early stabilization, the cost-effectiveness of this measure is infinite.

<u>4.m. Require Dust Control Plans for residential projects equal to or greater than 10 acres, or commercial projects equal to or greater than 5 acres, in size:</u> Rule 8021 requires the development, approval, and implementation of a Dust Control Plan for every construction project equal to or greater than 40 acres in size. Under this proposed BACM, Dust Control Plans would be required for residential and commercial projects equal to or greater than 10 and 5 acres, respectively. We selected a 10-acre residential construction project for our example calculation of this measure, and assumed that the practical effect of requiring a Dust Control Plan for a project of this size would be an increase in watering frequency to the level estimated in the analysis of controlled emissions for Measure 4.h. We also assumed that implementation of the Dust Control Plan would be supervised by an on-site dust control coordinator who had received training under a program certified by the District. Because the benefits of these two program components are so intertwined, <u>we evaluated the cost-effectiveness of the combination of the Dust Control Plan and trained on-site dust control coordinator measures together</u>.

The cost of implementing this proposed measure includes increases in administrative, enforcement, and emission control activities. We have estimated the cost to train an on-site dust control coordinator to be $60 per 6-month construction project, based on the duration of training classes in Clark County, Nevada,[*] the compensation rate for a project coordinator,[†] and the schedule for retraining required in Clark County. The cost of operating a water truck for an additional 4.8 hours per day was estimated to be $32,500 for the duration of a 10-acre residential construction project, based on operating cost data received from a local construction source.[‡] The total cost of implementation was estimated to be $33,600 under this scenario.

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[*] Section 94 Handbook, Clark County Department of Comprehensive Planning, January 2001, http://www.co.clark.nv.us/Air_Quality/AirQuality/PM10/AppendixG/intro.pdf
[†] Email from Larry Stauch, Granite Construction Company, November 19, 2002
[‡] Emails from Larry Stauch, Granite Construction Company/Fresno, October and November 2002

The air quality benefits of developing and implementing an effective dust control plan were estimated from ambient PM10 monitoring data reported for the Bay Area power plant project discussed in the analysis of Measure 4.h. Coincidentally, the power plant was constructed downwind and immediately adjacent to another construction site where the receiving electrical utility was constructing transmission facilities. As a result, the upwind monitor at the power plant site was essentially the downwind monitor for the transmission facility construction when winds were in the prevailing daytime direction. The transmission facility construction was not required to file and implement an approvable dust control plan. On many hours when winds blew from the transmission facility site to the power plant site, concentrations upwind of the power plant site were greater than those downwind. The ratios in concentrations between the upwind and downwind monitors at the power plant during these hours to some extent represent the ratios in construction emissions between the two facilities. During the hours in which upwind concentrations are higher than downwind concentrations, this ratio averaged 14.4%. At a minimum, the reduction in PM10 emissions resulting from implementation of a dust control plan by a trained coordinator and verification of effectiveness through ambient PM10 monitoring was 14.4%. If we assume that the ambient PM10 monitoring program resulted in a 0.8% reduction in emissions, as estimated in the analysis of Measure 4.h, then the minimum reduction that can be attributed to this proposed measure is 13.6%. Under an alternate scenario, we estimated that implementation of a Dust Control Plan by a trained onsite coordinator would reduce construction site emissions by 25%.[*]

Baseline emissions were computed in the manner that was used in the analysis of Measure 4.h. Uncontrolled emissions of 44.6 tons of PM10 per 50-acre project were converted to a per-acre basis and multiplied by 10 acres to produce an estimate of 8.93 tons of PM10 for this 10-acre project scenario. The control efficiency of Regulation VIII as it is currently applied to reduce construction fugitive PM10 emissions was estimated to be 15%. This control efficiency is equivalent to that produced by watering the actively disturbed portions of a construction site every 6.9 hours, as reported in the MRI study. Uncontrolled emissions were discounted by this estimated control efficiency to derive baseline emissions of 7.59 tons of PM10 per 10-acre residential construction project.

Controlled emissions were computed by applying the range of estimated control efficiency of this proposed measure to baseline emissions. Thus, the estimated minimum reductions ranging from 13.6% to 25% would result in a range of controlled emissions of 5.69 to 6.56 tons of PM10 per 10-acre project. The emission reductions were estimated to range from 1.03 to 1.90 tons, or 2,060 to 3,790 pounds, of PM10 per 10-acre project.

The cost-effectiveness of this proposed measure was estimated to range from $8.58 to $15.80 per pound, or $17,200 to $31,500 per ton, of PM10 reduced. These values will vary depending upon the level of emission reduction achieved in practice.

<u>4.n. Require District notification of earthmoving operations at smaller project sites:</u> Rule 8021 requires that emissions from earthmoving activities at construction sites not produce visible dust plumes with opacities greater than 20%. Under this proposed measure, a

[*] Memorandum from M. Zeldin, December 9, 2002

construction site manager would be required to notify the District in advance of any earthmoving operations so that a District inspector could inspect these activities, increasing the potential for compliance with the opacity limit. We assumed in evaluating this proposal that the smallest project to which this requirement would be imposed would be a 10-acre construction site.

We assumed that implementation of this requirement would cause project operators to increase watering activities during earthmoving, and we estimated that one water truck would be used an additional 3.7 hours per day to achieve the watering frequency estimated for a project subject to a Dust Control Plan, as discussed in the analysis of Measure 4.m. For a 10-acre project, we also estimated that earthmoving activities would require 5 days to complete. On the basis of these estimates, and cost data referenced in the evaluation of Measure 4.m, we estimated that increased watering would cost $1,620 during earthmoving activities. The total cost of implementing this proposal would be $1,700 per earthmoving phase at a 10-acre project.

In an alternate scenario, we assumed that projects were in compliance with the 20% opacity limit, and that the only cost incurred would be the administrative time on the part of the onsite dust control coordinator to notify the District of the earthmoving schedule. We assumed that this would require 2 hours at a labor and benefits cost of $50.00 per hour, or a total cost of $100.00

The emission factor for earthmoving was derived from a CARB emission factor database.[*] This emission factor of 0.42 tons of PM10 per acre-month of earthmoving was adjusted to represent emissions from a 5-day earthmoving period, and discounted by 15% to account for the estimated control efficiency of current Regulation VIII enforcement activities. The resulting emission baseline was computed to be 0.81 tons of PM10 per earthmoving phase on a 10-acre site.

We assumed that the control efficiency in the first scenario attributable to District inspection and increased watering of earthmoving activities would be equivalent to that estimated in the analysis of Measure 4.m for the requirement of smaller sites to implement Dust Control Plans. This control efficiency of 13.6% was applied to the baseline emission rate to compute an emission reduction for this measure of 0.11 tons, or 219 pounds, of PM10 per earthmoving phase. In the second scenario, we assumed that emissions from earthmoving activities would be reduced by 5% at sites already in compliance with the 20% opacity limit.[†] In this scenario, emission reductions were estimated to be 0.04 tons, or 81 pounds, of PM10 per earthmoving phase.

The cost-effectiveness of this proposed measure was estimated to range from $1.24 to $7.38 per pound, or $2,480 to $14,800 per ton, of PM10 reduced. These values will vary depending upon the level of emission reduction achieved in practice.

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[*] Section 7.7, Building Construction Dust, CARB Area Source Methodologies, August 1997, http://www.arb.ca.gov/emisinv/areasrc/fullpdf/full7-7.pdf
[†] Memorandum from M. Zeldin, December 9, 2002

5. BULK MATERIALS

Bulk materials refer to finely grained solid materials that are typically handled and stored in large quantities. These materials produce PM10 emissions when handling and storage in outdoors settings allows fine dust to become entrained in the air and transported over property boundaries. Emissions from bulk material handling and storage can only be controlled through preventive means, including the covering or enclosure of these materials, the formation of consolidated surface crusts on outdoor piles, or the wetting of these materials to bind fine particles to larger ones. All of the candidate BACMs that impact bulk materials are preventive measures. These measures, together with their respective cost-effectiveness ratios, are listed in Table 5. Supporting calculations are presented in Appendix B.

Table 5
Bulk Material Candidate BACM Cost-Effectiveness

Number	Measure	Cost-Effectiveness ($ per ton of PM10 reduced)
5.a	Require that VDE not exceed property line	NA
5.b	Require construction of 3-sided enclosures with 50% porosity	$659,000
5.c	Impose Rule 8031 requirements on sites storing less than 100 cubic yards of bulk materials	$659,000
5.d	Impose Rule 8031 requirements on agricultural off-field storage of non-commodity bulk materials	NA

5.a. Require that VDE not exceed property line: Rule 8031 currently requires that the outdoor handling, storage, and transport of bulk materials not cause VDE to exceed 20% opacity. Under this proposed BACM, control measures would have to be implemented that would additionally prevent VDE from crossing any property line. Unfortunately, the cost-effectiveness of this candidate BACM cannot be quantified because no data relating emissions to VDE plume density could be found in the research literature.

5.b. Require construction of 3-sided enclosures with 50% porosity: Rule 8031 currently allows for the construction and maintenance of wind barriers sufficient to limit VDE to 20% opacity as an alternative method of controlling windblown PM10 emissions from bulk material storage piles. Under this proposed measure, wind barriers would have to be 3-sided and constructed to a 50% porosity standard (i.e., each lateral side would be faced with horizontal strips alternating with open spaces of equal width). To evaluate this measure, we evaluated the costs and benefits of protecting a five-cubic-yard bulk material storage pile.

The cost of constructing a 3-sided enclosure around a storage pile was derived from a Caltrans construction cost database.* For construction materials, we assumed the use of a cyclone fence with slats and metal posts. The construction cost of this fence was estimated to be $832 which, over a 15-year useful life, would equate to an annualized capital cost of $109.

Baseline emissions were computed from the CARB emission factors for windblown dust from unpaved roads.† The emission factors are reported on a county-specific basis, and a Valley average factor was computed by weighting each county-specific factor by the county land area. The resulting factor, converted from units of pounds of PM10 emitted per mile of 20-foot-wide unpaved road to pounds of PM10 emitted per acre of disturbed soil, was calculated to be 156 pounds of PM10 per acre per year. The surface area of a 5-cubic-yard pile with a typical angle of repose of 35E is 124 square feet, or 0.003 acres. From these factors, uncontrolled emissions were estimated to be 0.44 pounds of PM10 per year.

The control efficiency of a windscreen fence was evaluated from limited research data and dispersion modeling. Research conducted on wind screens in a wind tunnel test indicate that 50% porosity fences are capable of reducing downwind wind speeds to 50% of upwind wind speeds.‡ To evaluate the effect of a 50% reduction in wind speed on windblown PM10 emissions, we reconfigured a District meteorological file and reevaluated PM10 impacts from an earlier modeling study. In the earlier study, we evaluated the impacts at the Corcoran PM10 monitoring station from windblown PM10 generated by nearby disturbed open fields using a meteorological database collected at the Lemoore Naval Air Station in 1968.§ In this subsequent effort, we reduced the recorded wind speeds by 50% in each hourly record, and reran the ISC model to determine the changes in impact at the monitoring station. Because wind erosion occurs only above a wind speed threshold that ranges from 12 to 18 miles per hour, the reduction of wind speeds by 50% results in a dramatic increase in the number of hours during which no emissions are generated. From this analysis, we concluded that reducing wind speeds by 50% in the Corcoran area reduced windblown PM10 emissions by 99.6%. Because the windscreen required by this proposed measure is 3-sided, we conservatively estimated that emissions would be sharply reduced when winds blew from three of the four cardinal wind directions, and that emissions would not be reduced at all when the wind blew from this fourth direction. On this basis, we adjusted the modeled control efficiency by 75% to compute an adjusted control efficiency of 74.7%. The emission

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* 2001 Contract Cost Data, A Summary of Cost by Items for Highway Construction Projects, California Department of Transportation, January 2002, http://www.dot.ca.gov/hq/esc/oe/awards/

† Section 7.13, Windblown Dust - Unpaved Roads, CARB Area Source Methodologies, August 1997, http://www.arb.ca.gov/emisinv/areasrc/fullpdf/full7-13.pdf

‡ A Wind Tunnel Study of Wind Screen Effectiveness for Fugitive Dust Control, Hoydysh, W.G, Holynskyj, O., Rothstein, R., and Lassonde, R., 95-TA34.01, A&WMA 88th Annual Meeting & Exhibition, June 1995

§ Analysis of Source Significance Levels Through Dispersion Modeling (draft), prepared by Sierra Research for San Joaquin Valley UAPCD, November 2002 reduction computed using this control efficiency was 0.33 pounds of PM10 per year per 5-cubic-yard bulk material storage pile.

The cost-effectiveness of this proposed measure was estimated to be $330 per pound, or $659,000 per ton, of PM10 reduced.

5.c. Impose Rule 8031 requirements on sites storing less than 100 cubic yards of bulk materials: Rule 8031 currently exempts any site where bulk materials are stored in quantities of less than 100 cubic yards. Under this proposed measure, emissions from bulk material storage would be controlled to Rule 8031 specifications if any quantity of materials were stored on a facility's premises. To evaluate the cost-effectiveness of this measure, we assumed that the smallest quantity of bulk materials that would be stored at a single site would be five cubic yards. We also assumed that the preferred method of control would be construction of a windscreen, as dust suppressants would be effective only if piles remain undisturbed and the tarping of piles would incur labor costs in the frequent uncovering and covering of piles. As the scenario evaluated for this measure is identical to that studied in Measure 5.b, the cost-effectiveness of this measure is estimated to be the same: $330 per pound, or $659,000 per ton, of PM10 reduced.

5.d. Impose Rule 8031 requirements on agricultural off-field storage of non-commodity bulk materials: Rule 8081, Section 5.1, imposes requirements on the off-field storage of bulk materials on agricultural lands that are identical to Rule 8031 requirements. As a result, no analysis of this proposed BACM was conducted because this measure is already being implemented in Regulation VIII.

6. DISTURBED OPEN AREAS

Disturbed open areas generate PM10 emissions when loose surface soil particles are entrained by gusting winds. Emissions can be reduced by preventive measures that prevent the disturbance of open areas, reduce wind speeds at soil surfaces, or bind soil particles together. All of the candidate BACMs that impact disturbed open areas fall into one or more of these categories. These measures, together with their respective cost-effectiveness ratios, are listed in Table 6. Supporting calculations are presented in Appendix B.

Table 6
Disturbed Open Area Candidate BACM Cost-Effectiveness

Number	Measure	Cost-Effectiveness ($ per ton of PM10 reduced)
6.a	Impose Rule 8051 requirements on urban parcels of 0.5 acres or more in size that contain at least 1,000 square feet of disturbed surface	$67,800
6.b	Impose Rule 8051 requirements immediately after cessation of disturbance	$6,450 - $33,600

<u>6.a. Impose Rule 8051 requirements on urban parcels of 0.5 acres or more in size that contain at least 1,000 square feet of disturbed surface:</u> Rule 8051 currently requires that disturbed areas of 3.0 acres or more be stabilized within seven days through the application of water, vegetation, chemical dust suppressants, gravel, or paving. In addition, to prevent unauthorized vehicle trespass and redisturbance of such areas, physical barriers to prevent access or “No Trespassing” signs must be installed at the perimeter of the property. Under this proposed BACM, disturbed areas of 1,000 square feet (0.023 acres) or more on parcels equal to or greater than 0.5 acres in size would be required to be stabilized within seven days following disturbance. To evaluate this proposal, we assumed that the highest cost-effectiveness ratio would result from the treatment and signing of the smallest area required to be stabilized, and selected a disturbed area of 1,000 square feet on a 0.5 acre parcel for purposes of evaluation. We also assumed that the application of chemical dust suppressant would be the preferred choice of affected property owners because neither watering nor vegetative growth will produce a stabilized surface within seven days, and the application of gravel or paving would be more expensive.

The cost of applying polymer emulsion dust suppressant to a disturbed open area was derived from data reported in an unpaved road emission study[*] and from vendor data.[†] From these sources, we computed the cost of surface preparation and emulsion purchase and application to be $5,340 per acre. Since this dust suppressant has a useful life of one year under moderate traffic levels, we assumed that one application would effectively reduce emissions and maintain a stabilized surface for three years under a condition of no vehicle disturbance. On this basis, the annualized cost of dust suppressant application is $49 per year per 1,000 square foot disturbed area. The cost of installing No Trespassing signs was obtained from the Merced County Department of Public Works.[‡] Estimating that these signs have a useful life of 15 years resulted in an annualized cost for signs of $53 per year, and a total annualized cost of control of $102 per year for this measure.

Baseline emissions were computed from the CARB emission factors for windblown dust from unpaved roads.[§] The emission factors are reported on a county-specific basis, and a Valley average factor was computed by weighting each county-specific factor by the county land area. The resulting factor, converted from units of pounds of PM10 emitted per mile of 20 foot wide unpaved road to pounds of PM10 emitted per acre of disturbed soil, was calculated to be 156 pounds of PM10 per acre per year. For a 1,000 square foot area of disturbed soil, windblown PM10 emissions were computed to be 3.58 pounds per year.

The control efficiency of polymer emulsion dust suppressant for reducing PM10 emissions from traveled unpaved roads has been certified by CARB to be 84%.[†] A search of the research literature revealed no data on the long-term control efficiency of dust suppressants to reduce windblown emissions from undisturbed areas. If "No Trespassing" signs are posted on these properties, vehicle travel over them should be zero following implementation of this measure. Because some deterioration in the control efficiency of dust suppressants will occur with weathering, we cannot assume that 100% control efficiency will be achieved if vehicles are kept out. As a result, we accepted the 84% control efficiency certified by CARB for use of polymer emulsion dust suppressant on unpaved road surfaces as a lower limit for control of windblown emissions on disturbed open areas. On this basis, emission reductions were computed to be 3.01 pounds of PM10 per year per 1,000 square feet of disturbed area.

The cost-effectiveness of this proposed measure was computed to be $33 per pound, or $67,800 per ton, of PM10 reduced. If the control efficiency of dust suppressants was as high as 100% for windblown PM10 emissions from untraveled open areas, the cost-effectiveness of this measure would decline (improve) slightly to $56,900 per ton of PM10 reduced. It should be noted that the cost-effectiveness of this proposed measure will not vary much with the size of parcel treated. Thus, the cost-effectiveness of this measure is approximately equal to that of existing requirements in Rule 8051.

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[*] Effectiveness Demonstration of Fugitive Dust Control Methods for Public Unpaved Roads and Unpaved Shoulders on Paved Roads, prepared by Desert Research Institute for San Joaquin Valley UAPCD, December 1996

[†] Evaluation of the Air Quality Performance Claims for the Midwest Industrial Supply, Inc. Soil Cement Dust Suppressant, California Air Resources Board, April 2002

[‡] Telecom with S. Hamilton, Merced County Department of Public Works, November 6, 2002

[§] Section 7.13, Windblown Dust - Unpaved Roads, CARB Area Source Methodologies, August 1997, http://www.arb.ca.gov/emisinv/areasrc/fullpdf/full7-13.pdf

6.b. Impose Rule 8051 requirements immediately after cessation of disturbance:
Currently under Rule 8051, disturbed areas on parcels of 3.0 acres or more in size must be stabilized within seven days after the cessation of disturbance. Under this proposed BACM, disturbed areas would be stabilized immediately instead of up to seven days after disturbance. In evaluating this proposed measure, we computed the costs and benefits of controlling emissions from a 3.0-acre disturbed area, the smallest area to be regulated. As in the analysis of Measure 6.a, we assumed that the application of polymer emulsion dust suppressant would be the preferred control method used by property owners.

The cost of stabilizing a 3.0-acre disturbed area was computed in the analysis of Measure 6.a to be $5,340 per acre. Assuming that a single application of polymer emulsion would stabilize this area for three years in the absence of vehicle disturbance, the annualized cost of control was computed to be $6,450 for the 3 acres. Extending the duration of this control technology by seven days would effectively cost $124 for the 3 acres ($6,450 x 7 days/365 days). Correspondingly, the installation of No Trespassing signs seven days early would cost an additional $3.

Baseline emissions were computed on the basis of the county area-weighted CARB emission factor for windblown PM10 emissions on unpaved roads, as discussed in the analysis of Measure 6.a. For a disturbed area of 3.0 acres, baseline emissions were computed to average 8.97 pounds of PM10 per seven day period, assuming that annual emissions were distributed uniformly over each day. Under an alternate scenario, we assumed that these emissions were generated on 10 high wind days, and that the early application of dust suppressant would reduce emissions on one of these high wind days.[*] Under this scenario, baseline emissions were estimated to be 15.6 pounds of PM10 per seven-day period.

The control efficiency of polymer emulsion dust suppressant was estimated to be no less than 84%, as also discussed in the analysis of Measure 6.a. Applied to the baseline emissions computed for these scenarios, the emission reductions achieved through the early application of polymer emulsion would range from 1.44 to 7.54 pounds of PM10 during the seven days following application.

The cost-effectiveness of this proposed BACM was estimated to range from $3.22 to $16.80 per pound, or $6,450 to $33,600 per ton, of PM10 reduced.

[*] Memorandum from M. Zeldin, December 4, 2002

7. WINDBLOWN DUST

Windblown dust is produced whenever gusting winds cause loose soil particles to be entrained into the air. A fraction of these particles remain suspended in the air and contribute to concentrations of PM10. Sources of entrained soil particles include disturbed open areas, construction sites, unpaved roads, unpaved parking areas, and areas under agricultural cultivation, among others. Emissions can be reduced by measures that prevent the disturbance of open areas, reduce wind speeds at soil surfaces, or bind soil particles together. All of the candidate BACMs that impact disturbed open areas fall into one or more of these categories. These measures, together with their respective cost-effectiveness ratios, are listed in Table 7. Supporting calculations are presented in Appendix B.

Table 7
Windblown Dust Candidate BACM Cost-Effectiveness

Number	Measure	Cost-Effectiveness ($ per ton of PM10 reduced)
7.a	Require cessation of construction when wind events are declared	$7,770 - $12,700
7.b	Require cessation of construction when 20% opacity is exceeded	NA
7.c	Require continued operation of water trucks when construction ceases	$0
7.d	Require more than one stabilization method when 20% opacity exceeded on disturbed open areas	$15,000 - $65,600
7.e	Cease material handling activities when dust plumes cross property lines	NA
7.f	Water storage pile or cover when wind events are declared	$9,240 - $27,700

7.a. Require cessation of construction when wind events are declared: Rule 8021 currently requires that construction activities be sufficiently controlled so as to prevent the generation of visible dust plumes having an opacity greater than 20%. Under this proposed BACM, construction activities would cease on the days when wind events are declared, and dust control activities intended to maintain compliance with the 20% opacity standard would continue at construction sites. In evaluating this proposed measure, we used a 40-acre construction site, the smallest required to develop and implement a Dust Control Plan, as the example for calculation. We also assumed that the watering schedule used on a typical construction day would continue on a wind event day. As men and equipment allocated to construction would be idled on a wind event day, and as these resources could not be redirected to another nearby job site due to the fact that all construction sites in the local area would be shut down during a wind event, we assumed that the implementation costs would consist of the costs of idling these men and equipment for the day. These costs were concluded to dwarf those of interest costs on construction loans that were not evaluated or included in this analysis.

The cost of idled labor and equipment was computed on the basis of charge rate information received from construction managers. These costs were estimated to total $388 per hour total for four operators, one scraper, one bulldozer, one frontend loader, and one grader, or $3,100 per eight-hour day idled. The total cost of this proposed measure was calculated to be $5,070 per high wind day under this scenario.

Baseline emissions for this scenario represent the combination of construction and high wind emissions. Construction emissions were computed from an emission factor published by CARB.[*] For a 40-acre project, uncontrolled earthmoving emissions would total 1,547 pounds of PM10 per day. To control these emissions in the baseline scenario, we assumed that two water trucks would be used in continuous operation to water areas actively disturbed by earthmoving operations. We also assumed that no more than 30% of a project site, equal to 12 acres under this scenario, would be actively disturbed by earthmoving activities at any one time. From data collected by the District,[†] we estimated that two water trucks could spray the 12-acre area every 2.5 hours. The control efficiency of watering actively disturbed areas continuously was estimated to be 68.5%, based on data collected by MRI.[‡] Applying this control efficiency to the uncontrolled emission rate allowed us to estimate that baseline construction emissions under this scenario would be 487 pounds of PM10 per day per 40-acre site.

Windblown emissions were computed from emission factors developed by University of Nevada, Las Vegas (UNLV) research of windblown soil emissions in the Las Vegas area.[§] From these portable wind tunnel studies, the highest emission factor computed for a wind speed of 25 mph, the highest hourly average wind speed recorded in a Lemoore Naval Air Station database used in the modeling of windblown emissions in an earlier Sierra Research study,[**] was used to compute a maximum 24-hour emission rate for this scenario. For a 12-acre disturbed area, we estimated that the uncontrolled emissions would be 990 pounds per high wind day. Continuous watering of this site during the two hours that winds exceed 25 mph, at a rate of 0.055 gallons per square foot per hour and an interval of 2.5 hours between waterings, was estimated to produce a minimum control efficiency during a high wind event of 68.5%, based on the MRI research.[††] The

[*] Section 7.7, Building Construction Dust, CARB Area Source Methodologies, August 1997, http://www.arb.ca.gov/emisinv/areasrc/fullpdf/full7-7.pdf
[†] Draft Regulation VIII Staff Report, San Joaquin Valley UAPCD, September 2001
[‡] Particulate Emission Measurements from Controlled Construction Activities, EPA/60/R-01-031, prepared by Midwest Research Institute for U.S. Environmental Protection Agency, April 2001
[§] Development of Vacant Land PM-10 Emission Factors in the Las Vegas Valley, D. James/UNLV et al, November 2001
[**] Analysis of Source Significance Levels Through Dispersion Modeling, prepared by Sierra Research for the San Joaquin Valley UAPCD, October 2002
[††] Particulate Emission Measurements from Controlled Construction Activities, EPA/600/R-01/031, prepared by Midwest Research Institute for U.S. Environmental Protection Agency, April 2001

resulting baseline windblown PM10 emission rate under this scenario was estimated to be 312 pounds of PM10 per high wind event. The total baseline emission rate was calculated from construction and high wind contributions to be 799 pounds of PM10 per high wind day.

For the controlled emission scenario, we assumed that no construction would occur on the forecast high-wind day, and that the two water trucks assigned to the site would water the disturbed earthmoving area on a continuous basis, just as on a construction day. We assumed that negligible emissions would be produced by gusting winds impacting stabilized areas not involved in active earthmoving operations, and that watering would reduce windblown emissions on the active earthmoving areas by the minimum 68.5% forecasted by the MRI research. On this basis, we estimated construction emissions to be zero, and windblown emissions to be 312 pounds of PM10 per high wind event. The emission reduction under this scenario was calculated to be 487 pounds of PM10 per high wind day.

Under an alternate scenario, we assumed that watering of the active earthmoving areas would reduce windblown emissions by 100% on high-wind days. For this scenario, the emission reduction was estimated to be 799 pounds of PM10 per high wind day.

The cost-effectiveness of this measure was calculated to range from $3.88 to $6.37 per pound, or $7,770 to $12,700 per ton, of PM10 reduced.

<u>7.b. Require cessation of construction when 20% opacity is exceeded:</u> Rule 8021 currently requires that construction activities be sufficiently controlled so as to prevent the generation of visible dust plumes having an opacity greater than 20%. Under this proposed BACM, construction activities would be shut down when visible dust plumes exceeded 20% opacity. Because no research data could be found that relate emission strength with the opacity of visible dust plumes, the cost-effectiveness of this measure could not be evaluated.

<u>7.c. Require continued operation of water trucks when construction ceases:</u> Rule 8021 currently requires that construction activities be sufficiently controlled so as to prevent the generation of visible dust plumes having an opacity greater than 20%. Under this proposed BACM, construction activities would cease on the days when wind events are declared, and dust control activities intended to maintain compliance with the 20% opacity standard would continue at construction sites on days when wind events are declared and construction ceases. Because Rule 8021 requires dust control measures to be used to prevent windblown dust opacities from exceeding 20% during periods of inactivity, this measure is currently required, and the additional cost of implementing the measure as a BACM is zero. Because the cost is zero, the cost-effectiveness is also zero.

<u>7.d. Require more than one stabilization method when 20% opacity is exceeded on disturbed open areas:</u> Rule 8051 currently requires that disturbed areas of 3.0 acres or more be stabilized within seven days through the application of water, vegetation, chemical dust suppressants, gravel, or paving. Under this proposed BACM, owners would be required to treat disturbed areas with more than one stabilization method when the opacity of visible dust plumes from these areas exceeds 20%. To evaluate this

proposal, we assumed that the highest cost-effectiveness ratio would result from the treatment of a 3-acre disturbed area, the smallest area currently regulated under Rule 8051. We also assumed that the first stabilization method would have been the cultivation of vegetation, as the least expensive in terms in initial investment, and that the application of chemical dust suppressant would be the preferred choice for a second stabilization method, as the next least expensive, by affected property owners. In a second analysis, we assumed that gravel would be spread over the 3-acre, partially vegetated, site to achieve compliance.

The cost of applying polymer emulsion dust suppressant to a disturbed open area was derived from data reported in an unpaved road emission study[*] and from vendor data.[†] From these sources, we computed the cost of surface preparation and emulsion purchase and application to be $5,340 per acre. Since this dust suppressant has a useful life of one year under moderate traffic levels, we assumed that one application would effectively reduce emissions and maintain a stabilized surface for three years under a condition of no vehicle disturbance. On this basis, the annualized cost of dust suppressant application is $6,450 per year per 3-acre disturbed area.

The cost of spreading gravel over a disturbed open area was derived from data obtained from a Valley aggregate producer.[‡] Class II base rock was estimated to cost $6.40 per ton, and hauling charges were estimated at $0.15 per ton-mile. A one-inch layer of gravel was estimated to cost $1,700 per acre for delivered materials, and $157 for spreading. The gravel was expected to have a useful life of 5 years, resulting in an annualized treatment cost of $490 per acre-year. Under this scenario, we also assumed that only 75% of the partially vegetated site needed additional treatment, which resulted in an estimated annual cost for gravel application of $1,100 per year for the a 3-acre site.

Baseline emissions were computed from the CARB emission factors for windblown dust from unpaved roads.[§] The emission factors are reported on a county-specific basis, and a Valley-average factor was computed by weighting each county-specific factor by the county land area. The resulting factor, converted from units of pounds of PM10 emitted per mile of 20-foot-wide unpaved road to pounds of PM10 emitted per acre of disturbed soil, was calculated to be 156 pounds of PM10 per acre per year. For a 3-acre site of disturbed soil, uncontrolled windblown PM10 emissions were estimated to be 468 pounds per year. From a study conducted in the Antelope Valley area of southern California, we estimated that the cultivation of vegetation would reduce PM10 emissions by a minimum of 50% in an arid, unirrigated area.[**] By applying this control efficiency to the estimate of uncontrolled emissions, we calculated that baseline emissions would be 234 pounds of

[*] Effectiveness Demonstration of Fugitive Dust Control Methods for Public Unpaved Roads and Unpaved Shoulders on Paved Roads, prepared by Desert Research Institute for San Joaquin Valley UAPCD, December 1996

[†] Evaluation of the Air Quality Performance Claims for the Midwest Industrial Supply, Inc. Soil Cement Dust Suppressant, California Air Resources Board, April 2002

[‡] Telecom with D. Harrald, Keweah River Rock Co., September 24, 2002

[§] Section 7.13, Windblown Dust - Unpaved Roads, CARB Area Source Methodologies, August 1997, http://www.arb.ca.gov/emisinv/areasrc/fullpdf/full7-13.pdf

[**] Stabilizing Fugitive Dust Emissions in the Antelope Valley from Abandoned Farmlands and Overgrazing, D. Grantz et al, 95-MP12.04, 88th Annual Meeting of the Air & Waste Management Association, June 1995

PM10 per year for a 3-acre area of disturbed open area. For an area where vegetation provided adequate protection to 25% of the site, baseline emissions were estimated to be 175 pounds of PM10 per year.

The control efficiency of polymer emulsion dust suppressant for reducing PM10 emissions from traveled unpaved roads has been certified by CARB to be 84%.* A search of the research literature revealed no data on the long-term control efficiency of dust suppressants to reduce windblown emissions from undisturbed areas. We conservatively estimated that dust suppressants applied to inactive disturbed areas would provide a minimum 84% control efficiency on the basis of the CARB certification for actively disturbed areas. From this control efficiency, emission reductions were computed to be 196 pounds of PM10. For an undisturbed site, we assumed that a 1-inch gravel blanket would also provide an equivalent 84% control efficiency for windblown emissions. Under this scenario, emission reductions were estimated to be 147 pounds of PM10 per year.

The cost-effectiveness of this proposed measure was computed to range from $7.48 to $32.80 per pound, or $15,000 to $65,600 per ton, of PM10 reduced.

<u>7.e. Cease material handling activities when dust plumes cross property lines:</u> Rule 8031 currently requires that the outdoor handling, storage, and transport of bulk materials not cause VDE to exceed 20% opacity. Under this proposed BACM, control measures would have to be implemented that would additionally prevent VDE from crossing any property line. Unfortunately, the cost-effectiveness of this candidate BACM cannot be quantified because no data relating emissions to VDE plume density could be found in the research literature.

<u>7.f. Water storage piles or cover when wind events are declared:</u> Rule 8031 requires that visible dust plumes from storage piles not exceed 20% opacity. Approvable methods for satisfying this condition in advance include stabilizing storage pile surfaces with dust suppressants or vegetation, covering piles with anchored tarps, or constructing wind barriers sufficient to limit visible dust plumes to 20% opacity. Under this proposed measure, storage piles must be watered or covered upon the declaration of a wind event that would be issued the evening before high winds were expected to occur. To evaluate this proposal, we used a single storage pile containing 100 cubic yards for the calculation example as this is the smallest volume of material regulated under Rule 8031, and a single pile provides the smallest surface area for any stored volume. We also assumed that watering would be the preferred method of compliance as this control method is the least expensive on the basis of infrequent use.

The cost of watering was computed on the basis of minimum wage labor rates. The surface area of a 100-cubic-yard pile was estimated to be 102 square yards, and we assumed that the surface could be watered manually with a hose in 20 minutes. We also

* Evaluation of the Air Quality Performance Claims for the Midwest Industrial Supply, Inc. Soil Cement Dust Suppressant, California Air Resources Board, April 2002

assumed that the storage pile would be watered hourly for eight hours during the day forecasted to have high winds. The labor cost for a minimum wage employee,[*] plus an estimated 20% for benefits, working 20 minutes in each hour over an eight-hour day is $21.60.

Baseline emissions for this scenario were computed from emission factors developed by University of Nevada Las Vegas (UNLV) research of windblown soil emissions in the Las Vegas area.[†] From these portable wind tunnel studies, the highest emission factor computed for a wind speed of 25 mph (the highest hourly average wind speed recorded in a Lemoore Naval Air Station data base used in the modeling of windblown emissions in an earlier Sierra Research study[‡]) was used to compute a maximum 24-hour emission rate assuming that such winds occurred for two consecutive hours under this scenario. We estimated that the pile surface would equal 0.012 acres, and that the uncontrolled emissions from this pile would be 1.73 pounds per high-wind day. Under an alternate scenario, we assumed that high winds would occur for six consecutive hours, which resulted in uncontrolled emissions of 5.19 pounds of PM10 per high-wind day.

For the controlled emission scenario, we assumed that hourly watering would be performed prior to and during high winds on a high-wind day. No research data were found that reported the control efficiency of watering during high-wind events in the absence of soil disturbing activities. However, research conducted by the University of California Riverside concluded that frequent watering of an area under active earthmoving operation reduced windblown emissions by 90%.[§] On the basis of these data, we estimated that hourly watering would reduce emissions from a storage pile by a minimum of 90% on a high wind day. The resulting emission reductions were estimated to range from 1.56 to 4.68 pounds of PM10 per high wind day.

The cost-effectiveness of this measure was calculated to range from $4.62 to $13.86 pound, or $9,240 to $27,700 per ton, of PM10 reduced.

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[*] California Minimum Wage Office Notice, California Department of Industrial Relations, January 2001, http://www.dir.ca.gov/Iwc/Minwage2001.pdf

[†] Development of Vacant Land PM-10 Emission Factors in the Las Vegas Valley, D. James/UNLV et al, November 2001

[‡] Analysis of Source Significance Levels Through Dispersion Modeling, prepared by Sierra Research for the San Joaquin Valley UAPCD, October 2002

[§] Evaluation of Watering to Control Dust in High Winds, D. Fitz et al, CCERT, UC Riverside, Volume 50, JA&WMA, April 2002

Appendix A

Final Candidate BACM List

Final Candidate BACM List
(Subject to Change Based on BACM Feasibility Analysis)

Fugitive Dust Source Category	Subcategory	Candidate BACM
Applicable Reg. VIII Sources (not for unpaved roads)	Opacity Limit	Create a distance and opacity limit to the visible dust plume, with the use of distance to not more than 100 yards and the use of an opacity limit of 20%.
Paved Roads	New/Modified Roads	Eliminate the ADVT threshold for paving 4 feet from the current ADVT trigger level of 500 for such a paving requirement (consistent with EPA's guidance for BACM).
	Unpaved shoulders	Get commitments from incorporated municipalities to "retrofit" existing unpaved shoulders with the following conditions: 1. Determine cumulative miles of unpaved shoulders according to road ADVT; 2. Pave or stabilize (per R. 8061) shoulder-miles of top 50% ADVT according to a phase-in schedule: 10% by end of 2004, and an additional 10% by the end of 2005.
	Street Sweepers	Require incorporated municipalities to do the following as it applies to new purchases of street sweepers for city or city-contracted fleets: 1. Purchase certified PM10-efficient street sweepers as new or replacement purchases to existing fleet; 2. Purchase at least one such unit within three years of the adoption and/or amendment of an applicable rule for existing street sweeper fleets of two or more (fleet refers to city-owned or contracted—if contractor fleet, the minimum purchase requirement applies separately to each jurisdiction for which the street sweeping contract exists); 3. If fleet contains both certified sweepers and non-certified sweepers, prioritize the use of certified sweepers for dirt-laden streets prior to any routine street sweeping. Municipalities are required to identify such dirt-laden routes and provide the District with a priority list of such routes within one year of rule adoption and/or amendment; 4. Use certified-PM10 efficient street sweeper at least once per month; 5. Operate and maintain such sweepers according to manufacturer specifications.
	Erosion Clean-up	Require incorporated municipalities to: 1. Remove debris/material after wind or rain runoff event by using street sweepers within 24 hours of identification, or prior to opening up traffic lanes in the event lanes were originally shut due to the erosion event; 2. Follow adequate dust control procedures in the removal of the material.

Fugitive Dust Source Category	Subcategory	Candidate BACM
Unpaved Roads	Control requirements	1. Set maximum speed limit at 25 mph (requires local legislator to sponsor);* 2. Prohibit the existence of new non-temporary† unpaved roads within any incorporated municipality or within a buffer distance (e.g. 5 miles) of any city limit; 3. Establish provisions for the paving of existing unpaved roads under the purview of any government entity for a cumulative total of 5 miles over a five year period (exemptions could apply to any road more than five miles from any city boundary);
Unpaved Parking Lots/Staging Areas	Applicability	1. Eliminate the one acre exemption level; 2. Lower the AVTD thresholds and add an additional tier to capture 1-25 VTD 3. Use real counts not averages
	Requirements	1. Use three tiers of dust control options to reduce VDE: a. 1-25 VTD 1. watering and 2. lower vehicle speed with various speed control options b. 26-75 VTD 1. Keep existing options under R. 8071, section 5.1.1 c. 76 -100 VTD 1. Keep existing options under R. 8071, section 5.1.2 d. For VTD greater than 100, or for VDT of greater than 10 of vehicles with more than two axles, require paving, gravel to a uniform depth of 4 inches, or use of dust suppressants in sufficient quantity and re-application to maintain a stabilized surface at all times. 2. For Special Events or Unpaved Areas for Periodic Use: a. Notify the District at least 48 hours prior to the occurrence of any special event; b. Define special events for notification purposes in which there are at least 1000 vehicles using the unpaved staging area/parking lots within a 24-hour, calendar-day, period; c. Require paving, gravel to a uniform depth of 4 inches, or use of dust suppressants in sufficient quantity and re-application to maintain a stabilized surface at all times.

* This would initially require legislation to amend §22365 of the California Vehicle Code to include the San Joaquin Valley in allowing maximum speed limits of 25 mph. Currently, this authorization only applies to the SCAQMD when necessary to meet PM standards, and there should be sufficient justification for legislative assistance in adding the need for the Valley. Assuming the enabling legislation can be sponsored, Regulation VIII could be modified.

† Non-temporary could be defined as any public or private road that will not be paved or otherwise prohibited from use after a six-month period.

Fugitive Dust Source Category	Subcategory	Candidate BACM
		3. Suggested Best Management Practices (BMP) as guidance, have owners and/or operators apply the following provisions for staging areas: a. Limit size of staging areas; b. Apply water and/or dust palliative; c. Limit vehicle speeds to 15 mph; d. Limit ingress and egress points.
Construction	Demolition	Modify actions A1 and A2 in Table 8021-1 to the following: 1. Apply chemical dust suppressants to all erodible surfaces within 100 feet of the structure to be demolished. Watering may be used in place of dust suppressants only if water is applied within one hour of the start of demolition; 2. Apply water or chemical dust suppressants to all areas where demolition equipment will operate; 3. Apply water and/or dust suppressants to all disturbed soil surfaces and debris within one hour of the completion of the demolition, and at the conclusion of each work day should the demolition activity extend over two or more days. 4. Prohibit demolition activities when wind speeds exceed 25 miles per hour.
	Earthmoving: Planning	1. Add the following reportable requirements to the Dust Control Plan: a. Define the boundaries and anticipated timelines for phased construction operations; b. Include an emergency contact person and phone number in the event of dust generation during periods of non-activity; c. Require Dust Control Training Class, to be completed within 90 days of Dust Control Plan submittal, for at least one key person from the developer/builder responsible for on-site activities, and identify person(s) attending such training. 2. District Outreach: a. Provide examples of acceptable Dust Control Plans; b. Provide dust control training courses for key construction personnel at regular intervals (e.g., quarterly basis).
	Earthmoving: On-site Dust Monitoring	Require an on-site dust monitoring person with specific dust control duties for projects with more than 50 acres of disturbed surface.
	Earthmoving: Exemptions	Suggested BMP as guidance: Consider limited exemptions (limited District oversight in the form of providing dust control plan information and using an on-site dust monitoring person) for all earthmoving operations of 10 acres or more occurring throughout the year except for the months of July, August, Septembers, and October. A limited District oversight agreement can be devised to involve a signed agreement or statement assuring that no earthmoving operations would be conducted during the 4-month period (July through October) as part of initiating a limited District oversight of the construction operation.

Fugitive Dust Source Category	Subcategory	Candidate BACM
	Earthmoving: Active Operations	1. Require minimum soil moisture content of 12% (per applicable test method, e.g., ASTM Method D-2216-98); 2. Limit all on-site vehicle speeds to 15 mph. For all sites greater than 10 acres, require posting of speed limit signs.
	Inactive Disturbed Land	Clarify Table 8021-2, Section C2 to read: "Meet conditions of a stabilized surface as defined in Rule 8011, Section 3.56."
General	Dust Control Plan Applicability	1. Lower the existing de minimis level for requiring a Dust Control Plan to 10 acres for residential developments and 5 acres for commercial developments that are within 5 miles of any urban area; and 2. Add a requirement for Dust Control Plan notification for all earthmoving operations between 1 and 10 acres for residential developments and between 1 and 5 acres for commercial developments that are within 5 miles of any urban area; and 3. Notification should include the following: a. Information on the owner/operator b. Site Location c. Operation Size d. Expected Start and End Dates e. Acknowledgment of Regulation VIII Requirements f. Signature of Authorized Representative
	Dust Control Plan Requirements	See requirements under "Construction, Earthmoving: Planning,"
Bulk Materials	Handling/Storage	1. Add provision that VDE not exceed the property line; 2. In Table 8031-1, A4, specify that wind barriers must be less than 50% porosity and define "porosity" in Rule 8011; 3. Add option A5 to Table 8031-1, which would specify utilization of enclosures with at least 3 sides with less than 50% porosity, and at least as high as the height of the storage pile; 4. Under Rule 8031, Section 4.4, delete the words: "…and handling…" 5. Amend Exemption Section 4.5 of Rule 8031, so that it does not apply to on-field storage of non-commodity bulk material; 6. Suggested BMP as guidance for handling/loading bulk materials into containers: a. Minimize drop height; b. Empty bucket slowly; c. Remove material from leeward side of pile.
	Transport	Change provisions to "prevent VDE" rather than to limit VDE to 20% opacity (tighten 8031 1 B and C).
	Outdoor Chute/Conveyor	Include an additional provision to Rule 8031-1, as D4, that VDE not exceed the property line.

Fugitive Dust Source Category	**Subcategory**	**Candidate BACM**
Carryout/Trackout	Removal	1. Add provision to Rule 8041, Section 5.8, as a requirement in addition to the options specified in sections 5.8.1-5.8.3, as follows: Remove any trackout onto public paved roadways within one hour of such occurrence; 2. Modify exemptions so that only on-field ag sources are exempt.
	Prevention	1. Under Rule 8041, Section 5.3, add the underlined words: An owner/operator of any site with 150 or more vehicle trips per day, <u>or 10 or more vehicle trips per day with vehicles of more than two axles</u>, shall prevent carryout and trackout as specified in Section 5.8. 2. Modify section 5.8.1 to specify minimum dimensions for trackout control devices to be from the point of intersection with the public paved road to at least 25 feet in length and full width of access road; 3. Modify section 5.8.2 to specify minimum dimensions for minimum paved road to be from the point of intersection with the public paved road to at least 100 feet in length and full width of access road; 4. Add another option to allow gravel pads at least 3 inches deep, and extending from the point of intersection with the public paved road to at least 50 feet in length and the full width of the access road.
	Clean-Up Methods	None required.
Disturbed Open Lands	Definition of Stabilized Surface	None required.
Disturbed Open Areas	Applicability	1. Conduct specific technical analyses to determine if this source category is de minimis, and therefore only requires RACM demonstration: <u>Analysis A</u>: a. For de minimis determination, break-down emission components of this source category to determine percentage component from open areas versus other components, such as from construction or agriculture; b. Compare PM10 levels from the top 10 windiest days to the highest fugitive dust days with corresponding average wind speeds to demonstrate that windblown emissions are not associated with episodic days. <u>Analysis B</u>: If (a) and (b) above apply, then determine, of the total acreage of disturbed lands, what percent is exempted by the 3-acre limit. If that percent is reasonable low, the case can be made acceptable for RACM. 2. Under Rule 8051, Section 2.0, if the case cannot be made for a de minimis source category under Analysis A, then modify existing rule language to read as follows: This rule applies to any open area having 0.5 acres or more within urban areas, or 3.0 acres or more elsewhere, which contains at least 1000 square feet of disturbed surface area. (Note: This adds the urban area limit, the 1000 square foot limit, and deletes the 7-day provision).
	Control Measures	Additional stringency is not required. See analysis suggestions under “applicability” for this source category.

Fugitive Dust Source Category	Subcategory	Candidate BACM
Weed Abatement	Requirements	1. Move requirements to Rule 8051; 2. Grant an exemption for weed abatement activities that use mowing and/or cutting which maintains stubble of at least 3 inches above the soil.
Windblown Dust	General/Definitions	1. Add a definition for "windblown fugitive dust" as "any visible emissions caused by wind action alone emanating from any disturbed surface area." 2. Add a definition for "wind event" as "any day in which winds exceed 25 miles per hour, as a 1-minute averaged gust, as determined by the District and made available to the public."
	Construction and Earthmoving Operations	1. Cease all earthmoving operations whenever a wind event is declared. 2. If there is no declaration of a wind event, and application of dust control measures are insufficient to limit VDE to 20% opacity and a plume distance of 100 yards, then operations must cease until wind conditions subside sufficiently so that dust control efforts can meet VDE standards. 3. During times when operations cease, water trucks must continue to operate unless unsafe to do so.
	Disturbed Open Lands	If requirements for a stabilized surface, as defined in Rule 8011, Section 3.56, are insufficient to limit windblown fugitive dust VDE to 20% opacity and plume distance of 100 yards, then require more than one stabilization method or a greater level of application.
	Bulk Materials, Handling and Storage	1. During a wind event, if the application of dust control measures is insufficient to limit VDE to a plume distance beyond the property line, then handling activities must cease. 2. During a wind event, open storage piles must be watered at least once per hour or covered with tarps, or other similar coverings.
Agricultural Operations	Requirements	1. Prohibit end-row turnarounds onto public paved roadways 2. Consider no-tilling days when wind events are declared **Need candidate BACM controls in response to EPA TSD comment, p. 20, with respect to on-field bulk materials. Also need to consult with the AG Tech Group.**
	BMPs	BMPs are suggested for agricultural cultural practices. Details of such practices from the South Coast AQMD and Maricopa County of Governments may be used as guides.

Appendix B

BACM Cost-Effectiveness Calculations

SOURCE: PAVED ROADS

		Measure	Cost Effectiveness of Measure (2002 $/ton PM10 reduction)	
1	a	Require 4 ft paved shoulders for all new or modified paved roads	$13,800	$554,000
1	b	Require construction of 4 ft paved or stabilized shoulders on 50% of highest ADVT existing paved roads	$7,290	$11,300
1	c	Limit purchase of new or replacement street sweepers to PM10-efficient units	$33	
1	d	Require purchase of one PM10-efficiency sweeper within 3 years	$792	
1	e	Require municipalities to identify dirt-laden streets for priority sweeping by PM10-efficient units	NA	
1	f	Require streets to be swept by PM10-efficient sweepers at least once per month	$1,070	
1	g	Require PM10-efficient street sweepers to be operated and maintained according to manufacturer's specs	NA	
1	h	Require wind- or water-borne deposition to be cleaned up within 24 hr after discovery	$2,850	

Common Parameters:

Annual Interest Rate = 10.0%
Average Vehicle Weight = 2.4 ton (CARB Emission Inventory Methods, 7.9 Road Dust, http://www.arb.ca.gov/emisinv/areasrc/fullpdf/full7-9.pdf)
PM10-Efficiency Sweeper Capital Cost = $152,000 (Maricopa Association of Governments PM-10 Efficient Street Sweeper Study, MAG, December 2001)
Non-PM10-Efficient Sweeper Capital Cost = $149,000 (Maricopa Association of Governments PM-10 Efficient Street Sweeper Study, MAG, December 2001)
Sweeper Useful Life = 8 yr (S. Howard/Phoenix, October 2002)

Measure: **1a. Require 4 ft paved shoulders for all new or modified paved roads**

Construction/Operational Cost:

Construction Cost = $33,000 /curb mile (R. Stauch/Granite Const., 10/28/02)
= $66,000 /road mile
Useful Life = 20 yr (estimated)
Capital Recovery Factor = 0.117
Annualized Capital Cost = $7,752 /road mile-yr

Chip Seal Cost = $2,625 /road mile (R. Stauch/Granite Const., 10/28/02)
Useful Life = 10 yr (estimated)
Capital Recovery Factor = 0.163
Annualized Capital Cost = $427 /road mile-yr

Total Annual Cost = $8,180 /road mile-yr

Baseline Emissions:

Worst Case Cost-Effectiveness Scenario
Truck Wake Emission Factor = 0.03 lb PM10/mile-truck (DRI, 1996)
Average Truck Traffic Fraction = 3% (2000 Annual Average DailyTruck Traffic, Caltrans, November 2001)
Minimum Traffic Volume = 100 vehicles/day (estimated from local rural paved road ADT survey of San Joaquin Valley transportation planning agencies)
Minimum Volume Truck Traffic Level = 3 trucks/day
Daily Emission Rate = 0.09 lb PM10/mile
Annual Truck Wake Emission Rate = 32.9 lb PM10/mile

Unpaved Shoulder Traffic =	10 LDT vehicle entrances/day (estimated)
	1 18-wheel vehicle entrances/day (estimated)
Deposition to Paved Road =	0.0033 lb/pickup-pass (Particulate Emission Measurement from Controlled Construction Activities, EPA/600/R-01/031, EPA, April 2001)
=	0.0008 lb/pickup tire-pass
=	0.0021 lb/18-wheel heavy duty truck tire (based on tread area and wheel force ratios)
=	0.0378 lb/18-wheel truck
Deposition to Paved Road Rate =	0.07 lb soil/mile-day
Deposition Fraction Emitted as PM10 =	30% (M. Zeldin email, 10/8/02)
Deposition Emitted as PM10 =	0.02 lb PM10/mile-day
=	7.72 lb PM10/mile-yr
Baseline Emissions =	40.6 lb PM10/mile-yr

Typical Emission/Cost Scenario

Truck Wake Emission Factor =	0.03 lb PM10/mile-truck (DRI, 1996)
Average Truck Traffic Fraction =	3% (2000 Annual Average DailyTruck Traffic, Caltrans, November 2001)
50th Percentile Traffic Volume on Local Roads =	2700 vehicles/day (estimated from local rural paved road ADT survey of San Joaquin Valley transportation planning agencies)
Average Truck Traffic Level =	81 trucks/day
Daily Emission Rate =	2.43 lb PM10/mile-day
Annual Truck Wake Emission Rate =	887.0 lb PM10/mile-yr
Unpaved Shoulder Traffic =	270 LDT vehicle entrances/day (estimated)
	8 18-wheel vehicle entrances/day (estimated)
Deposition to Paved Road =	0.0287 lb/vehicle-pass (Control of Open Fugitive Dust Sources, EPA-450/3-88-008, EPA, September 1988)
=	0.0072 lb/vehicle tire-pass
=	0.0185 lb/18-wheel heavy duty truck tire (based on tread area and wheel force ratios)
=	0.3322 lb/18-wheel truck
Deposition to Paved Road Rate =	10.43 lb soil/mile-day
Deposition Fraction Emitted as PM10 =	30% (M. Zeldin email, 10/8/02)
Deposition Emitted as PM10 =	3.13 lb PM10/mile-day
=	1,142 lb PM10/mile-yr
Baseline Emissions =	2,029 lb PM10/mile-yr

Controlled Emissions:

No study of the control effectiveness of road shoulder paving on road shoulder/truck bow wake emissions has been conducted.

Estimated Control Efficiency of Road Shoulder Paving on Truck Wake Emissions =	80% (estimated)
Control Efficiency of Road Shoulder Paving on Trackout Emissions =	42% (Particulate Emission Measurements from Controlled Construction Activities, EPA/600/R-01/031, EPA, April 2001)

Worst Case Cost-Effectiveness Scenario

Controlled Emissions = 11.0 lb PM10/mile-yr

Typical Emission/Cost Scenario

Controlled Emissions = 840 lb PM10/mile-yr

Emission Reduction:

Worst Case Cost-Effectiveness Scenario
Emission Reduction = 29.5 lb PM10/mile-yr

Typical Emission/Cost Scenario
Emission Reduction = 1,189 lb PM10/mile-yr

Cost-Effectiveness:

Worst Case Cost-Effectiveness Scenario
Cost-Effectiveness = $277.07 /lb PM10
= $554,142 /ton PM10

Typical Emission/Cost Scenario
Cost-Effectiveness = $6.88 /lb PM10
= $13,756 /ton PM10

Measure: **1b. Require construction of 4 ft paved or stabilized shoulders on 50% of highest ADVT existing paved roads**

Option: Stabilize shoulders on existing paved roads

Construction/Operational Cost:

Shoulder Treatment Cost = $0.92 /yd2-yr (see Measure 6.a)
Annualized Treatment Cost = $4,337 /road mile-yr

Total Annual Cost = $4,337 /road mile-yr

Baseline Emissions:

Worst Case Cost-Effectiveness Scenario
Emission Factor = 0.03 lb PM10/mile-truck (DRI, 1996)
Average Truck Traffic Fraction = 3% (2000 Annual Average DailyTruck Traffic, Caltrans, November 2001)
50th Percentile Traffic Volume on Local Roads = 2700 vehicles/day (estimated from local rural paved road ADT survey of San Joaquin Valley transportation planning agencies)
Minimum Volume Truck Traffic Level = 81 trucks/day
Daily Emission Rate = 2.43 lb PM10/mile
Annual Emission Rate = 887.0 lb PM10/mile

Unpaved Shoulder Traffic = 270 LDT vehicle entrances/day (estimated)
8 18-wheel vehicle entrances/day (estimated)
Deposition to Paved Road = 0.0033 lb/pickup-pass (Particulate Emission Measurement from Controlled Construction Activities, EPA/600/R-01/031, EPA, April 2001)
= 0.0008 lb/pickup tire-pass
= 0.0021 lb/18-wheel heavy duty truck tire (based on tread area and wheel force ratios)
= 0.0378 lb/18-wheel truck
Deposition to Paved Road Rate = 1.19 lb soil/mile-day
Deposition Fraction Emitted as PM10 = 30% (M. Zeldin email, 10/8/02)
Deposition Emitted as PM10 = 0.36 lb PM10/mile-day
= 130.1 lb PM10/mile-yr

Baseline Emissions =	1,017	lb PM10/mile-yr
Typical Emission/Cost Scenario		
Emission Factor =	0.03	lb PM10/mile-truck (DRI, 1996)
Average Truck Traffic Fraction =	3%	(2000 Annual Average DailyTruck Traffic, Caltrans, November 2001)
50th Percentile Traffic Volume on Local Roads =	2700	vehicles/day (estimated from local rural paved road ADT survey of San Joaquin Valley transportation planning agencies)
Minimum Volume Truck Traffic Level =	81	trucks/day
Daily Emission Rate =	2.43	lb PM10/mile
Annual Emission Rate =	887.0	lb PM10/mile
Unpaved Shoulder Traffic =	270	LDT vehicle entrances/day (estimated)
	8	18-wheel vehicle entrances/day (estimated)
Deposition to Paved Road =	0.0287	lb/vehicle-pass (Control of Open Fugitive Dust Sources, EPA-450/3-88-008, EPA, September 1988)
=	0.0072	lb/pickup tire-pass
=	0.0185	lb/18-wheel heavy duty truck tire (based on tread area and wheel force ratios)
=	0.3322	lb/18-wheel truck
Deposition to Paved Road Rate =	10.43	lb soil/mile-day
Deposition Fraction Emitted as PM10 =	30%	(M. Zeldin email, 10/8/02)
Deposition Emitted as PM10 =	3.13	lb PM10/mile-day
=	1,142	lb PM10/mile-yr
Baseline Emissions =	2,029	lb PM10/mile-yr

Controlled Emissions:

No study of the control effectiveness of road shoulder paving on road shoulder/truck bow wake emissions has been conducted.

Estimated Control Efficiency of Road Shoulder Paving on Truck Wake Emissions =	80%	(estimated)
Control Efficiency of Road Shoulder Paving on Trackout Emissions =	42%	(Particulate Emission Measurements from Controlled Construction Activities, EPA/600/R-01/031, EPA, April 2001)
Worst Case Cost-Effectiveness Scenario		
Controlled Emissions =	253	lb PM10/mile-yr
Typical Emission/Cost Scenario		
Controlled Emissions =	840	lb PM10/mile-yr

Emission Reduction:

Worst Case Cost-Effectiveness Scenario		
Emission Reduction =	764	lb PM10/mile-yr
Typical Emission/Cost Scenario		
Emission Reduction =	1,189	lb PM10/mile-yr

Cost-Effectiveness:

Worst Case Cost-Effectiveness Scenario		
Cost-Effectiveness =	$5.67	/lb PM10

= $11,350 /ton PM10

Typical Emission/Cost Scenario
Cost-Effectiveness = $3.65 /lb PM10
= $7,293 /ton PM10

Measure: **1c. Limit purchase of new or replacement street sweepers to PM10-efficient units**

Construction/Operational Cost:

PM10-Effic. Sweeper Capital Cost = $152,000 (Maricopa Association of Governments PM-10 Efficient Street Sweeper Study, MAG, December 2001)
Non-PM10 Efficiency Sweeper Capital Cost = $149,000 (MAG, December 2001)
Difference in Capital Cost = $3,000
Useful Life = 8 yr (S. Howard/Phoenix, October 2002)
Capital Recovery Factor = 0.187
Annualized Capital Cost = $562 /yr

Major Street/Collector Sweeping Schedule = 14 days/circuit (S. Howard/Phoenix, October 2002)
Effective Sweeping Schedule = 6 hr/day (S. Howard/Phoenix, October 2002)
= 5 day/week (S. Howard/Phoenix, October 2002)
Average Sweeping Rate = 5 curb-miles/hr (MAG, December 2001)
= 30 curb-miles/day
= 15 centerline-miles/day
= 150 centerline-miles/yr (within the 14-day circuit)

Total Annual Cost = $562 /yr
= $3.75 /yr-centerline-mile

Baseline Emissions:

Default Street Silt Loading = 0.035 gm/m2 (Section 7.9, arterials/collectors, CARB Area Source Methodology, August 1997)
= 0.32 gm/m2 (Section 7.9, local roads, CARB Area Source Methodology, August 1997)
Baseline Emission Factor = 825.5 lb PM10/10^6 VMT (Section 7.9, arterials/collectors, CARB Area Source Methodology, August 1997)
= 3478.8 lb PM10/10^6 VMT (Section 7.9, local roads, CARB Area Source Methodology, August 1997)

Reduction in Street Soil Loading From Sweeping = 55% Non-PM10-efficient sweeping (Fugitive Dust BACM, 9/92, p. 3-1)

Equilibrium Return Time = 5.5 days - non-PM10-efficient sweeping (Particulate Control Measure Feasibility Study, Sierra Research, August 1996)

Non-PM10-Efficient Sweeping Effectiveness:

	Average Silt		Emission Factor		Sweeping Effective.	
Days Between Sweeping	Arterials/ Collector (gm/m2)	Local Streets (gm/m2)	Arterials/ Collector 1e6VMT)	Local Streets 1e6VMT)	Arterials/ Collector (%)	Local Streets (%)
1	0.000	0.000	0.0	0.0	100.0%	100.0%
2	0.005	0.042	219.8	926.1	73.4%	73.4%
3	0.009	0.084	344.9	1453.3	58.2%	58.2%
4	0.014	0.125	448.9	1891.5	45.6%	45.6%
5	0.018	0.167	541.2	2280.6	34.4%	34.4%
6	0.023	0.209	625.7	2636.7	24.2%	24.2%
7	0.026	0.237	678.5	2859.2	17.8%	17.8%
10	0.029	0.262	724.3	3052.2	12.3%	12.3%

14	0.030	0.278	753.9	3177.2	8.7%	8.7%
15	0.031	0.281	758.8	3197.8	8.1%	8.1%
21	0.032	0.292	778.2	3279.4	5.7%	5.7%
28	0.033	0.299	790.2	3329.8	4.3%	4.3%
30	0.033	0.301	792.6	3339.9	4.0%	4.0%

VMT-Weighted Average Non-PM10-Efficient Sweeping Effectiveness:

City	Arterial/ Collector KVMT/day	Sweeping Frequency (days)	Sweeping Effective. (%)	Local Urban Street KVMT/day	Sweeping Frequency (days)	Sweeping Effective. (%)
Fresno	12,283	30	4.0%	722	30	4.0%
Bakersfield	6,619	7	17.8%	244	14	8.7%
Hanford	1,113	7	17.8%	78	7	17.8%
Madera	1,751	14	8.7%	29	14	8.7%
Merced	4,122	15	8.1%	26	15	8.1%
Stockton	6,344	30	4.0%	307	30	4.0%
Modesto	7,009	7	17.8%	169	7	17.8%
Visalia	4,828	7	17.8%	250	30	4.0%
Total	44,069			1,827		

VMT-weighted
Sweeping Effectiveness = 10.7% (arterial/collector streets)
= 6.6% (local streets)

Total Arterial/Collector Streets = 8,505 centerline-miles (Arterial_Collector.xls, all counties combined, from EarthMatters survey of road length and VMT by ADT range, October 2002)

Total Local Urban Streets = 2,618 centerline-miles (LocalRd.xls, ")

Average Travel on Arterial/ Collector Streets = 5.18 KVMT/centerline-mile

Average Travel on Local Urban Streets = 0.70 KVMT/centerline-mile

Average Emissions on Arterial/ Collector Streets = 4.28 lb PM10/day-centerline mile

Average Emissions on Local Urban Streets = 2.43 lb PM10/day-centerline mile

Emission Reduction on Arterial/ Collector Streets = 0.46 lb PM10/day-centerline mile

Emission Reduction on Local Urban Streets = 0.16 lb PM10/day-centerline mile

Street Length-Weighted Average Emission Reduction = 0.42 lb PM10/day-centerline mile

Controlled Emissions:

Default Street Silt Loading = 0.035 gm/m2 (Section 7.9, arterials/collectors, CARB Area Source Methodology, August 1997)
= 0.32 gm/m2 (Section 7.9, local roads, CARB Area Source Methodology, August 1997)

Baseline Emission Factor = 825.5 lb PM10/10^6 VMT (Section 7.9, arterials/collectors, CARB Area Source Methodology, August 1997)
= 3478.8 lb PM10/10^6 VMT (Section 7.9, local roads, CARB Area Source Methodology, August 1997)

Reduction in Street Soil Loading
From Sweeping = 86% PM10-efficient sweeping (PM10-Efficient Street Sweeper Evaluations, CERT/UC Riverside, June 1999)
=

Equilibrium Return Time = 8.6 days - PM10-efficient sweepers (estimated from Sierra Research, August 1996)

PM10-Efficient Sweeping Effectiveness:

	Average Silt		Emission Factor		Sweeping Effective.	
Days Between Sweeping	Arterials/ Collector (gm/m2)	Local Streets (gm/m2)	Arterials/ Collector 1e6VMT)	Local Streets 1e6VMT)	Arterials/ Collector (%)	Local Streets (%)
1	0.000	0.000	0.0	0.0	100.0%	100.0%
2	0.002	0.021	141.4	595.8	82.9%	82.9%
3	0.005	0.042	221.8	934.9	73.1%	73.1%
4	0.007	0.061	282.4	1190.1	65.8%	65.8%
5	0.009	0.085	348.1	1467.0	57.8%	57.8%
6	0.012	0.106	402.5	1696.1	51.2%	51.2%
7	0.014	0.127	453.1	1909.4	45.1%	45.1%
10	0.020	0.187	583.0	2456.9	29.4%	29.4%
14	0.025	0.225	657.1	2769.3	20.4%	20.4%
15	0.025	0.232	669.1	2819.5	19.0%	19.0%
21	0.028	0.257	715.6	3015.7	13.3%	13.3%
28	0.030	0.273	743.9	3134.9	9.9%	9.9%
30	0.030	0.276	749.5	3158.4	9.2%	9.2%

VMT-Weighted Average Non-PM10-Efficient Sweeping Effectiveness:

City	Arterial/ Collector KVMT/day	Sweeping Frequency (days)	Sweeping Effective. (%)	Local Urban Street KVMT/day	Sweeping Frequency (days)	Sweeping Effective. (%)
Fresno	12,283	30	9.2%	722	30	9.2%
Bakersfield	6,619	7	45.1%	244	14	20.4%
Hanford	1,113	7	45.1%	78	7	45.1%
Madera	1,751	14	20.4%	29	14	20.4%
Merced	4,122	15	19.0%	26	15	19.0%
Stockton	6,344	30	9.2%	307	30	9.2%
Modesto	7,009	7	45.1%	169	7	45.1%
Visalia	4,828	7	45.1%	250	30	9.2%
Total	44,069			1,827		

VMT-Weighted
Sweeping Effectiveness = 26.5% (arterial/collector streets)
= 15.9% (local streets)

Total Arterial/Collector Streets = 8,505 centerline-miles (Arterial_Collector.xls, all counties combined, from EarthMatters survey of road length and VMT by ADT range, October 2002)

Total Local Urban Streets = 2,618 centerline-miles (LocalRd.xls, ")

Average Travel on Arterial/
Collector Streets = 5.18 KVMT/centerline-mile

Average Travel on Local
Urban Streets = 0.70 KVMT/centerline-mile

Average Emissions on Arterial/
Collector Streets = 4.28 lb PM10/day-centerline mile

Average Emissions on Local
Urban Streets = 2.43 lb PM10/day-centerline mile

Emission Reduction on Arterial/

Collector Streets =	1.13	lb PM10/day-centerline mile
Emission Reduction on Local Urban Streets =	0.39	lb PM10/day-centerline mile
Street Length-Weighted Average Emission Reduction =	1.05	lb PM10/day-centerline mile
Emission Reduction =	0.62	lb PM10/day-centerline mile
=	227	lb PM10/yr-centerline mile
Cost-Effectiveness =	$0.02	/lb PM10
=	$33	/ton PM10

Measure: **1d. Require purchase of one PM10-efficiency sweeper within 3 years**

Construction/Operational Cost:

Assume that the worst case financial cost is incurred by purchasing a non-PM10-efficient street sweeper in year 0, purchasing a PM10-efficient street sweeper in year 3, and selling the non-PM10-efficient sweeper.

Non-PM10-Efficient Sweeper Capital Cost =	$149,000	(MAG, December 2001)
PM10-Efficient Sweeper Capital Cost =	$152,000	(Maricopa Association of Governments PM-10 Efficient Street Sweeper Study, MAG, December 2001)
Non-PM10-Efficient Sweeper Salvage Value =	$80,000	@ 3 years (estimated)
Increase in Asset Value =	$72,000	
Useful Life =	8	yr
Capital Recovery Factor =	0.187	
Annualized Capital Cost =	$13,496	/yr
Difference in Operating Cost =	$0	(MAG, December 2001)
Major Street/Collector Sweeping Schedule =	14	days/circuit (S. Howard/Phoenix, October 2002)
Effective Sweeping Schedule =	6	hr/day (S. Howard/Phoenix, October 2002)
=	5	day/week (S. Howard/Phoenix, October 2002)
Average Sweeping Rate =	5	curb-miles/hr (MAG, December 2001)
=	30	curb-miles/day
=	15	centerline-miles/day
=	150	centerline circuit-miles/yr
Total Annual Cost =	$13,496	/yr
=	$89.97	/yr - centerline circuit-mile
Baseline Emissions:		
Street Length-Weighted Average Emission Reduction =	0.42	lb PM10/day-centerline mile (see Measure 1.c above)
Controlled Emissions:		
Street Length-Weighted Average Emission Reduction =	1.05	lb PM10/day-centerline mile (see Measure 1.c above)
Emission Reduction =	0.62	lb PM10/day-centerline mile
=	227	lb PM10/yr-centerline mile
=	227	lb PM10/yr-centerline circuit-mile
Cost Effectiveness =	$0.40	/lb PM10
=	$792	ton PM10

Measure: **1e. Require municipalities to identify dirt-laden streets for priority sweeping by PM10-efficient units**

The cost-effectiveness of this measure is zero if municipalities own PM10-efficient street sweepers. There is no difference in cost between using PM10-efficient street sweepers to sweep dirty versus clean streets. Thus, although there will be a reduction in emissions, the absence of a cost increase will result in a cost-effectiveness ratio of zero.

Measure: **1f. Require streets to be swept by PM10-efficient sweepers at least once per month**

Assume that the worse case cost impact is the replacement of an existing non-PM10-efficient sweeper with a new PM10-efficient sweeper. This would be the implementation scenario in the City of Fresno, where all arterials, collectors, and local streets are now swept once a month by non-PM10-efficient sweepers.

Construction/Operational Cost:

Non-PM10-Efficient Sweeper Capital Cost =	$149,000	(MAG, December 2001)
PM10-Efficient Sweeper Capital Cost =	$152,000	(Maricopa Association of Governments PM-10 Efficient Street Sweeper Study, MAG, December 2001)
Non-PM10-Efficient Sweeper Salvage Value =	$60,000	@ 4 years (estimated)
Increase in Asset Value =	$92,000	
Useful Life =	8	yr
Capital Recovery Factor =	0.187	
Annualized Capital Cost =	$17,245	/yr
Major Street/Collector Sweeping Schedule =	30	days/circuit - City of Fresno (2001 road survey, SJVUAPCD, 2001)
Effective Sweeping Schedule =	6	hr/day (S. Howard/Phoenix, October 2002)
Average Sweeping Rate =	5	curb-miles/hr (MAG, December 2001)
=	30	curb-miles/day
=	15	centerline-miles/day
=	450	centerline circuit-miles/yr

Total Annual Cost =	$17,245	/yr
=	$38.32	/yr - centerline circuit-mile

Baseline Emissions:

Baseline Emission Factor =	825.5	lb PM10/10^6 VMT (Section 7.9, arterials/collectors, CARB Area Source Methodology, August 1997)
=	3478.8	lb PM10/10^6 VMT (Section 7.9, local roads, CARB Area Source Methodology, August 1997)
Sweeping Effectiveness =	4.0%	(arterial/collector streets - Fresno, see Measure 1.c)
=	4.0%	(local streets - Fresno, see Measure 1.c)
Total Arterial/Collector Streets =	2,166	centerline-miles (Arterial_Collector.xls, Fresno County, from EarthMatters survey of road length and VMT by ADT range, October 2002)
Total Local Urban Streets =	1,197	centerline-miles (LocalRd.xls, ")
Average Travel on Arterial/ Collector Streets =	5.67	KVMT/centerline-mile

Average Travel on Local

Urban Streets =	0.60	KVMT/centerline-mile
Average Emissions on Arterial/ Collector Streets =	4.68	lb PM10/day-centerline mile
Average Emissions on Local Urban Streets =	2.10	lb PM10/day-centerline mile
Emission Reduction on Arterial/ Collector Streets =	0.19	lb PM10/day-centerline mile
Emission Reduction on Local Urban Streets =	0.08	lb PM10/day-centerline mile
Street Length-Weighted Average Emission Reduction =	0.15	lb PM10/day-centerline mile

Controlled Emissions:

Sweeping Effectiveness =	9.2%	(arterial/collector streets)
=	9.2%	(local streets)
Total Arterial/Collector Streets =	2,166	centerline-miles (Arterial_Collector.xls, Fresno County, from EarthMatters survey of road length and VMT by ADT range, October 2002)
Total Local Urban Streets =	1,197	centerline-miles (LocalRd.xls, ")
Average Travel on Arterial/ Collector Streets =	5.67	KVMT/centerline-mile
Average Travel on Local Urban Streets =	0.60	KVMT/centerline-mile
Average Emissions on Arterial/ Collector Streets =	4.68	lb PM10/day-centerline mile
Average Emissions on Local Urban Streets =	2.10	lb PM10/day-centerline mile
Emission Reduction on Arterial/ Collector Streets =	0.43	lb PM10/day-centerline mile
Emission Reduction on Local Urban Streets =	0.19	lb PM10/day-centerline mile
Street Length-Weighted Average Emission Reduction =	0.35	lb PM10/day-centerline mile

Emission Reduction =	0.20	lb PM10/day-centerline mile
=	72	lb PM10/yr-centerline mile
Cost-Effectiveness =	$0.54	/lb PM10
=	$1,070	/ton PM10

Measure: **1g. Require PM10-efficient street sweepers to be operated and maintained according to manufacturer's specs**

Insufficient data are available to evaluate either the cost or emission differences between compliance versus noncompliance with respect to operation and maintenance of PM10-efficient street sweepers within manufacturer's specifications.

Measure: **1h. Require wind- or water-borne deposition to be cleaned up within 24 hr after discovery**

Construction/Operational Cost:

Deposition Cleanup Time =	3	hr (assumed)
Response Driving Time =	1	hr (assumed)
Number of Maintenance Workers on Crew =	2	(estimated)
Number of Maintenance Supervisors on Crew =	1	(estimated)
Public Sector Maintenance Worker Hourly Wage Rate =	$21.31	/hr (K. Jacobs/Merced DPW, November 2002)
Public Sector Maintenance Supervisor Hourly Wage Rate =	$26.76	/hr (K. Jacobs/Merced DPW, November 2002)
Total Labor Charge Rate =	$69.39	/hr
Total Labor Costs =	$277.54	/cleanup operation
Grader Charge Rate =	$57.00	/hr (L. Stauch/Granite Construction, November 2002)
Water Truck Charge Rate =	$31.00	/hr (L. Stauch/Granite Construction, November 2002)
Pickup Charge Rate =	$2.73	/hr (F. Bates/SJVUAPCD, 9/30/02 email)
Total Equipment Charge Rate =	$90.73	/hr
Total Equipment Costs =	$362.90	/cleanup operation
Total Costs =	$640.44	/cleanup operation

Baseline Emissions:

Hypothetical Spill Quantity =	6000	lb (assumed for 3 hr cleanup)
Fraction of Spill in Roadway =	25%	(estimated)
Deposition Fraction Emitted as PM10 =	30%	(M. Zeldin email, 10/8/02)
Deposition Emitted as PM10 =	450.0	lb
Baseline Emissions =	450.0	lb

Controlled Emissions:

Controlled Emissions =	0	lb (assumed if cleanup commences before traffic disturbs soil deposited on roadway)

Emission Reduction =	450.0	lb PM10/spill
Cost-Effectiveness =	$1.42	/lb PM10
=	$2,846	/ton PM10

Source: **Carryout/Trackout**

		Measure	Cost Effectiveness of Measure (2002 $/ton PM10 reduction)	
2	a	Impose Rule 8041 requirements on any site with >10 trips by vehicles > 2 axles	$44,100	$387,000
2	b	Require trackout control devices to be 25 ft long and full road width	$13,700	$322,000
2	c	Require paved interior roads to be 100 ft long and full road width	$7,930	$186,000
2	d	Require gravel pads 3 in. deep, 50 ft long, and full road width	$27,500	$322,000

Common Parameters:

Private Sector Laborer Hourly Wage Rate = $12.69 /hr (2000 Wage Estimates, Fresno, Bureau of Labor Stastics, http://www.bls.gov/)
Private Sector Laborer Benefit Burden = 41% (Dave Harrald/Keweah River Rock telecon, 9/24/02)
Private Sector Laborer Hourly Cost = $17.89 /hr (Bureau of Labor Statistics, D. Harrald/Keweah River Rock, September 2002)
Grader Hourly Rate = $57.00 /hr (L. Stauch/Granite Construction, November 2002)
District Inspector Hourly Cost = $38.50 /hr (F. Bates/SJVUAPCD, 9/30/02 email)
District Pickup Hourly Rate = $2.73 /hr (F. Bates/SJVUAPCD, 9/30/02 email)

Measure: **2a. Impose Rule 8041 requirements on any site with >10 trips by vehicles > 2 axles**

Option: Pipe-grid Trackout Control Device

Construction/Operational Cost:

Pipe-grid Purchase Cost = $3,495 (Jeff Lane/Trackout Control telecon, 9/23/02; http://www.trackoutcontrol.com)
Shipping Cost = $1,300 (Federal Express Freight quote, 9/27/02)
Installation Time = 1.5 man-hr (Richard Polito/Maricopa ESD telecon, 9/23/02)
Laborer Rate = $17.89 /hr (Bureau of Labor Statistics, D. Harrald/Keweah
Labor Cost = $26.84
Aggregate Needed = 16.7 yd3 (estimated from Jeff Lane telecon, 9/24/02)
= 22.5 tons
-1"Aggregate Delivered Cost = $10.40 '/ton (Dave Harrald/Keweah River Rock telecon, 9/24/02)
Total Aggregate Cost = $234.00
Aggregate Grading Time = 1.0 hr (estimated)
Aggregate Grading Cost = $57.00
Total Installed Cost = $5,113
Useful Life = 8 yr (estimated from Jeff Lane telecon, 9/24/02)
Capital Recovery Factor = 0.187
Annualized Capital Cost = $958 /yr

Maintenance Time = 4 man-hr/month (Jeff Lane telecon, 9/23/02)
= 48 man-hr/yr
Maintenance Cost = $859 /yr

Total Annual Cost = $1,817 /yr

Baseline Emissions:

Worst Case Cost-Effectiveness Scenario
Access Point Traffic Level = 10 3-axle vehicle trips/day
= 5 3-axle exiting trips/day
Deposition to Paved Road = 0.0033 lb/pickup-pass (Particulate Emission Measurement from Controlled Construction Activities, EPA/600/R-01/031, EPA, April 2001)
= 0.0008 lb/pickup tire-pass
= 0.0031 lb/10-wheel heavy duty truck tire (based on tread area and wheel force ratios)
= 0.0313 lb/10-wheel truck
Deposition to Street Rate = 0.16 lb soil/facility-day
Deposition Fraction Emitted

as PM10 = 30% (M. Zeldin email, 10/8/02)
Deposition Emitted as PM10 = 0.05 lb soil/facility-day
Number of Facility Annual
Operating Days = 250 day/yr (estimated)
Increase in Street Emission Rate = 0.05 lb PM10/facility-day
= 11.7 lb PM10/facility-yr

Typical Emission/Cost Scenario
Deposition to Paved Road = 0.0287 lb/vehicle-pass (Control of Open Fugitive Dust Sources, EPA-450/3-88-008, EPA, September 1988)
= 0.0072 lb/pickup tire-pass
= 0.0275 lb/10-wheel heavy duty truck tire (based on tread area and wheel force ratios)
= 0.2749 lb/10-wheel truck
Deposition to Street Rate = 1.37 lb soil/facility-day
Deposition Fraction Emitted
as PM10 = 30% (M. Zeldin email, 10/8/02)
Deposition Emitted as PM10 = 0.41 lb soil/facility-day
Number of Facility Annual
Operating Days = 250 day/yr (estimated)
Increase in Street Emission Rate = 0.41 lb PM10/facility-day
= 103.1 lb PM10/facility-yr

Controlled Emissions:

Pipe Grid Control Efficiency = 80% (R. Polita/Maricopa Co. telecon, 9/24/02)

Worst Case Cost-Effectiveness Scenario
Controlled Emission Rate = 0.01 lb PM10/facility-day
= 2.35 lb PM10/facility-yr
Typical Emission/Cost Scenario
Controlled Emission Rate = 0.08 lb PM10/facility-day
= 20.61 lb PM10/facility-yr

Emission Reduction:

Worst Case Cost-Effectiveness Scenario
Emission Reduction = 9.39 lb PM10/facility-yr

Typical Emission/Cost Scenario
Emission Reduction = 82.46 lb PM10/facility-yr

Cost-Effectiveness:

Worst Case Cost-Effectiveness Scenario
Cost-Effectiveness = $193.50 /lb PM10
$387,004 /ton PM10

Typical Emission/Cost Scenario
Cost-Effectiveness = $22.04 /lb PM10
$44,078 /ton PM10

Measure: **2b. Require trackout control devices to be 25 ft long and full road width**

Scenario: Gravel Bed Trackout Control

Construction/Operational Cost:

Worst Case Cost-Effectiveness Scenario
Gravel Bed Construction Cost = $500 (A. Bashor/Clark County, November 2002)

Maintenance Time = 4 man-hr/month (estimated)
= 48 man-hr/yr
Laborer Cost = $17.89 /hr
Maintenance Cost = $859 /yr

Typical Emission/Cost Scenario
Gravel Bed Construction Cost = $250 (M. Zeldin email, 1/6/03)

Maintenance Time =	2	man-hr/month (estimated)
=	24	man-hr/yr
Laborer Cost =	$17.89	/hr
Maintenance Cost =	$429	

Total Annual Cost =	$1,359	/yr (worst case cost-effectiveness scenario)
	$679	/yr (typical emission/cost scenario)

Baseline Emissions:

Worst Case Cost-Effectiveness Scenario

Access Point Traffic Level =	150	vehicle trips/day
	75	exiting trips/day
Deposition to Paved Road =	0.0033	lb/pickup-pass (Particulate Emission Measurement from Controlled Construction Activities, EPA/600/R-01/031, EPA, April 2001)
Deposition to Street Rate =	0.24	lb soil/facility-day
Deposition Fraction Emitted as PM10 =	30%	(M. Zeldin email, 10/8/02)
Deposition Emitted as PM10 =	0.07	lb soil/facility-day
Number of Facility Annual Operating Days =	250	day/yr (estimated)
Increase in Street Emission Rate =	0.07	lb PM10/facility-day
=	18.4	lb PM10/facility-yr

Typical Emission/Cost Scenario

Access Point Traffic Level =	200	vehicle trips/day (M. Zeldin email, 1/6/03)
	100	exiting trips/day
Deposition to Paved Road =	0.0287	lb/vehicle-pass (Control of Open Fugitive Dust Sources, EPA-450/3-88-008, EPA, September 1988)
Deposition to Street Rate =	2.87	lb soil/facility-day
Deposition Fraction Emitted as PM10 =	30%	(M. Zeldin email, 10/8/02)
Deposition Emitted as PM10 =	0.86	lb soil/facility-day
Number of Facility Annual Operating Days =	250	day/yr (estimated)
Increase in Street Emission Rate =	0.86	lb PM10/facility-day
=	214.9	lb PM10/facility-yr

Controlled Emissions:

Gravel Bed Control Efficiency =	46%	(Particulate Emission Measurements from Controlled Construction Activities, EPA/600/R-01/031, EPA, April 2001)

Worst Case Cost-Effectiveness Scenario

Controlled Emission Rate =	0.04	lb PM10/facility-day
=	9.92	lb PM10/facility-yr

Typical Emission/Cost Scenario

Controlled Emission Rate =	0.46	lb PM10/facility-day
=	116.07	lb PM10/facility-yr

Emission Reduction:

Worst Case Cost-Effectiveness Scenario

Emission Reduction =	8.45	lb PM10/facility-yr

Typical Emission/Cost Scenario

Emission Reduction =	98.9	lb PM10/facility-yr

Cost-Effectiveness:

Worst Case Cost-Effectiveness Scenario

Cost-Effectiveness =	$160.89	/lb PM10
=	$321,771	/ton PM10

Typical Emission/Cost Scenario

Cost-Effectiveness =	$6.87	/lb PM10
=	$13,743	/ton PM10

Measure: **2c. Require paved interior roads to be 100 ft long and full road width**

Construction/Operational Cost:

Worst Case Cost-Effectiveness Scenario		
Paved Interior Road Width =	30	ft (L. Stauch/Granite Construction telecon, 9/26/02)
Paved Interior Road Length =	100	ft
Asphalt Thickness =	3	in
Construction Cost =	$6,500	(L. Stauch/Granite Construction telecon, 9/26/02)
Useful Life =	25	yr (PM10 BACM, SCAQMD, 9/94)
Capital Recovery Factor =	0.110	
Annualized Capital Cost =	$716	/yr
Typical Emission/Cost Scenario		
Paved Interior Road Width =	30	ft (L. Stauch/Granite Construction telecon, 9/26/02)
Paved Interior Road Length =	50	ft (M. Zeldin email, 1/6/03)
Asphalt Thickness =	3	in
Construction Cost =	$3,250	(L. Stauch/Granite Construction telecon, 9/26/02)
Useful Life =	25	yr (PM10 BACM, SCAQMD, 9/94)
Capital Recovery Factor =	0.110	
Annualized Capital Cost =	$358	/yr

Total Annual Cost =	$716	/yr (worst case cost-effectiveness scenario)
	$358	/yr (typical emission/cost scenario)

Baseline Emissions:

Worst Case Cost-Effectiveness Scenario		
Access Point Traffic Level =	150	vehicle trips/day
	75	exiting trips/day
Deposition to Paved Road =	0.0033	lb/pickup-pass (Particulate Emission Measurement from Controlled Construction Activities, EPA/600/R-01/031, EPA, April 2001)
Deposition to Street Rate =	0.24	lb soil/facility-day
Deposition Fraction Emitted as PM10 =	30%	(M. Zeldin email, 10/8/02)
Deposition Emitted as PM10 =	0.07	lb soil/facility-day
Number of Facility Annual Operating Days =	250	day/yr (estimated)
Increase in Street Emission Rate =	0.07	lb PM10/facility-day
=	18.4	lb PM10/facility-yr
Typical Emission/Cost Scenario		
Access Point Traffic Level =	200	vehicle trips/day (M. Zeldin email, 1/6/03)
	100	exiting trips/day
Deposition to Paved Road =	0.0287	lb/vehicle-pass (Control of Open Fugitive Dust Sources, EPA-450/3-88-008, EPA, September 1988)
Deposition to Street Rate =	2.87	lb soil/facility-day
Deposition Fraction Emitted as PM10 =	30%	(M. Zeldin email, 10/8/02)
Deposition Emitted as PM10 =	0.86	lb soil/facility-day
Number of Facility Annual Operating Days =	250	day/yr (estimated)
Increase in Street Emission Rate =	0.86	lb PM10/facility-day
=	214.9	lb PM10/facility-yr

Controlled Emissions:

Paved Interior Road Control Efficiency =	42%	(Particulate Emission Measurements from Controlled Construction Activities, EPA/600/R-01/031, EPA, April 2001)
Worst Case Cost-Effectiveness Scenario		
Controlled Emission Rate =	0.04	lb PM10/facility-day

= 10.65 lb PM10/facility-yr

Typical Emission/Cost Scenario
Controlled Emission Rate = 0.50 lb PM10/facility-day
= 124.7 lb PM10/facility-yr

Emission Reduction:

Worst Case Cost-Effectiveness Scenario
Emission Reduction = 7.71 lb PM10/facility-yr

Typical Emission/Cost Scenario
Emission Reduction = 90.28 lb PM10/facility-yr

Cost-Effectiveness:

Worst Case Cost-Effectiveness Scenario
Cost-Effectiveness = $92.86 /lb PM10
$185,716 /ton PM10

Typical Emission/Cost Scenario
Cost-Effectiveness = $3.97 /lb PM10
$7,932 /ton PM10

Measure: **2d. Require gravel pads 3 in. deep, 50 ft long, and full road width**

Option: Gravel Bed Trackout Control

Construction/Operational Cost:

Gravel Bed Construction Cost = $500 (A. Bashor/Clark County, November 2002)

Maintenance Time = 4 man-hr/month (estimated)
= 48 man-hr/yr
Maintenance Cost = $859 /yr

Total Annual Cost = $1,359 /yr

Baseline Emissions:

Worst Case Cost-Effectiveness Scenario
Access Point Traffic Level = 150 vehicle trips/day
75 exiting trips/day
Deposition to Paved Road = 0.0033 lb/pickup-pass (Particulate Emission Measurement from Controlled Construction Activities, EPA/600/R-01/031, EPA, April 2001)
Deposition to Street Rate = 0.24 lb soil/facility-day
Deposition Fraction Emitted as PM10 = 30% (M. Zeldin email, 10/8/02)
Deposition Emitted as PM10 = 0.07 lb soil/facility-day
Number of Facility Annual Operating Days = 250 day/yr (estimated)
Increase in Street Emission Rate = 0.07 lb PM10/facility-day (= Deposition Rate)
= 18.4 lb PM10/facility-yr

Typical Emission/Cost Scenario
Access Point Traffic Level = 200 vehicle trips/day (M. Zeldin email, 1/6/03)
100 exiting trips/day
Deposition to Paved Road = 0.0287 lb/pickup-pass (Particulate Emission Measurement from Controlled Construction Activities, EPA/600/R-01/031, EPA, April 2001)
Deposition to Street Rate = 2.87 lb soil/facility-day
Deposition Fraction Emitted as PM10 = 30% (M. Zeldin email, 10/8/02)
Deposition Emitted as PM10 = 0.86 lb soil/facility-day
Number of Facility Annual Operating Days = 250 day/yr (estimated)
Increase in Street Emission Rate = 0.86 lb PM10/facility-day (= Deposition Rate)

= 214.9 lb PM10/facility-yr

Controlled Emissions:

Gravel Bed Control Efficiency = 46% (Particulate Emission Measurements from Controlled Construction Activities, EPA/600/R-01/031, EPA, April 2001)

Worst Case Cost-Effectiveness Scenario

Controlled Emission Rate =	0.04	lb PM10/facility-day
=	9.92	lb PM10/facility-yr

Typical Emission/Cost Scenario

Controlled Emission Rate =	0.46	lb PM10/facility-day
=	116.1	lb PM10/facility-yr

Emission Reduction:

Worst Case Cost-Effectiveness Scenario

Emission Reduction = 8.45 lb PM10/facility-yr

Typical Emission/Cost Scenario

Emission Reduction = 98.88 lb PM10/facility-yr

Cost-Effectiveness:

Worst Case Cost-Effectiveness Scenario

Cost-Effectiveness =	$160.89	/lb PM10
	$321,771	/ton PM10

Typical Emission/Cost Scenario

Cost-Effectiveness =	$13.74	/lb PM10
	$27,486	/ton PM10

SOURCE: UNPAVED ROADS AND PARKING AREAS

		Measure	Cost Effectiveness of Measure (2002 $/ton PM10 reduction)	
3	a	Limit maximum speed on unpaved roads to 25 mph	$1,080	
3	b	Require all new non-temporary roads in urban areas to be paved	$2,160	$5,920
3	c	Require existing public unpaved roads in urban areas to be paved	$2,160	$5,920
3	d	Impose Rule 8071 requirements on all unpaved parking areas receiving more than 75 trips per day	$3,510	
3	e	Require watering and speed controls on unpaved parking areas receiving up to 25 trips per day	$1,960,000	
3	f	Limit VDE to 20% opacity on unpaved parking areas receiving up to 75 trips per day	$9,420	$91,400
3	g	Limit VDE to 20% opacity and require stabilized surface on unpaved parking areas receiving up to 100 trips per day	$5,230	$30,500
3	h	Require paving, gravel, or dust suppressants on unpaved parking areas receiving more than 100 trips per day or more than 10 trips per day by vehicles with more than 2 axles	$22,800	$207,000
3	i	Require notification to District of special event parking of more than 1000 vehicles on unpaved surfaces	$15,800	
3	j	Require paving, 4 in gravel, or dust suppressants to maintain stabilized surface at special event parking	$5,980	$59,800

Common Parameters:

Unpaved Road Emission Factor =	2.00	lb PM10/VMT (P. Gaffney/CARB, January 2000)
Number of Annual Rain Days =	44.3	day/yr (S. Ferreria/SJVUAPCD, July 2002)
Road Maint. Worker FTE Cost =	$44,453	/yr (K. Jacobs/Merced DPW, November 2002)
	$21.31	/hr (K. Jacobs/Merced DPW, November 2002)
Road Maint. Asst. Supervisor FTE Cost =	$55,811	/yr (K. Jacobs/Merced DPW, November 2002)
	$26.76	/hr (K. Jacobs/Merced DPW, November 2002)
Grader Cost =	$57.00	/hr (L. Stauch/Granite Construction, November 2002)
Broom Cost =	$65.00	/hr (L. Stauch/Granite Construction, November 2002)
Water Truck Cost =	$31.00	/hr (L. Stauch/Granite Construction, November 2002)

Measure: **3a. Limit maximum speed on unpaved roads to 25 mph**

Construction/Operational Cost:

Miles of Unpaved Roads =	219	miles - Merced County (1999-2000 Rule 8060 Qluestionnaire, SJVUAPCD, July 2001)
Unit Sign Installation Cost =	$200	/yr (S. Hamilton/Merced DPW, November 2002)
Number of Signs Required =	438	signs (2 per mile - estimated)
Total Sign Installation Cost =	$87,600	
Useful Life =	15	yr (S. Hamilton/Merced DPW, November 2002)
Capital Recovery Factor =	0.1315	
Annualized Sign Cost =	$11,517	/yr
=	$52.59	/yr-centerline mile
Total Cost =	$52.59	/yr-centerline mile

Baseline Emissions:

Average Traffic Level =	15.4	vehicles/day - Merced County (traffic count data collected by VRPA, October 2002)
Unpaved Road Emission Factor =	2.00	lb PM10/VMT (P. Gaffney/CARB, January 2000)
Baseline Emissions =	30.8	lb/day-centerline mile
=	11,242	lb PM10/yr-centerline mile

Controlled Emissions:

Baseline Emission Factor Speed =	25.9	mph (UCD, April 1994 and DRI, December 1996)
Emission Factor @ 25.0 mph =	1.93	lb/VMT (assumes linear relationship between speed and emissions)
Controlled Emissions =	29.7	lb/day-centerline mile
=	10,851	lb/yr-centerline mile

Emission Reductions:

Emission Reduction @ 100% Compliance =	391	lb PM10/yr-centerline mile
Compliance Factor =	25%	(estimated)
Expected Emission Reduction =	98	lb PM10/yr-centerline mile

Cost-Effectiveness =	$0.54	/lb PM10
=	$1,077	ton PM10

Measure: **3b. Require all new non-temporary roads in urban areas to be paved**

Construction/Operational Cost:

Reconstruction Cost =	$400,000	/centerline-mile (including roadway excavation, aggregate base, striping, and traffic control, L. Stauch/Granite Construction, November 2002)
Useful Life =	25	yr (PM10 BACM, SCAQMD, 9/94)
Capital Recovery Factor =	0.1102	
Annualized Paving Cost =	$44,067	/yr

Baseline Emissions:

Worst Case Cost-Effectiveness Scenario

Minimum Number of Residences on Unpaved Public Road =	2	residences (estimated)
Number of Daily Trips =	28.4	one-way trips/day - 2 residences (URBEMIS7G Manual, Table 2, October 2000)
Fraction of Trips Starting or Ending at Home =	72%	(URBEMIS7G Manual, App. C)
Minimum Vehicle Trips =	20.4	one-way trips/day-2 residences
Average Trip Length =	1.0	mile (assumed)
Daily Mileage Traveled =	20.4	VMT
Unpaved Road Travel Emission Factor =	2.00	lbs PM10/VMT
Baseline Emissions =	40.8	lb PM10/day - centerline-mile
=	14,902	lb PM10/yr - centerline-mile

Typical Emission/Cost Scenario

Typical Number of Residences on Unpaved Public Road =	6	residences (M. Zeldin email, 1/6/03)
Number of Daily Trips =	77.9	one-way trips/day - 6 residences (URBEMIS7G Manual, Table 2, October 2000)
Fraction of Trips Starting or Ending at Home =	72%	(URBEMIS7G Manual, App. C)
Minimum Vehicle Trips =	56.1	one-way trips/day-6 residences
Average Trip Length =	1.0	mile (assumed)
Daily Mileage Traveled =	56.1	VMT
Unpaved Road Travel Emission Factor =	2.00	lbs PM10/VMT
Baseline Emissions =	112.2	lb PM10/day - centerline-mile
=	40,944	lb PM10/yr - centerline-mile

Controlled Emisisons:

Paved Road Travel Emission Factor =	3479	lb PM10/10^6 VMT
Worst Case Cost-Effectiveness Scenario		
Controlled Emissions =	0.07	lb PM10/day - centerline-mile
	25.9	lb PM10/yr - centerline-mile
Typical Emission/Cost Scenario		
Controlled Emissions =	0.20	lb PM10/day - centerline-mile
	71.2	lb PM10/yr - centerline-mile

Emission Reduction:

Worst Case Cost-Effectiveness Scenario		
Emission Reduction =	14,876	lb PM10/yr - centerline-mile
Typical Emission/Cost Scenario		
Emission Reduction =	40,873	lb PM10/yr - centerline-mile

Cost-Effectiveness:

Worst Case Cost-Effectiveness Scenario		
Cost-Effectiveness =	$2.96	/lb PM10
	$5,925	/ton PM10
Typical Emission/Cost Scenario		
Cost-Effectiveness =	$1.08	/lb PM10
	$2,156	/ton PM10

Measure: **3c. Require existing public unpaved roads in urban areas to be paved**

The cost-effectiveness of this measure is the same as that of Measure 3b.

Cost-Effectiveness:

Worst Case Cost-Effectiveness Scenario		
Cost-Effectiveness =	$2.96	/lb PM10
	$5,925	/ton PM10
Typical Emission/Cost Scenario		
Cost-Effectiveness =	$1.08	/lb PM10
	$2,156	/ton PM10

Measure: **3d. Impose Rule 8071 requirements on all unpaved parking areas receiving more than 75 trips per day**

Construction/Operational Cost:

Minimum Parking Duration =	0.4	hr (Transportation and Traffic Engineering Handbook, 1976)
Maximum Number of Parking Cycles Per Business Day =	22.5	cycles/8-hr day
Maximum Number of Vehicle Trips Per Business Day =	45	vehicle trips/day (1 cycle = 2 trips, District Rule 8011)
Minimum Number of Parking Spaced Needed to Accomodate 75 Vehicle Trips Per Day =	2	parking spaces
Average Area Needed for Parking =	276	ft2/vehicle (Transportation and Traffic Engineering Handbook, 1976)
Minimum Parking Lot Size =	553	ft2
Paving Cost =	$2.10	/ft2 (L. Stauch/Granite Construction, November 2002)
=	$1,160	
Useful Life =	25	yr (PM10 BACM, SCAQMD, 9/94)

Capital Recovery Factor =	0.1102	
Annualized Paving Cost =	$128	/yr

Baseline Emissions:

Width of Minimum Parking Lot =	65	ft (Transportation and Traffic Engineering Handbook, 1976)
Depth of Minimum Parking Lot =	9	ft
Average Vehicle Trip Travel Distance =	37	ft (estimated from minimum parking lot dimensions)
Number of Vehicle Trips =	75	vehicle trips/day
Minimum Parking Travel Distance =	2,756	ft/day
=	190.5	mi/yr
Average Parking Cycle Travel Speed =	5	mph (estimated)
Unpaved Road Travel Emission Factor =	2.00	lb PM10/VMT (P. Gaffney/CARB, January 2000)
Average Unpaved Road Test Travel Speed =	25.9	mph (average of UCD and DRI unpaved road emission studies, 1994 and 1996)
Parking Cycle Emission Factor =	0.39	lb PM10/VMT (assuming linear proportionality between emission factor and speed)
Baseline Emissions =	73.57	lb PM10/yr

Controlled Emissions:

Paved Parking Lot Travel Emission Factor =	3479	lb PM10/10^6 VMT (Section 7.9, local roads, CARB Area Source Methodology, July 1997)
Minimum Parking Travel Distance =	190.5	mi/yr
Controlled Emissions =	0.66	lb PM10/yr

Emission Reduction =	72.9	lb PM10/yr (minimum parking lot size)
Cost-Effectiveness =	$1.75	/lb PM10
	$3,507	/ton PM10

Measure: **3e. Require watering and speed controls on unpaved parking areas receiving up to 25 trips per day**

On small unpaved parking lots receiving up to 25 trips per day, parking speeds are too low to benefit from speed controls; in this analysis, daily watering is evaluated.

Construction/Operational Cost:

Maximum Exempt Parking Lot Size =	1	acre (District Rule 8071)
Water Application Rate =	629	gal/acre (Draft Regulation VIII Staff Report, SJVUAPCD, September 2001)
Surface Coverage Rate =	2.9	acre/hr (Draft Regulation VIII Staff Report, SJVUAPCD, September 2001)
Parking Lot Watering Duration =	0.3	hr/day
Water Truck Filling and Driving Time =	1.0	hr/day
Total Truck Use Time =	1.3	hr/day
Water Charge Rate =	$0.0010	/gal (Sierra Research telephone survey of water purveyors, August, 2002)
Water Cost =	$0.63	/day

Water Truck Rental Rate =	$31.00	/hr (L. Stauch, Granite Construction, November 2002)
Truck Driver Rate =	$19.00	/hr (L. Stauch, Granite Construction, November 2002)
Water Truck Cost =	$50.00	/hr
=	$67.24	/day
Total Watering Cost =	$67.87	/day

Baseline Emissions:

Average Parking Cycle Travel Distance =	417	ft (estimated from example lot dimensions)
Number of Vehicle Trips =	25	trips/day
Number of Parking Cycles =	12.5	cycles/day
Daily Parking Travel Distance =	5218	ft/day
=	0.99	mi/day
Average Parking Cycle Travel Speed =	5	mph (estimated)
Unpaved Road Travel Emission Factor =	2.00	lb PM10/VMT (P. Gaffney/CARB, January 2000)
Average Unpaved Road Test Travel Speed =	25.9	mph (average of UCD and DRI unpaved road emission studies, 1994 and 1996)
Parking Cycle Emission Factor =	0.39	lb PM10/VMT (assuming linear proportionality between emission factor and speed)
Baseline Emissions =	0.38	lb PM10/day

Controlled Emissions:

Assume watering occurs each morning just prior to parking initiation.

Watering Control Efficiency =	85%	-1st hour (Particulate Emission Measurements from
	50%	-2nd hour Controlled Construction Activities, MRI,
	10%	-3rd hour April 2001, test series 701)
	0%	-4th and following hours
8-Hour Average Control Efficiency =	18.1%	
Controlled Emissions =	0.31	lb PM10/day

Emission Reductions =	0.07	lb PM10/day
Cost-Effectiveness =	$981.41	/lb PM10
=	$1,962,827	/ton PM10

Measure: **3f. Limit VDE to 20% opacity on unpaved parking areas receiving up to 75 trips per day**

Scenario: Apply dust suppressant (polymer emulsion) annually to unpaved parking areas

Construction/Operational Cost:

Worst Case Cost-Effectiveness Scenario

Maximum Exempt Parking Lot Size =	1	acre (District Rule 8071)
=	4,840	yd2
Surface Preparation Cost =	$0.04	/yd2 (DRI, 12/96)
=	$193.60	/acre-yr
Polymer Emulsion Application Rate =	0.28	gal/yd2-yr (Evaluation of Air Quality Performance Claims for Soil-Sement, CARB, April 2002)
Polymer Emulsion Cost =	$3.30	/gal (Midwest Industrial Supply, October 1999)
=	$0.92	/yd2-yr

Polymer Emulsion

Application Cost = $0.18 /yd2-yr (DRI, 12/96)
Total Polymer Emulsion
Treatment Cost = $1.10 /yd2-yr
= $5,343 /acre-yr

Typical Emission/Cost Scenario
Maximum Exempt Parking
Lot Size = 1 acre (District Rule 8071)
= 4,840 yd2
Area Coverage Fraction = 75% (M. Zeldin email, 1/6/03)
Area To Be Covered = 3,630 yd2

Surface Preparation Cost = $0.04 /yd2 (DRI, 12/96)
= $145.20 /acre-yr
Polymer Emulsion
Application Rate = 0.28 gal/yd2-yr (Evaluation of Air Quality Performance Claims for Soil-Sement, CARB, April 2002)
Polymer Emulsion Cost = $3.30 /gal (Midwest Industrial Supply, October 1999)
= $0.92 /yd2-yr
Polymer Emulsion
Application Cost = $0.18 /yd2-yr (DRI, 12/96)
Total Polymer Emulsion
Treatment Cost = $1.10 /yd2-yr
= $4,008 /acre-yr

Baseline Emissions:

Worst Case Cost-Effectiveness Scenario
Parking Area = 1 acre
= 43,560 ft2
Average Parking Cycle Distance = 417 ft

Number of Vehicle Trips = 25 trips/day
Number of Parking Cycles = 12.5 cycle/day

Daily Parking Travel Distance = 5218 ft/day
= 0.99 mi/day
Average Parking Cycle
Travel Speed = 5 mph (estimated)
Unpaved Road Travel
Emission Factor = 2.00 lb PM10/VMT (P. Gaffney/CARB, January 2000)
Average Unpaved Road
Test Travel Speed = 25.9 mph (average of UCD and DRI unpaved road emission studies, 1994 and 1996)
Parking Cycle Emission Factor = 0.39 lb PM10/VMT (assuming linear proportionality between emission factor and speed)

Baseline Emissions = 0.38 lb PM10/day

Typical Emission/Cost Scenario
Parking Area = 1 acre
= 43,560 ft2
Average Parking Cycle Distance = 417 ft

Number of Vehicle Trips = 50 trips/day (M. Zeldin email, 1/6/03)
Number of Parking Cycles = 25 cycle/day

Daily Parking Travel Distance = 10436 ft/day
= 1.98 mi/day
Average Parking Cycle
Travel Speed = 7 mph (M. Zeldin email, 1/6/03)
Unpaved Road Travel
Emission Factor = 2.00 lb PM10/VMT (P. Gaffney/CARB, January 2000)
Average Unpaved Road
Test Travel Speed = 25.9 mph (average of UCD and DRI unpaved road emission studies, 1994 and 1996)
Speed Adjustment Factor = 0.27 (assuming linear proportionality between emission factor and speed)
Average Test Vehicle Weight = 1.80 ton (UCD, April 1994; DRI, DEcember 1996)
Average Scenario Vehicle

Weight = 15.0 ton (M. Zeldin email, 1/6/03)
Weight Adjustment Factor = 2.60

Parking Cycle Emission Factor = 1.40 lb PM10/VM

Baseline Emissions = 2.78 lb PM10/day

Controlled Emissions:

Polymer Emulsion
Control Efficiency = 84% (Evaluation of Air Quality Performance Claims for Soil-Sement, CARB, April 2002)

Worst Case Cost-Effectiveness Scenario
Controlled Emissions = 0.06 lb PM10/day

Typical Emission/Cost Scenario
Controlled Emissions = 0.44 lb PM10/day

Emission Reduction:

Worst Case Cost-Effectiveness Scenario
Emission Reduction = 0.32 lb PM10/day
= 116.98 lb PM10/yr

Typical Emission/Cost Scenario
Emission Reduction = 2.33 lb PM10/day
= 850.92 lb PM10/yr

Cost-Effectiveness:

Worst Case Cost-Effectiveness Scenario
Cost-effectiveness = $45.68 /lb PM10
= $91,353 /ton PM10

Typical Emission/Cost Scenario
Cost-effectiveness = $4.71 /lb PM10
= $9,419 /ton PM10

Measure: **3g. Limit VDE to 20% opacity and require stabilized surface on unpaved parking areas receiving up to 100 trips per day**

Construction/Operational Cost:

Worst Case Cost-Effectiveness Scenario
Total Polymer Emulsion
Treatment Cost = $1.10 /yd2-yr (see Measure 3f)
= $5,343 /acre-yr

Typical Emission/Cost Scenario
Total Polymer Emulsion
Treatment Cost = $1.10 /yd2-yr (see Measure 3f)
= $4,008 /acre-yr

Baseline Emissions:

Worst Case Cost-Effectiveness Scenario
Minimum Number of
Vehicle Trips = 75 /day (assumed in conjunction with Measure 3f)
Average Parking Cycle
Travel Distance = 417 ft (see Measure 3f)
Average Vehicle Trip
Travel Distance = 209 ft
Daily Parking Travel Distance = 15653 ft/day
= 2.96 mi/day

Parking Cycle Emission Factor = 0.39 lb PM10/VMT (see Measure 3f)

Baseline Emissions = 1.14 lb PM10/day

Typical Emission/Cost Scenario

Minimum Number of Vehicle Trips =	90	/day (M. Zeldin email, 1/6/03)
Average Parking Cycle Travel Distance =	417	ft (see Measure 3f)
Average Vehicle Trip Travel Distance =	209	ft
Daily Parking Travel Distance =	18784	ft/day
=	3.56	mi/day
Parking Cycle Emission Factor =	1.40	lb PM10/VMT (see Measure 3f)
Baseline Emissions =	5.00	lb PM10/day

Controlled Emissions:

Polymer Emulsion
Control Efficiency = 84% (Evaluation of Air Quality Performance Claims for Soil-Sement, CARB, April 2002)

Worst Case Cost-Effectiveness Scenario
Controlled Emissions = 0.18 lb PM10/day

Typical Emission/Cost Scenario
Controlled Emissions = 0.80 lb PM10/day

Emission Reduction:

Worst Case Cost-Effectiveness Scenario
Emission Reduction = 0.96 lb PM10/day
= 351 lb PM10/yr

Typical Emission/Cost Scenario
Emission Reduction = 4.20 lb PM10/day
= 1,532 lb PM10/yr

Cost-Effectiveness:

Worst Case Cost-Effectiveness Scenario
Cost-effectiveness = $15.23 /lb PM10
= $30,451 /ton PM10

Typical Emission/Cost Scenario
Cost-effectiveness = $2.62 /lb PM10
= $5,233 /ton PM10

Measure: **3h. Require paving, gravel, or dust suppressants on unpaved parking areas receiving more than 100 trips per day or more than 10 trips per day by vehicles with more than 2 axles**

Scenario: Apply dust suppressant (polymer emulsion) annually to unpaved parking areas

Construction/Operational Cost:

Total Polymer Emulsion
Treatment Cost = $1.10 /yd2-yr (see Measure 3f)
= $5,343 /acre-yr

Baseline Emissions:

Light Duty Vehicles:

Minimum Number of Light Duty Vehicle Trips =	100	trips/day
Average Parking Cycle Travel Distance =	417	ft (see Measure 3f)
Average Vehicle Trip Travel Distance =	209	ft/trip
Daily Parking Travel Distance =	20871	ft/day
=	3.95	mi/day
Parking Cycle Emission Factor =	0.39	lb PM10/VMT (see Measure 3f)
Baseline Emissions =	1.53	lb PM10/day

3-Axle Vehicles:

Minimum Number of 3-Axle Vehicle Trips =	10	trips/day
Average Parking Cycle Travel Distance =	417	ft (see Measure 3f)
Average Vehicle Trip Travel Distance =	209	ft/trip
Daily Parking Travel Distance =	2087	ft/day
=	0.40	mi/day
Unpaved Road Travel Emission Factor =	2.00	lb PM10/VMT (P. Gaffney/CARB, January 2000)
Average Test Vehicle Weight =	1.80	ton (UCD, April 1994; DRI, DEcember 1996)
Minimum 3-Axle Vehicle Weight =	2.30	ton (Chevrolet Silverado 3500 with dual real axles)

(assume that unpaved road travel emission vary by weight^0.4 as indicated in AP-42, Section 13.2.2, 9/98)

Emission Factor Weight Adjustment Factor =	1.10	
3-Axle Vehicle Emission Factor =	0.43	lb PM10/VMT @ 5 mph
Baseline Emissions =	0.17	lb PM10/day

Controlled Emissions:

Polymer Emulsion Control Efficiency =	84%	(Evaluation of Air Quality Performance Claims for Soil-Sement, CARB, April 2002)
Controlled Emissions =	0.24	lb PM10/day - 100 light duty vehicles/day
=	0.03	lb PM10/day - 10 3-axle vehicles/day

Emission Reduction =	1.28	lb PM10/day - 100 light duty vehicles/day
=	467.93	lb PM10/yr - 100 light duty vehicles/day
=	0.14	lb PM10/day - 10 3-axle vehicles/day
=	51.64	lb PM10/yr - 10 3-axle vehicles/day
Cost-effectiveness =	$11.42	/lb PM10 - 100 light duty vehicles/day
=	$22,838	/ton PM10 - 100 light duty vehicles/day
=	$103.48	/lb PM10 - 10 3-axle vehicles/day
=	$206,951	/ton PM10 - 10 3-axle vehicles/day

Measure: **3i. Require notification to District of special event parking of more than 1000 vehicles on unpaved surfaces**

Scenario: Water application to control dust prior to event commencement

Construction/Operational Cost:

Parking Lot Capacity =	1,000	vehicles
Parking Space Size =	400	ft2 (estimated for unstriped, unpaved lots)
Parking Lot Size =	400,000	ft2
	9.2	acres
Water Application Rate =	629	gal/acre (Draft Regulation VIII Staff Report,

SJVUAPCD, September 2001)

Surface Coverage Rate =	2.9	acre/hr (Draft Regulation VIII Staff Report, SJVUAPCD, September 2001)
Parking Lot Watering Duration =	3.2	hr/day
Water Truck Filling and Driving Time =	2.0	hr/day
Total Truck Use Time =	5.2	hr/day
Water Charge Rate =	$0.0010	/gal (Sierra Research telephone survey of water purveyors, August, 2002)
Water Cost =	$5.78	/day
Water Truck Rental Rate =	$31.00	/hr (L. Stauch, Granite Construction, November 2002)
Truck Driver Rate =	$19.00	/hr (L. Stauch, Granite Construction, November 2002)
Water Truck Cost =	$50.00	/hr
=	$258.32	/day
Total Cost =	$264.10	/day

Baseline Emisisons:

Average Vehicle Trip Travel Distance =	632	ft (estimated from example lot dimensions)
Daily Parking Travel Distance =	1,264,911	ft/day
=	239.57	mi/day
Average Parking Travel Speed =	10	mph (estimated)
Unpaved Road Travel Emission Factor =	2.00	lb PM10/VMT (P. Gaffney/CARB, January 2000)
Average Unpaved Road Test Travel Speed =	25.9	mph (average of UCD and DRI unpaved road emission studies, 1994 and 1996)
Parking Cycle Emission Factor =	0.77	lb PM10/VMT (assuming linear proportionality between emission factor and speed)
Baseline Emissions =	184.99	lb PM10/event day

Controlled Emissions:

Watering Control Efficiency =	85%	-1st hour (Particulate Emission Measurements from
	50%	-2nd hour Control Construction Activities, MRI,
	10%	-3rd hour April 2001, test series 701)
	0%	-4th and following hours
8-Hour Average Control Efficiency =	18.1%	
Average Controlled Emissions =	151.46	lb PM10/event day

Emission Reductions =	33.53	lb PM10/event day
Cost Effectiveness =	$7.88	/lb PM10
	$15,753	/ton PM10

Measure: **3j. Require paving, 4 in gravel, or dust suppressants to maintain stabilized surface at special event parking**

Scenario: Apply dust suppressant (polymer emulsion) annually to maintain stabilized surface

Construction/Operational Cost:

Parking Lot Capacity =	1,000	vehicles (assumed)
Parking Space Size =	400	ft2 (estimated for unstriped, unpaved lots)
Parking Lot Size =	400,000	ft2
	9.2	acres
Water Application Rate =	629	gal/acre (Draft Regulation VIII Staff Report, SJVUAPCD, September 2001)
Surface Coverage Rate =	2.9	acre/hr (Draft Regulation VIII Staff Report, SJVUAPCD, September 2001)

Parking Lot Watering Duration =	3.2	hr/day
Water Truck Filling and Driving Time =	2.0	hr/day
Total Truck Use Time =	5.2	hr/day
Water Charge Rate =	$0.0010	/gal (Sierra Research telephone survey of water purveyors, August, 2002)
Water Cost =	$5.78	/day
Water Truck Rental Rate =	$31.00	/hr (L. Stauch, Granite Construction, November 2002)
Truck Driver Rate =	$19.00	/hr (L. Stauch, Granite Construction, November 2002)
Water Truck Cost =	$50.00	/hr
=	$258.32	/day
Total Watering Cost =	$264.10	/day
Minimum Number of Event Days Per Year =	10	day/yr (estimated)
Annual Watering Cost =	$2,641	/yr
Polymer Emulsion Treatment Cost =	$1.10	/yd2-yr (see Measure 3f)
=	$5,343	/acre-yr
Annual Treatment Cost =	$49,067	/yr
Net Annual Cost =	$46,426	/yr

Baseline Emissions:

Worst Case Cost-Effectiveness Scenario		
Average Vehicle Trip Travel Distance =	632	ft (estimated from example lot dimensions)
Daily Parking Travel Distance =	1,264,911	ft/day
=	239.57	mi/day
Average Parking Travel Speed =	10	mph (estimated)
Unpaved Road Travel Emission Factor =	2.00	lb PM10/VMT (P. Gaffney/CARB, January 2000)
Average Unpaved Road Test Travel Speed =	25.9	mph (average of UCD and DRI unpaved road emission studies, 1994 and 1996)
Parking Cycle Emission Factor =	0.77	lb PM10/VMT (assuming linear proportionality between emission factor and speed)
Minimum Number of Event Days Per Year =	10	day/yr (estimated)
Baseline Emissions =	185	lb PM10/event day
=	1,850	lb PM10/yr
Typical Emission/Cost Scenario		
Typical Number of Event Days Per Year =	100	day/yr (estimated)
Baseline Emissions =	185	lb PM10/event day
=	18,499	lb PM10/yr

Controlled Emission:

Polymer Emulsion Control Efficiency =	84%	(Evaluation of Air Quality Performance Claims for Soil-Sement, CARB, April 2002)
Worst Case Cost-Effectiveness Scenario		
Controlled Emissions =	296	lb PM10/yr
Typical Emission/Cost Scenario		
Controlled Emissions =	2,960	lb PM10/yr

Emission Reduction:

Worst Case Cost-Effectiveness Scenario

Emission Reduction =	1,554	lb PM10/yr

Typical Emission/Cost Scenario

Emission Reduction =	15,539	lb PM10/yr

Cost-effectiveness:

Worst Case Cost-Effectiveness Scenario

Cost-Effectiveness =	$29.88	/lb PM10
=	$59,752	/ton PM10

Typical Emission/Cost Scenario

Cost-Effectiveness =	$2.99	/lb PM10
=	$5,975	/ton PM10

SOURCE: CONSTRUCTION

		Measure	Cost Effectiveness of Measure (2002 $/ton PM10 reduction)	
4	a	Limit visible dust plume length to 100 yards	NA	
4	b	Apply dust suppressants within 100 feet of structure to be demolished	$129,000	$159,000
4	c	Apply water within 1 hour within 100 feet of structure to be demolished	NA	
4	d	Apply water or dust suppressants to areas where demolition equipment will operate	NA	
4	e	Apply water and/or dust suppressants to disturbed soils after demolition completion or at end of each day of cleanup	$7,220,000	
4	f	Prohibit demolition activities when wind speeds exceed 25 mph	$847,000	
4	g	Require Dust Control Training Class for on-site dust control coordinator	NA	
4	h	Require dust monitoring for projects with disturbed areas > 50 acres	$231,000	$339,000
4	i	Require minimum soil moisture of 12% for earthmoving	$21,600	$56,000
4	j	Limit on-site vehicle speeds to 15 mph	$850	
4	k	Require posting of speed limit signs for sites > 10 acres	$2,490	$74,600
4	l	Require stabilization of inactive areas immediately after disturbance	NA	
4	m	Require Dust Control Plans for residential projects > 10 acres, commercial projects > 5 acres	$17,200	$31,500
4	n	Require District notification of earthmoving operations at smaller project sites	$2,480	$14,800

Measure: **4a. Limit visible dust plume length to 100 yards**

The cost-effectiveness of this candidate BACM cannot be quantified because no data relating emissions to visible plume length could be found.

Measure: **4b. Apply dust suppressants within 100 feet of structure to be demolished**

Scenario: Lot remains vacant for at least six months after structural demolition

Construction/Operational Cost:

Worst Case Cost-Effectiveness Scenario

Minimum Structure Footprint Area =	1000	ft2 (estimated)
Area Treated With Dust Suppressants =	52,649	ft2
=	5,850	yd2
Surface Preparation Cost =	$0.04	/yd2 (DRI, 12/96)
Polymer Emulsion Application Rate =	0.28	gal/yd2 (Evaluation of Air Quality Performance Claims for Soil-Sement, CARB, April 2002)
Polymer Emulsion Cost =	$3.30	/gal (Midwest Industrial Supply, October 1999)
=	$0.92	/yd2
Polymer Emulsion Application Cost =	$0.18	/yd2 (DRI, 12/96)
Total Polymer Emulsion Treatment Cost =	$1.10	/yd2
=	$6,458	/demolition

Typical Emission/Cost Scenario

Typical Structure Footprint Area =	5000	ft2 (M. Zeldin memo, 12/9/02)
Fraction of Area Requiring Treatment =	50%	(M. Zeldin memo, 12/8/02)
Area Treated With Dust Suppressants =	34,142	ft2
=	3,794	yd2
Surface Preparation Cost =	$0.04	/yd2 (DRI, 12/96)
Polymer Emulsion Application Rate =	0.28	gal/yd2 (Evaluation of Air Quality Performance Claims for Soil-Sement, CARB, April 2002)
Polymer Emulsion Cost =	$3.30	/gal (Midwest Industrial Supply, October 1999)
=	$0.92	/yd2
Polymer Emulsion Application Cost =	$0.18	/yd2 (DRI, 12/96)
Total Polymer Emulsion Treatment Cost =	$1.10	/yd2
=	$4,188	/demolition

Baseline Emissions:

(assume that 20% opacity limit currently required by Rule 8021 can be met by watering twice per day)

Worst Case Cost-Effectiveness Scenario

Demolition Volume =	4,000	ft3 (based on one story structure height)
=	148	yd3
Demolition Haul Truck Capacity =	10	yd3 (assumed)
Number of Haul Truck Trips =	15	trips
Demolition Trip Onsite Distance =	232	ft/trip
Total Haul Truck Onsite Travel Distance =	3,474	ft/demolition
=	0.66	mile/demolition
Loader Capacity =	4.0	yd3 (Caterpillar 960 wheel loader, Caterpillar Performance Handbook, 1997)
Loader Travel Distance =	300	ft/load (includes demolition travel)
Number of Loader Trips =	38	trips
Total Loader Onsite Travel Distance =	11,400	ft/demolition
=	2.16	mile/demolition
Unpaved Road Travel Emission Factor =	2.00	lb PM10/VMT (P. Gaffney/CARB, January 2000)
Average Unpaved Road Test Travel Speed =	25.9	mph (average of UCD and DRI unpaved road emission studies, 1994 and 1996)
Average Onsite Travel Speed =	8	mph (estimated)
Speed-Adjusted Onsite Travel Emission Factor =	0.62	lb PM10/VMT (assuming linear proportionality between emission factor and speed)
Average Unpaved Road Test Vehicle Weight =	1.80	ton/vehicle (UCD, April 1994; DRI, December 1995)
Haul Truck Average Weight =	22.8	ton (estimated)
Weight Adjustment Factor =	2.76	(assumes that emissions are proportional to vehicle weight^0.4 as indicated in AP-42, 13.2.2-3, 9/98)
Haul Truck Emission Factor =	1.70	lb/VMT (adjusted for both 8 mph speed and 22.8 ton weight)
Loader Average Weight =	16.3	ton (Caterpillar Performance Handbook, 1997)
Weight Adjustment Factor =	2.41	(assumes that emissions are proportional to vehicle weight^0.4 as indicated in AP-42, 13.2.2-3, 9/98)
Loader Emission Factor =	1.49	lb/VMT (adjusted for both 8 mph speed and 16.7 ton weight)
Haul Truck Travel Emissions =	1.12	lb PM10/demolition
Loader Travel Emissions =	3.22	lb PM10/demolition
Total Uncontrolled Emissions =	4.34	lb PM10/demolition
Watering Control Efficiency =	85%	-1st hour (Particulate Emission Measurements from
	50%	-2nd hour Control Construction Activities, MRI,
	10%	-3rd hour April 2001, test series 701)
	0%	-4th and following hours
4-Hour Average Control Efficiency =	36.3%	
Baseline Demolition Emissions =	2.77	lb PM10/demolition
Windblown Dust Emission Factor =	156	lb PM10/acre-yr (Section 7.13, CARB Area Source Methodology, average of county factors weighted by county area)
=	78	lb PM10/acre-6 months
Minimum Disturbed Area =	1.21	acre
Baseline Windblown Emissions =	94.24	lb PM10/6 months
Baseline Emissions =	97.01	lb PM10/6 months

Typical Emission/Cost Scenario

Demolition Volume =	50,000	ft3 (based on two story structure height)
=	1,852	yd3
Demolition Haul Truck Capacity =	10	yd3 (assumed)
Number of Haul Truck Trips =	186	trips
Demolition Trip Onsite Distance =	205	ft/trip
Total Haul Truck Onsite		

Travel Distance =	38,147	ft/demolition
=	7.22	mile/demolition
Total Haul Truck Onsite Travel Distance on Soil Surfaces =	3.61	mile/demolition
Loader Capacity =	4.0	yd3 (Caterpillar 960 wheel loader, Caterpillar Performance Handbook, 1997)
Loader Travel Distance =	300	ft/load (includes demolition travel)
Number of Loader Trips =	463	trips
Total Loader Onsite Travel Distance =	138,900	ft/demolition
=	26.31	mile/demolition
Total Loader Onsite Travel Distance on Soil Surfaces =	13.15	mile/demolition
Unpaved Road Travel Emission Factor =	2.00	lb PM10/VMT (P. Gaffney/CARB, January 2000)
Average Unpaved Road Test Travel Speed =	25.9	mph (average of UCD and DRI unpaved road emission studies, 1994 and 1996)
Average Onsite Travel Speed =	8	mph (estimated)
Speed-Adjusted Onsite Travel Emission Factor =	0.62	lb PM10/VMT (assuming linear proportionality between emission factor and speed)
Average Unpaved Road Test Vehicle Weight =	1.80	ton/vehicle (UCD, April 1994; DRI, December 1995)
Haul Truck Average Weight =	22.8	ton (estimated)
Weight Adjustment Factor =	2.76	(assumes that emissions are proportional to vehicle weight^0.4 as indicated in AP-42, 13.2.2-3, 9/98)
Haul Truck Emission Factor =	1.70	lb/VMT (adjusted for both 8 mph speed and 22.8 ton weight)
Loader Average Weight =	16.3	ton (Caterpillar Performance Handbook, 1997)
Weight Adjustment Factor =	2.41	(assumes that emissions are proportional to vehicle weight^0.4 as indicated in AP-42, 13.2.2-3, 9/98)
Loader Emission Factor =	1.49	lb/VMT (adjusted for both 8 mph speed and 16.7 ton weight)
Haul Truck Travel Emissions =	6.16	lb PM10/demolition
Loader Travel Emissions =	19.60	lb PM10/demolition
Total Uncontrolled Emissions =	25.76	lb PM10/demolition
Watering Control Efficiency =	85%	-1st hour (Particulate Emission Measurements from
	50%	-2nd hour Control Construction Activities, MRI,
	10%	-3rd hour April 2001, test series 701)
	0%	-4th and following hours
4-Hour Average Control Efficiency =	36.3%	
Baseline Demolition Emissions =	16.42	lb PM10/demolition
Windblown Dust Emission Factor =	156	lb PM10/acre-yr (Section 7.13, CARB Area Source Methodology, average of county factors weighted by county area)
=	78	lb PM10/acre-6 months
Minimum Disturbed Area =	0.78	acre
Baseline Windblown Emissions =	61.11	lb PM10/6 months
Baseline Emissions =	77.54	lb PM10/6 months

Controlled Emissions:

Polymer Emulsion Control Efficiency =	84%	for actively disturbed areas (Evaluation of Air Quality Performance Claims for Soil-Sement, CARB, April 2002)
Worst Case Cost-Effectiveness Scenario Controlled Emissions =	15.52	lb PM10/demolition-vacant period
Typical Emission/Cost Scenario Controlled Emissions =	12.41	lb PM10/demolition-vacant period

Emission Reduction:

Worst Case Cost-Effectiveness Scenario
Emission Reduction = 81.49 lb PM10/demolition

Typical Emission/Cost Scenario
Emission Reduction = 65.13 lb PM10/demolition

Cost-Effectiveness:

Worst Case Cost-Effectiveness Scenario
Cost-Effectiveness = $79.25 lb PM10/demolition
$158,510 ton PM10/demolition

Typical Emission/Cost Scenario
Cost-Effectiveness = $64.30 lb PM10/demolition
$128,604 ton PM10/demolition

Measure: **4c. Apply water within 1 hour within 100 feet of structure to be demolished**

Rule 8021, Section 5.1, currently prohibits any demolition activity from producing emissions that exceed 20% opacity. In order to comply with this requirement, watering or other dust control activity must be conducted prior to the commencement of demolition.

Measure: **4d. Apply water or dust suppressants to areas where demolition equipment will operate**

Rule 8021, Section 5.1, currently prohibits any demolition activity from producing emissions that exceed 20% opacity. In order to comply with this requirement, watering or other dust control activity must be conducted prior to and during demolition.

Measure: **4e. Apply water and/or dust suppressants to disturbed soils after demolition completion or at end of each day of cleanup**

Scenario: Apply water to disturbed soils at the end of each day of demolition cleanup

Construction/Operational Cost:

Minimum Area to be Watered =	52,649	ft2 (see Measure 4.b)
=	1.21	acre
Water Application Rate =	629	gal/acre (Draft Regulation VIII Staff Report, SJVUAPCD, September 2001)
=	760	gal/demolition site
Surface Coverage Rate =	2.9	acre/hr (Draft Regulation VIII Staff Report, SJVUAPCD, September 2001)
Demolition Area Watering Duration =	0.4	hr/day
Water Truck Filling and Travel Time =	1.5	hr/day (estimated)
Total Truck Use Time =	1.9	hr/day
Water Charge Rate =	$0.0010	/gal (Sierra Research telephone survey of water purveyors, August, 2002)
Water Cost =	$0.76	/day
Water Truck Rental Rate =	$31.00	/hr (L. Stauch, Granite Construction, November 2002)
Truck Driver Rate =	$19.00	/hr (L. Stauch, Granite Construction, November 2002)
Water Truck Cost =	$50.00	/hr
=	$95.84	/day
Total Watering Cost =	$96.60	/day

Baseline Emissions:

Emission Factor =	156	lb PM10/acre-yr (Section 7.13, CARB Area Source Methodology, average of county factors weighted by county area)
Minimum Disturbed Area =	1.21	acre
Baseline Emissions =	188.49	lb PM10/yr
=	0.26	lb PM10/night

Controlled Emissions:

Watering Control Efficiency =	85%	-1st hour (Particulate Emission Measurements from
	50%	-2nd hour Control Construction Activities, MRI,
	10%	-3rd hour April 2001, test series 701)
	0%	-4th and following hours
14-Hour Average Control Efficiency =	10.4%	
Controlled Emissions =	0.23	lb PM10/day
Emission Reductions =	0.03	lb PM10/day
Cost-Effectiveness =	$3,612.26	/lb PM10
=	$7,224,511	/ton PM10

Measure: **4f. Prohibit demolition activities when wind speeds exceed 25 mph**

Construction/Operational Cost:

Borrowed Capital Cost		
Demolition Costs =	$150	/m3 (2001 Contract Cost Data, Caltrans, 2002)
=	$115	/yd3
Minimum Demolition Waste Volume =	148	yd3 (see Measure 4.b)
Total Demolition Cost =	$16,990	
Borrowing Rate =	5.15%	/yr (construction loan, American Home Loan Bank, November 2002)
=	0.0141%	/day
Daily Borrowing Cost =	$2.40	/day
Extra Watering Cost		
Minimum Area to be Watered =	1.21	acre (see Measure 4.b)
Water Application Rate =	629	gal/acre (Draft Regulation VIII Staff Report, SJVUAPCD, September 2001)
=	760	gal/demolition site
Water Truck Capacity =	4,000	gal (assumed)
Surface Coverage Rate =	2.9	acre/hr (Draft Regulation VIII Staff Report, SJVUAPCD, September 2001)
=	1,824	gal/hr
Watering Interval =	0.4	hr
Watering Time Per Truckload =	2.2	hr/truckload
Truckloads of Water Applied =	2	truckloads/day (estimated)
Demolition Area Watering Duration =	4.4	hr/day
Water Truck Filling and Travel Time =	2.0	hr/day
Total Truck Use Time =	6.4	hr/day
Water Charge Rate =	$0.0010	/gal (Sierra Research telephone survey of water purveyors, August, 2002)
Water Cost =	$8.00	/day
Water Truck Rental Rate =	$31.00	/hr (L. Stauch, Granite Construction, November 2002)
Truck Driver Rate =	$19.00	/hr (L. Stauch, Granite Construction, November 2002)
Water Truck Cost =	$50.00	/hr
=	$319.29	/day
Total Watering Cost =	$327.29	/day

Idled Labor and Equipment Cost

(assume that idled labor and equipment cannot be sent to an alternative job site as all demolition sites will be shut down on high wind days under this proposal)

Frontend Loader Charge Rate =	$56.00	/hr (L. Stauch/Granite Construction, November 2002)
Loader Operator Charge Rate =	$27.00	/hr (estimated)
Debris Haul Truck Charge Rate =	$60.00	/hr (D. Harrald/Kaweah River Rock, September 2002)
Haul Truck Operator Charge Rate =	$27.00	/hr (estimated)
Demolition Day Duration =	8.0	hr (estimated)
Idled Labor and Equipment Cost =	$1,360.00	/day
Total Cost =	$1,689.68	/day

Baseline Emissions:

Minimum Disturbed Area =	1.21	acre (see Measure 4.b)
Windblown Emission Factor =	0.0206	ton PM10/acre-hr @ 25 mph (Development of Vacant Land PM-10 Emission Factors in the Las Vegas Valley, D. James/UN Las Vegas, November 2001)
Duration of High Winds =	2	hr (D. James/UNLV, November 2001)
Uncontrolled High Wind Emissions =	99.7	lb PM10/high wind day
Watering Control Efficiency =	94%	@ 0.4 hr interval (Particulate Emission Measurements from Controlled Construction Activities, MRI, April 2001)
Baseline Emissions =	6.0	lb PM10/high wind day

Controlled Emissions:

Watering Control Efficiency in the Absence of Soil Disturbance Activities =	98%	on high wind days (estimated)
Controlled Emissions =	1.99	lb PM10/high wind day

Emission Reduction =	3.99	lb PM10/high wind day
Cost-Effectiveness =	$423.73	/lb PM10
=	$847,470	/ton PM10

Measure: **4g. Require Dust Control Training Class for on-site dust control coordinator**

The analysis of this measure is combined with that of Measure 4.m (dust control plans for smaller projects) because the two measures are inseparable.

Measure: **4h. Require dust monitoring for projects with disturbed areas > 50 acres**

Construction/Operational Cost:

Worst Case Cost-Effectiveness Scenario

Monitoring Cost

Project Area =	50	acres (assumed)
Residential Project Duration =	6	months (Section 7.7, CARB Area Source Methodologies, August 1997)
Monitoring Cost =	$7,500	/month (S. DeYoung/Calpine C*Power, November 26, 2002)
=	$45,000	/50 acre project

Watering Cost

Partial Day Water Application Cost =	$327	/6.4 hour day (see Measure 4.f)
Full Day Water Application Cost =	$409	/8 hr day
Residential Project Duration =	133	day/project
Increased Watering Cost =	$54,353	/50 acre project
Total Cost =	$99,353	/50 acre project

Typical Emission/Cost Scenario

Dust Control Coordinator Cost

Dust Control Coordinator Compensation Rate =	$50.00	/hr (L. Stauch/Granite Construction Company, November 2002)
Daily Time Allocated to Dust Control Duties =	2	hr/day (estimated)
Dust Coordinator Cost =	$13,286	/50 acre project

Watering Cost

Partial Day Water Application Cost =	$327	/6.4 hour day (see Measure 4.f)
Full Day Water Application Cost =	$409	/8 hr day
Residential Project Duration =	133	day/project
Increased Watering Cost =	$54,353	/50 acre project

Total Cost =	$67,639	/50 acre project

Baseline Emissions:

Construction Site Area =	50	acres (assumed)
Construction Emission Factors =	0.11	ton PM10/acre-month - non-earthmoving activities (Section 7.7, CARB Area Source Methodologies, August 1997)
=	0.42	ton PM10/acre-month - earthmoving activities (Section 7.7, CARB Area Source Methodologies, August 1997)
Residential Project Duration =	6	months/project (Section 7.7, CARB Area Source Methodologies, August 1997)
Earthmoving Duration =	0.75	months/project (MAG, May 1998)
Non-Earthmoving Emissions =	28.9	ton PM10/project
Earthmoving Emissions =	15.8	ton PM10/project
Total Uncontrolled Project Emissions =	44.6	ton PM10/project
Fraction of Construction Site Under Active Distrubance =	30%	(estimated)
=	15	acres
Number of Water Trucks Operating =	2	trucks/site (estimated)
Water Application Rate =	629	gal/acre (Draft Regulation VIII Staff Report, SJVUAPCD, September 2001)
=	9,435	gal/15 acre disturbed area
Water Truck Capacity =	4,000	gal (assumed)
Surface Coverage Rate =	2.9	acre/hr (Draft Regulation VIII Staff Report, SJVUAPCD, September 2001)
=	1,824	gal/hr-truck
=	3,648	gal/hr - 2 trucks
Watering Time Per Truckload =	2.2	hr/truckload
Water Truck Filling Time =	0.5	hr/truckload (estimated)
Water Truck Effective Watering Time =	2.7	hr/truckload
Effective Surface Coverage Rate =	2,971	gal/hr - 2 trucks
Watering Interval =	3.2	hr
Control Efficiency =	60.6%	(Particulate Emission Measurements from Controlled Construction Activities, MRI, April 2001, test series 701)
Baseline Emissions =	17.57	ton PM10/50 acre project

Controlled Emissions:

Number of Water Trucks Operating =	3	trucks/site
Effective Surface Coverage Rate =	4,456	gal/hr - 3 trucks
Watering Interval =	2.1	hr
Control Efficiency =	73.7%	(Particulate Emission Measurements from Controlled Construction Activities, MRI, April 2001, test series 701)
Controlled Emissions =	11.7	ton PM10/50 acre project

Emission Reduction =	5.86	ton PM10/50 acre project - 6 months
=	0.29	ton PM10/50 acre project - exceedance days
=	586	lb PM10/50 acre project

Cost-Effectiveness:

Worst Case Cost-Effectiveness Scenario

Cost-Effectiveness =	$169.60	/lb PM10
=	$339,208	/ton PM10

Typical Emission/Cost Scenario

Cost-Effectiveness =	$115.46	/lb PM10
=	$230,930	/ton PM10

Measure: **4i. Require minimum soil moisture of 12% for earthmoving**

Construction/Operational Cost:

Sprinkler Scenario

Residential Project Size =	40	acres (assumed)
Earthmoving Duration =	0.75	months (MAG, May 1998)
Irrigation Pipe Length Needed =	1060	ft (estimated)
Irrigation Pipe Rental =	$8.00	/mo per 30' length of 3" diameter latch style aluminum w/ sprinkler Rain For Rent, November 2002)
=	$282.67	/project
=	$7.07	/acre
Irrigation Pipe Setup and Breakdown Time =	1.5	hr/day (estimated)
Number of Laborers Needed =	2	laborers/day
Laborer Labor Rate =	$17.89	/hr (Bureau of Labor Statistics, D. Harrald/Keweah River Rock, September 2002)
Labor Cost =	$53.68	/day
=	$886	/project
=	$22.14	/acre
Earthmoving Depth =	1.0	ft - average (estimated)
Earthmoving Volume =	43,560	ft3/acre (estimated)
=	1,613	yd3/acre
Earth Density =	3,200	lb/yd3 - banked (Caterpillar Performance Handbook, 1999)
Weight of Earth Moved =	5,162,667	lb/project
=	129,067	lb/acre
=	65	ton/acre
Natural Earth Moisture Content =	4%	(estimated)
Desired Earth Moisture Content =	12%	
Weight of Water Needed =	413,013	lb
=	49,512	gal
=	1,238	gal/acre
Water Charge Rate =	$0.0010	/gal (Sierra Research telephone survey of water purveyors, August, 2002)
Water Cost =	$1.24	/acre
Total Cost =	$30.45	/acre
=	$1,218	/40 acre project

Water Truck Scenario

(assume that water trucks are already onsite, and that the only costs are the cost of labor devoted to watering and the cost of additional water applied to bring soil moisture up to 12%)

Water Cost =	$1.24	/acre
=	$49.51	/40 acre project
Residential Project Size =	40	acres (assumed)
Earthmoving Duration =	0.75	months (MAG, May 1998)
=	16.6	days
=	132.9	hours
Earthmoving Depth =	1.0	ft - average (estimated)
Total Earthmoving Volume =	1,742,400	ft3
=	64,533	yd3
Scraper Earthmoving Rate =	70,000	yd3/month (PM10 Fugitive Dust Integration Project, Countess Environmental, July 1996)
=	52,500	yd3/0.75 month
Number of Scrapers Needed =	1.2	minimum
Number of Water Trucks Needed =	1.2	minimum
Truck Driver Rate =	$19.00	/hr (L. Stauch, Granite Construction, November 2002)
Truck Driver Cost =	$3,103	/40 acre project
Total Cost =	$3,152	/40 acre project

Baseline Emissions:

Scraper Loading

Emission Factor =		0.0302	lb PM10/ton (AP-42, 11.9.-10, July 1998)
Scraper Unloading Emission Factor =		0.0208	lb PM10/ton (AP-42, 11.9.-10, July 1998)
Scraper Travel Emission Factor, E =		(2.6)[(s/12)^0.8][(W/3)^0.4]/[(M/0.2)^0.3]	(p. 13.2.2-3, AP-42, September 1998)
where:	s =	6.5%	(UCD, April 1994; DRI, December 1996)
	W =	99.4	tons - avg. of empty and loader weights, 651E scraper, Caterpillar Performance Handbook, 1999)
	M =	4%	
	E =	2.63	lb PM10/VMT
Scraper Haul Distance =		0.25	miles/trip (estimated)
Scraper Capacity =		52	ton/trip (651E scraper, Caterpillar Performance Handbook, 1999)
Scraper Travel Emission Factor =		1.26E-02	lb PM10/ton
Baseline Emissions =		0.0636	lb PM10/ton
=		4.11	lb PM10/acre

Controlled Emissions:

(assume that scraper loading and unloading emission factors vary by moisture content^-1.4 as specified in the AP-42 emission factor equation for material handling)

Scraper Loading Emission Factor =		0.0065	lb/ton
for:	M =	12%	
Scraper Unloading Emission Factor =		0.0045	lb PM10/ton
for:	M =	12%	
Scraper Travel Emission Factor, E =		1.89	lb PM10/VMT
=		9.09E-03	lb PM10/ton
for:	M =	12%	
Controlled Emissions =		0.0200	lb PM10/ton
		1.29	lb PM10/acre

Emission Reduction =	2.81	lb PM10/acre
=	112.5	lb PM10/40 acre project

Cost-Effectiveness:

Sprinkler Scenario		
Cost-Effectiveness =	$10.82	/lb PM10
	$21,645	/ton PM10
Water Truck Scenario		
Cost-Effectiveness =	$28.01	/lb PM10
	$56,027	/ton PM10

Measure: **4j. Limit on-site vehicle speeds to 15 mph**

Scenario: Enforcement by District inspectors using radar guns

Construction/Operational Cost:

Purchase Cost of Handheld Radar:	$700	(www.radar-gun.com)
Useful Life =	8	yr (estimated)
Capital Recovery Factor =	0.1874	
Annualized Capital Cost =	$131.21	/yr
Annual Days of Use =	50	day/yr (estimated)
Daily Cost =	$2.62	/day

(assume that inspectors perform speed checks as part of regular construction site inspections)

Speed Check Duration =	0.5	hr/day (estimated)
Inspector Labor Rate =	$38.50	/hr (F. Bates/SJVUAPCD, 9/30/02 email)
Inspector Cost =	$19.25	/day

Daily Cost =	$21.87	/day
Number of Site Visits Per Project =	6	visits/project (estimated)
Total Cost =	$131.25	/project

Baseline Emissions:

(all scraper, grader, bulldozer, and water trucks operate at speeds slower than 15 mph - field notes from Improvement of Specific Emission Factors (BACM Project No. 1), prepared by Midwest Research Institute for South Coast AQMD, March 1996)

Residential Project Size =	40	acres (assumed - smallest required to have Dust Control Plan)
Light-Duty Truck Travel =	40	VMT/acre (PM10 Emission Inventory, Engineering-Science, 10/87)
=	1600	VMT/project
Light-Duty Truck Speed =	20	mph (estimated)
Unpaved Road Emission Factor =	2.00	lb PM10/VMT (P. Gaffney/CARB, January 2000)
Baseline Emission Factor Speed =	25.9	mph (UCD, April 1994 and DRI, December 1996)
Emission Factor @ 20.0 mph =	1.54	lb/VMT (assumes linear relationship between speed and emissions)
Baseline Emissions =	2,471	lb PM10/project

Controlled Emissions:

Enforced Speed Limit =	15	mph
Compliance Fraction =	50%	(estimated)
Average Light-Duty Truck Speed =	17.5	mph
Emission Factor @ 17.5 mph =	1.35	lb/VMT (assumes linear relationship between speed and emissions)
Controlled Emissions =	2,162	lb PM10/project

Emission Reduction =	309	lb PM10/project
Cost-Effectiveness =	$0.42	/lb PM10
=	$850	/ton PM10

Measure: **4k. Require posting of speed limit signs for sites > 10 acres**

Scenario: Post signs limiting speed on unpaved areas to 15 mph

Construction/Operational Cost:

Worst Case Cost-Effectiveness Scenario		
Residential Project Size =	10	acres (assumed - minimum size to be regulated)
Road Length =	2,087	ft (estimated)
Spacing of Speed Signs =	2	/500 ft of road (estimated)
Number of Signs Needed =	8	signs/project
Installed Sign Cost =	$200	/yr (S. Hamilton/Merced DPW, November 2002)
Total Sign Cost =	$1,600	
Salvage Value of Metal Sign =	$20	/sign (S. Hamilton/Merced DPW, November 2002)
=	$160	/project
Total Net Sign Cost =	$1,440	/project

Typical Emission/Cost Scenario		
Residential Project Size =	50	acres (M. Zeldin email, 1/6/03)
Number of Signs Needed =	4	signs/project (M. Zeldin email, 1/6/03)
Installed Sign Cost =	$200	/yr (S. Hamilton/Merced DPW, November 2002)
Total Sign Cost =	$800	
Salvage Value of Metal Sign =	$20	/sign (S. Hamilton/Merced DPW, November 2002)
=	$80	/project
Total Net Sign Cost =	$720	/project

Baseline Emissions:

Worst Case Cost-Effectiveness Scenario		
Light-Duty Truck Travel =	40	VMT/acre (PM10 Emission Inventory,

		Engineering-Science, 10/87)
=	400	VMT/10 acre-project
Light-Duty Truck Speed =	20	mph (estimated)
Unpaved Road Emission Factor =	2.00	lb PM10/VMT (P. Gaffney/CARB, January 2000)
Baseline Emission Factor Speed =	25.9	mph (UCD, April 1994 and DRI, December 1996)
Emission Factor @ 20.0 mph =	1.54	lb/VMT (assumes linear relationship between speed and emissions)
Baseline Emissions =	618	lb PM10/project
Typical Emission/Cost Scenario		
Light-Duty Truck Travel =	40	VMT/acre (PM10 Emission Inventory, Engineering-Science, 10/87)
=	2000	VMT/50 acre-project
Light-Duty Truck Speed =	20	mph (estimated)
Unpaved Road Emission Factor =	2.00	lb PM10/VMT (P. Gaffney/CARB, January 2000)
Baseline Emission Factor Speed =	25.9	mph (UCD, April 1994 and DRI, December 1996)
Emission Factor @ 20.0 mph =	1.54	lb/VMT (assumes linear relationship between speed and emissions)
Baseline Emissions =	3,089	lb PM10/project

Controlled Emissions:

Worst Case Cost-Effectiveness Scenario		
Enforced Speed Limit =	15	mph
Compliance Fraction =	25%	(estimated)
Average Light-Duty Truck Speed =	18.8	mph
Emission Factor @ 18.8 mph =	1.45	lb/VMT (assumes linear relationship between speed and emissions)
Controlled Emissions =	579	lb PM10/project
Typical Emission/Cost Scenario		
Enforced Speed Limit =	15	mph
Compliance Fraction =	75%	(M. Zeldin email, 1/6/03)
Average Light-Duty Truck Speed =	16.3	mph
Emission Factor @ 16.3 mph =	1.25	lb/VMT (assumes linear relationship between speed and emissions)
Controlled Emissions =	2,510	lb PM10/project

Emission Reduction:

Worst Case Cost-Effectiveness Scenario		
Emission Reduction =	38.6	lb PM10/project
Typical Emission/Cost Scenario		
Emission Reduction =	579	lb PM10/project

Cost-Effectiveness:

Worst Case Cost-Effectiveness Scenario		
Cost-Effectiveness =	$37.30	/lb PM10
	$74,592	/ton PM10
Typical Emission/Cost Scenario		
Cost-Effectiveness =	$1.24	/lb PM10
	$2,486	/ton PM10

Measure: **4l. Require stabilization of inactive areas immediately after disturbance**

No additional cost is incurred in the early stabilization of inactive areas, provided that these areas are not redisturbed and require restabilization within the current seven day grace period. Since the probability of this contingency is impossible to predict, we can only assume that the cost of this measure is zero and, because implementation would reduce emissions, that the cost-effectiveness of this measure is infinite.

Measure: **4m. Require Dust Control Plans for residential projects > 10 acres, commercial projects > 5 acres**

Scenario: Dust Control Plan for 10 Acre Residential Project, Training for On-site Dust Control Coordinator, Increased Water Application

Construction/Operational Cost:

Training Cost		
Project Size =	10	acres (assumed)
Residential Project Duration =	6	months (Section 7.7, CARB Area Source Methodologies, August 1997)
Dust Control Class Duration =	4	hr (Section 94 handbook, Clark County Department of Comprehensive Planning, January 2001)
Class Travel Time =	2	hr (estimated)
Total Class Time =	6	hr
Dust Control Coordinator Compensation Rate =	$50.00	/hr (L. Stauch/Granite Construction Company, November 2002)
Training Cost =	$300.00	total
Useful Life of Training =	3	yr (Section 94 handbook, Clark County Department of Comprehensive Planning, January 2001)
Capital Recovery Factor =	0.4021	
Annualized Training Cost =	$120.63	/yr
Training Cost Per Project =	$60.32	/project
Additional Watering Cost		
Baseline Watering Control Efficiency =	15%	(estimated)
Baseline Watering Interval =	6.9	hr (Particulate Emission Measurements from Controlled Construction Activities, MRI, April 2001, test series 701)
Fraction of Construction Site Under Active Distrubance =	30%	(estimated)
=	3.0	acres
Surface Coverage Rate =	2.9	acre/hr (Draft Regulation VIII Staff Report, SJVUAPCD, September 2001)
Water Application Rate =	629	gal/acre (Draft Regulation VIII Staff Report, SJVUAPCD, September 2001)
Number of Watering Passes =	1.2	passes/8 hr day
Baseline Watering Duration =	1.2	hr/8 hr day
Water Application Rate =	7,341	gal/day
Number of Water Truck Trips to Construction Site =	2	trips/day (estimated)
Number of Truck Fillings =	2	fillings/day
Travel and Filling Time =	3.0	hr/day
Baseline Truck Use Time =	4.2	hr/day
Controlled Watering Interval =	2.1	hr (see Measure 4.h)
Number of Watering Passes =	3.8	passes/8 hr day
Controlled Watering Duration =	3.9	hr/day
On-Site Truck Time =	8.0	hr/day
Travel Time =	1.0	hr/day
Total Truck Use Time =	9.0	hr/day
Total Additional Truck Use Time =	4.8	hr/day
Project Construction Days =	133	day/10 acre project
Additional Watering Duration =	2.7	hr/day (estimated)
Additional Water Application =	4,928	gal/day
Water Charge Rate =	$0.0010	/gal (Sierra Research telephone survey of water purveyors, August, 2002)
Water Cost =	$4.93	/day
=	$654.68	/10 acre project
Water Truck Rental Rate =	$31.00	/hr (L. Stauch, Granite Construction, November 2002)
Truck Driver Rate =	$19.00	/hr (L. Stauch, Granite Construction, November 2002)
Water Truck Cost =	$50.00	/hr
=	$239.63	/day
=	$31,837	/10 acre project
Total Additional Watering Cost =	$32,492	/10 acre project
Total Cost =	$32,552	/10 acre project

Baseline Emissions:

Residential Project Emissions =	44.63	ton PM10/50 acre project (see Measure 4.h)
=	8.93	ton PM10/10 acre project
Regulation VIII Control Efficiency =	15%	(estimated)
Baseline Emissions =	7.59	ton PM10/10 acre project

Controlled Emissions:

Worst Case Cost-Effectiveness Scenario

Dust Control Plan, Training, and Monitoring Control Efficiency =	14.4%	(Dust Monitoring Summaries, Los Esteros Energy Facility, Lowney Associates, September 2002)
Measure 4.h Emission Reduction =	0.29	ton PM10/50 acre project
=	0.06	ton PM10/10 acre project
Measure 4.h Effective Control Efficiency =	0.8%	
Dust Control Plan and Training Control Efficiency =	13.6%	
Controlled Emissions =	6.56	ton PM10/10 acre project

Typical Emission/Cost Scenario

Dust Control Plan and Training Control Efficiency =	25%	(M. Zeldin email, 12/9/02)
Controlled Emissions =	5.69	ton PM10/10 acre project

Emission Reduction:

Worst Case Cost-Effectiveness Scenario

Emission Reduction =	1.03	ton PM10/10 acre project
=	2,061	lb PM10/10 acre project

Typical Emission/Cost Scenario

Emission Reduction =	1.90	ton PM10/10 acre project
=	3,793	lb PM10/10 acre project

Cost-Effectiveness:

Cost-Effectiveness =	$15.77	/lb PM10
=	$31,533	/ton PM10

Typical Emission/Cost Scenario

Cost-Effectiveness =	$8.58	/lb PM10
=	$17,164	/ton PM10

Measure: **4n. Require District notification of earthmoving operations at smaller project sites**

Construction/Operational Cost:

Worst Case Cost-Effectiveness Scenario
(assume that increased inspection of smaller project sites will result in greater use of watering to control dust during earthmoving operations)

Project Size =	10	acres (assumed)
Duration of Earthmoving =	5	days (estimated)
Surface Coverage Rate =	2.9	acre/hr (Draft Regulation VIII Staff Report, SJVUAPCD, September 2001)
Additional Watering Duration =	4.8	hr/day (see Measure 4.m)
Water Application Rate =	629	gal/acre (Draft Regulation VIII Staff Report, SJVUAPCD, September 2001)
Additional Water Application =	8,742	gal/day
Number of Tank Fillings =	3	fillings/day
Water Truck Filling Time =	1.5	hr/day
Total Truck Use Time =	6.3	hr/day
Water Charge Rate =	$0.0010	/gal (Sierra Research telephone survey of water purveyors, August, 2002)
Water Cost =	$8.74	/day
Water Truck Rental Rate =	$31.00	/hr (L. Stauch, Granite Construction, November 2002)

Truck Driver Rate =	$19.00	/hr (L. Stauch, Granite Construction, November 2002)
Water Truck Cost =	$50.00	/hr
=	$314.63	/day
Total Cost =	$323.38	/day
=	$1,616.89	/earthmoving phase

Typical Emission/Cost Scenario
(assume that the only increase in cost is that of devoting time to provide notification to the District regarding the schedule for earthmoving)

Dust Control Coordinator Compensation Rate =	$50.00	/hr (L. Stauch/Granite Construction Company, November 2002)
Notification Time Demand =	2	hr (M. Zeldin email, 12/9/02)
Notification Time Cost =	$100.00	

Baseline Emissions:

Earthmoving Phase Emissions =	0.42	ton PM10/acre-month - earthmoving activities (Section 7.7, CARB Area Source Methodologies, August 1997)
=	0.09	ton PM10/acre-earthmoving phase
Regulation VIII Control Efficiency =	15%	(estimated)
Baseline Emissions =	0.08	ton PM10/acre-earthmoving phase
=	0.81	ton PM10/earthmoving phase

Controlled Emissions:

Worst Case Cost-Effectiveness Scenario
(assume that the control efficiency of additional watering during earthmoving will be equivalent to the control efficiency achieved through the requirement of smaller construction site to implement Dust Control Plans)

Control Efficiency =	13.6%	(see Measure 4.m)
Controlled Emissions =	0.70	ton PM10/earthmoving phase

Typical Emission/Cost Scenario

Control Efficiency =	5%	(M. Zeldin email, 12/9/02)
Controlled Emissions =	0.77	ton PM10/earthmoving phase

Emission Reduction:

Worst Case Cost-Effectiveness Scenario

Emission Reduction =	0.11	ton PM10/earthmoving phase
=	219	lb PM10/earthmoving phase

Typical Emission/Cost Scenario

Emission Reduction =	0.04	ton PM10/earthmoving phase
=	81	lb PM10/earthmoving phase

Cost-Effectiveness:

Worst Case Cost-Effectiveness Scenario

Cost-Effectiveness =	$7.38	/lb PM10
=	$14,767	/ton PM10

Typical Emission/Cost Scenario

Cost-Effectiveness =	$1.24	/lb PM10
=	$2,481	/ton PM10

SOURCE: BULK MATERIALS

		Measure	Cost Effectiveness of Measure (2002 $/ton PM10 reduction)
5	a	Require that VDE not exceed property line	NA
5	b	Require construction of 3-sided enclosures with 50% porosity	$659,000
5	c	Impose Rule 8031 requirements on sites storing less than 100 yd3 of bulk materials	$659,000
5	d	Impose Rule 8031 requirements on agricultural off-field storage of non-commodity bulk materials	NA

Measure: **5a. Require that VDE not exceed property line**

The cost-effectiveness of this candidate BACM cannot be quantified because no data relating emissions to visible plume length could be found.

Measure: **5b. Require construction of 3-sided enclosures with 50% porosity**

Construction/Operational Cost:

Soil Angle of Repose =	35	degrees (estimated)
Minimum Pile Volume =	5.0	yd3 (assumed)
Minimum Pile Radius =	1.90	yd
Minimum Pile Diameter =	11.4	ft
Minimum Pile Height =	1.33	yd
=	3.98	ft
Minimum Pile Lateral Surface Area =	13.79	yd2
=	124.1	ft2
Construction Cost of 50% Porosity, 3-Sided Enclosure =	$52.39	/meter (2001 Contract Cost Data, Caltrans, January 2002)
=	$15.97	/ft
Length of Enclosure =	52.1	ft (estimated from pile dimensions)
3-Sided Enclosure Construction Cost =	$832	
Useful Life =	15	yr (estimated for metal fence)
Capital Recovery Factor =	0.1315	
Annualized Enclosure Cost =	$109	/yr

Baseline Emissions:

Emission Factor =	156	lb PM10/acre-yr (Section 7.13, CARB Area Source Methodology, average of county factors weighted by county area)
Disturbed Area =	124.1	ft2/minimum pile
=	0.003	acre
Baseline Emissions =	0.44	lb PM10/yr

Controlled Emissions:

Wind Reduction Efficiency =	50%	reduction in downwind wind speed (A Wind Tunnel Study of Wind Screen Effectiveness for Fugitive Dust Control, 95-TA34.01, 88th Annual Meeting of AWMA, June 1995)
Control Efficiency =	74.7%	(determined through modeling of open area windblown emissions with 50% reduction in wind speed and assuming no emission reduction when winds approach open side)
Controlled Emissions =	0.11	lb PM10/yr

Emission Reduction =	0.33	lb PM10/yr
Cost-Effectiveness =	$330	/lb PM10
	$659,481	/ton PM10

Measure: **5c. Impose Rule 8031 requirements on sites storing less than 100 yd3 of bulk materials**

Construction/Operational Cost:

Minimum Pile Lateral Surface Area =	124.1	ft2 (see Measure 5.b)
Construction Cost of 50% Porosity, 3-Sided Enclosure =	$52.39	/meter (2001 Contract Cost Data, Caltrans, January 2002)
=	$15.97	/ft
Length of Enclosure =	52.1	ft (estimated from pile dimensions)
3-Sided Enclosure Construction Cost =	$832	(see Measure 5.b)
Useful Life =	15	yr (estimated by metal fence)
Capital Recovery Factor =	0.1315	
Annualized Enclosure Cost =	$109	/yr

Baseline Emissions:

Emission Factor =	156	lb PM10/acre-yr (Section 7.13, CARB Area Source Methodology, average of county factors weighted by county area)
Disturbed Area =	124.1	ft2/minimum pile
=	0.003	acre
Baseline Emissions =	0.44	lb PM10/yr

Controlled Emissions:

Control Efficiency =	75%	(see Measure 5.b)
Controlled Emissions =	0.11	lb PM10/yr

Emission Reduction =	0.33	lb PM10/yr
Cost-Effectiveness =	$329.74	/lb PM10
=	$659,481	/ton PM10

Measure: **5d. Impose Rule 8031 requirements on agricultural off-field storage of non-commodity bulk materials**

Rule 8081 currently imposes Rule 8031 requirements on agricultural off-field handling and storage of bulk materials.

Source: Open Areas

		Measure	Cost Effectiveness of Measure (2002 $/ton PM10 reduction)	
6	a	Impose Rule 8051 requirements on urban parcels > 0.5 acres containing 1000 ft2 of disturbed surface area	$67,800	
6	b	Impose Rule 8051 requirements immediately after cessation of disturbance	$6,450	$33,600

Common Parameters:

Polymer Emulsion Dust Suppressant Cost = $3.30 /gal (Midwest Industrial Supply, October 1999)

Measure: **6a. Impose Rule 8051 requirements on urban parcels > 0.5 acres containing 1000 ft2 of disturbed surface area**

Scenario: Apply dust suppressants

Construction/Operational Cost:

Area To Be Treated =	1000	ft2 (assumed)
=	111	yd2
Surface Preparation Cost =	$0.04	/yd2 (DRI, 12/96)
=	$4.44	/acre
Polymer Emulsion Application Rate =	0.28	gal/yd2 (Evaluation of Air Quality Performance Claims for Soil-Sement, CARB, April 2002)
Polymer Emulsion Cost =	$3.30	/gal (Midwest Industrial Supply, October 1999)
=	$0.92	/yd2
Polymer Emulsion Application Cost =	$0.18	/yd2 (DRI, 12/96)
Total Polymer Emulsion Treatment Cost =	$1.10	/yd2
=	$123	/111 yd2
Useful Life =	3	yr (estimated)
Capital Recovery Factor =	0.4021	
Annualized Treatment Cost =	$49	/yr - 111 yd2
Number of Signs Needed =	2	/acre (estimated)

(assume that any parcel smaller than 1.0 acre will also require a minimum of 2 No Trespassing signs)

Cost of Sign Puchase and Installation =	$200	/yr (S. Hamilton/Merced DPW, November 2002)
Total Sign Cost =	$400	
Useful Life =	15	yr (S. Hamilton/Merced DPW, November 2002)
Capital Recovery Factor =	0.1315	
Annualized Sign Cost =	$53	/yr
Total Annualized Cost =	$102	/yr

Baseline Emissions:

Emission Factor =	156	lb PM10/acre-yr (Section 7.13, CARB Area Source Methodology, average of county factors weighted by county area)
Minimum Disturbed Area =	1000	ft2 (assumed)
=	0.023	acre
Baseline Emissions =	3.58	lb PM10/yr

Controlled Emissions:

Polymer Emulsion

Control Efficiency =	84%	for unpaved road use (Evaluation of Air Quality Performance Claims for Soil-Sement, CARB, April 2002)

(assume polymer emulsion control efficiency for windblown dust emissions is the same as that for unpaved road travel emissions)

Controlled Emissions =	0.57	lb PM10/yr
Emission Reduction =	3.01	lb PM10/yr
Cost-effectiveness =	$33.89	/lb PM10
=	$67,780	/ton PM10

Measure: **6b. Impose Rule 8051 requirements immediately after cessation of disturbance**

Construction/Operational Cost:

Area To Be Treated =	3.0	acres (assumed)
Total Polymer Emulsion Treatment Cost =	$1.10	/yd2 (see Measure 6.a)
=	$5,343	/acre
=	$16,030	/3 acres
Useful Life =	3	yr (estimated)
Capital Recovery Factor =	0.4021	
Annualized Treatment Cost =	$6,446	/yr
Cost of 7-Day Coverage =	$123.62	/3 acres for 7 days
Number of Signs Needed =	2	/acre (estimated)
Cost of Sign Puchase and Installation =	$200	/yr (S. Hamilton/Merced DPW, November 2002)
Total Sign Cost =	$1,200	
Useful Life =	15	yr (S. Hamilton/Merced DPW, November 2002)
Capital Recovery Factor =	0.1315	
Annualized Sign Cost =	$158	/yr
Cost of 7-Day Coverage =	$3.03	/6 signs for 7 days
Total Cost of 7-Day Coverage =	$126.65	

Baseline Emissions:

Worst Case Cost-Effectiveness Scenario

Emission Factor =	156	lb PM10/acre-yr (see Measure 6.a)
=	0.43	lb PM10/acre-day
Baseline Emissions =	8.97	lb PM10/3 acres for 7 days

Typical Emission/Cost Scenario

Emission Factor =	156	lb PM10/acre-yr (see Measure 6.a)
Number of Annual Wind Events =	10	(M. Zeldin email, 1/6/03)
Emissions Per Event =	15.6	lb PM10/acre-event
Baseline Emissions =	46.8	lb PM10/3 acres for 7 days

Controlled Emissions:

Polymer Emulsion Control Efficiency =	84%	for unpaved road use (Evaluation of Air Quality Performance Claims for Soil-Sement, CARB, April 2002)

(assume polymer emulsion control efficiency for windblown dust emissions is the same as that for unpaved road travel emissions)

Worst Case Cost-Effectiveness Scenario

Controlled Emissions =	1.44	lb PM10/3 acres for 7 days

Typical Emission/Cost Scenario

Controlled Emissions =	7.49	lb PM10/3 acres for 7 days

Emission Reduction:

Worst Case Cost-Effectiveness Scenario

Emission Reduction =	7.54	lb PM10/3 acres for 7 days

Typical Emission/Cost Scenario

Emission Reduction =	39.30	lb PM10/3 acres for 7 days

Cost-Effectiveness:

Worst Case Cost-Effectiveness Scenario

Cost-effectiveness =	$16.80	/lb PM10
=	$33,608	/ton PM10

Typical Emission/Cost Scenario

Cost-effectiveness =	$3.22	/lb PM10
=	$6,445	/ton PM10

SOURCE: WINDBLOWN DUST

		Measure	Cost Effectiveness of Measure (2002 $/ton PM10 reduction)	
7	a	Require cessation of construction when wind events are declared	$7,770	$12,700
7	b	Require cessation of construction when 20% opacity exceeded	NA	
7	c	Require continued operation of water trucks when construction ceases	$0	
7	d	Require more than one stabilization method when 20% opacity exceeded on disturbed open areas	$15,000	$65,600
7	e	Cease material handling activities when dust plumes cross property line	NA	
7	f	Water storage piles or cover when wind events are declared	$9,240	$27,700

Measure: **7a. Require cessation of construction when wind events are declared**

Construction/Operational Cost:

(assume that idled labor and equipment cannot be sent to an alternative job site as all construction sites will be shut down on high wind days under this proposal)

Scraper Charge Rate =	$60.00	/hr (estimated)
Number of Scrapers =	1	(estimated)
Bulldozer Charge Rate =	$60.00	/hr (estimated)
Number of Bulldozers =	1	(estimated)
Frontend Loader Charge Rate =	$56.00	/hr (L. Stauch/Granite Construction, November 2002)
Number of Loaders =	1	(estimated)
Grader Charge Rate =	$50.00	/hr (estimated)
Number of Graders =	1	(estimated)
Hourly Equipment Cost =	$226.00	/hr
Equipment Operator Charge Rate =	$27.00	/hr (estimated)
Number of Equipment Operators =	4	operators
Laborer Charge Rate =	$18.00	/hr
Number of Laborers =	3	laborers (estimated)
Hourly Labor Cost =	$162.00	/hr
Daily Operating Hours =	8	hr/day (estimated)
Equipment and Labor Cost =	$388.00	/hr
Total Cost =	$3,104	/day

Baseline Emissions:

Minimum Disturbed Area =	40	acre (assumed)
Number of Construction Days =	21.7	construction days/avg. month
Construction Emission Factors =	0.42	ton PM10/acre-month - earthmoving activities (Section 7.7, CARB Area Source Methodologies, August 1997)
=	38.7	lb PM10/acre-day
=	1,547	lb PM10/day - 40 acre site
Fraction of Construction Site Under Active Distrubance =	30%	(estimated)
=	12	acres
Number of Water Trucks Operating =	2	trucks/site (estimated)
Water Application Rate =	629	gal/acre (Draft Regulation VIII Staff Report, SJVUAPCD, September 2001)
=	7,548	gal/15 acre disturbed area
Water Truck Capacity =	4,000	gal (assumed)
Surface Coverage Rate =	2.9	acre/hr (Draft Regulation VIII Staff Report, SJVUAPCD, September 2001)
=	1,824	gal/hr-truck
=	3,648	gal/hr - 2 trucks

Watering Time Per Truckload =	2.2	hr/truckload
Water Truck Filling Time =	0.50	hr/truckload (estimated)
Water Truck Effective Watering Time =	2.7	hr/truckload
Effective Surface Coverage Rate =	2,971	gal/hr - 2 trucks
Watering Interval =	2.5	hr
Watering Control Efficiency =	68.5%	(Particulate Emission Measurements from Controlled Construction Activities, MRI, April 2001, test series 701)
Baseline Construction Emissions =	487	lb PM10/day - 40 acre site
Windblown Emission Factor =	0.0206	ton PM10/acre-hr @ 25 mph (Development of Vacant Land PM-10 Emission Factors in the Las Vegas Valley, D. James/UN Las Vegas, November 2001)
Duration of High Winds =	2	hr (D. James/UNLV, November 2001)
Uncontrolled High Wind Emissions =	990	lb PM10/high wind day - 12 acre disturbed area
Watering Control Efficiency =	68.5%	(Particulate Emission Measurements from Controlled Construction Activities, MRI, April 2001)
Baseline Windblown Emissions =	312	lb PM10/high wind day
Total Baseline Emissions =	799	lb PM10/high wind day - 40 acre site

Controlled Emissions:

Low Control Efficiency Scenario

Watering Control Efficiency in the Absence of Soil Disturbance Activities =	68.5%	on high wind days (MRI, April 2001)
Controlled Emissions =	312	lb PM10/high wind day

High Control Efficiency Scenario

Watering Control Efficiency in the Absence of Soil Disturbance Activities =	100.0%	on high wind days (estimated)
Controlled Emissions =	0	lb PM10/high wind day

Emission Reduction:

Low Control Efficiency Scenario

Emission Reduction =	487	lb PM10/high wind day

High Control Efficiency Scenario

Emission Reduction =	799	lb PM10/high wind day

Cost-Effectiveness:

Low Control Efficiency Scenario

Cost-Effectiveness =	$6.37	/lb PM10
=	$12,741	/ton PM10

High Control Efficiency Scenario

Cost-Effectiveness =	$3.88	/lb PM10
=	$7,769	/ton PM10

Measure: **7b. Require cessation of construction when 20% opacity exceeded**

The cost-effectiveness of this candidate BACM cannot be quantified because no data relating emissions to visible plume opacity could be found.

Measure: **7c. Require continued operation of water trucks when construction ceases**

This measure is already required by Rule 8021, Table 8021-2, C2. As a result, the cost of implementing is zero, and the cost-effectiveness is zero.

Measure: **7d. Require more than one stabilization method when 20% opacity exceeded on disturbed open areas**

Scenarios: Apply dust suppressants to area on which vegetation has been cultivated
apply gravel to a portion of area on which vegetation has been cultivated

Construction/Operational Cost:

Worst Case Cost-Effectiveness Scenario

Area To Be Treated =	3	acre (assumed)
=	14,520	yd2
Surface Preparation Cost =	$0.04	/yd2 (DRI, 12/96)
=	$581	/3 acre site
Polymer Emulsion Application Rate =	0.28	gal/yd2 (Evaluation of Air Quality Performance Claims for Soil-Sement, CARB, April 2002)
Polymer Emulsion Cost =	$3.30	/gal (Midwest Industrial Supply, October 1999)
=	$0.92	/yd2
Polymer Emulsion Application Cost =	$0.18	/yd2 (DRI, 12/96)
Total Polymer Emulsion Treatment Cost =	$1.10	/yd2
=	$16,030	/3 acre site
Useful Life =	3	yr (estimated)
Capital Recovery Factor =	0.4021	
Annualized Treatment Cost =	$6,446	/yr - 3 acre site

Typical Emission/Cost Scenario

Fraction of Area To Be Treated =	75%	(M. Zeldin email, 1/6/03)
Effective Area To Be Treated =	2.25	acres
=	10,890	yd2
Gravel Bulk Cost =	$6.40	/ton (D. Harrald/Keweah River, September 2002)
Truck Haul Rate =	$0.15	/ton-mile (D. Harrald/Keweah River, September 2002)
Average Haul Distance =	10	miles (estimated)
Delivered Gravel Cost =	$7.90	/ton
Gravel Depth =	1.0	in
Gravel Volume =	3,630	ft3/acre
=	134	yd3/acre
Gravel Density =	3,200	lb/yd3 (Caterpillar Performance Handbook, 1999)
Gravel Weight =	215	ton/acre
Gravel Cost =	$1,699	/acre
Grading Time =	2.0	hr/acre (estimated)
Grader Charge Rate =	$57.00	/hr (L. Stauch/Granite Construction, November 2002)
Operator Charge Rate =	$21.31	/hr (K. Jacobs/Merced DPW, November 2002)
Grading Cost =	$157	/acre
Total Gravel Placement Cost =	$1,856	/acre
Useful Life =	5.0	yr (estimated)
Capital Recovery Factor =	0.2638	
Annualized Gravel Cost =	$490	/acre-yr
=	$1,102	/yr - 2.25 acre site

Baseline Emissions:

Emission Factor =	156	lb PM10/acre-yr (Section 7.13, CARB Area Source Methodology, average of county factors weighted by county area)

Worst Case Cost-Effectiveness Scenario

Disturbed Area Size =	3	acres
Uncontrolled Emissions =	468	lb PM10/yr - 3 acre site
Vegetation Control Efficiency =	50%	(estimated from Grantz, June 1995)
Baseline Emissions =	234	lb PM10/yr - 3 acre site

Typical Emission/Cost Scenario

Disturbed Area Size =	2.25	acres
Uncontrolled Emissions =	351	lb PM10/yr - 2.25 acre site
Vegetation Control Efficiency =	50%	(estimated from Grantz, June 1995)
Baseline Emissions =	175	lb PM10/yr - 3 acre site

Controlled Emissions:

Worst Case Cost-Effectiveness Scenario

Polymer Emulsion

Control Efficiency =	84%	for unpaved road use (Evaluation of Air Quality Performance Claims for Soil-Sement, CARB, April 2002)

(assume polymer emulsion control efficiency for windblown dust emissions is at least equal to that for unpaved road travel emissions)

Controlled Emissions =	37	lb PM10/yr - 3 acre site

Typical Emission/Cost Scenario

Aggregate Layer

Control Efficiency =	84%	for windblown dust control (estimated to be as effective as polymer emulsion application)
Controlled Emissions =	28	lb PM10/yr - 2.25 acre site

Emission Reduction:

Worst Case Cost-Effectiveness Scenario

Emission Reduction =	196	lb PM10/yr - 3 acre site

Typical Emission/Cost Scenario

Emission Reduction =	147	lb PM10/yr - 3 acre site

Cost-Effectiveness:

Worst Case Cost-Effectiveness Scenario

Cost-effectiveness =	$32.81	/lb PM10
=	$65,610	/ton PM10

Typical Emission/Cost Scenario

Cost-effectiveness =	$7.48	/lb PM10
=	$14,950	/ton PM10

Measure: **7e. Cease material handling activities when dust plumes cross property line**

The cost-effectiveness of this candidate BACM cannot be quantified because no data relating emissions to visible plume length could be found.

Measure: **7f. Water storage piles or cover when wind events are declared**

Scenario: Manual water application hourly during wind event

Construction/Operational Cost:

Soil Angle of Repose =	35	degrees (estimated)
Pile Volume =	100	yd3 (assumed)
Pile Radius =	5.15	yd
=	15.4	ft
Pile Diameter =	30.9	ft
Pile Height =	3.60	yd
=	10.81	ft
Pile Lateral Surface Area =	102	yd2
=	915	ft2
Manual Watering Time =	0.33	hr/water application (estimated)
Watering Duration =	8	hr/day (estimated)
Laborer Charge Rate =	6.75	/hr (Bureau of Labor Statistics, D. Harrald/Keweah 'http://www.dir.ca.gov/Iwc/Minwage2001.pdf)
Benefit Rate =	20%	(estimated)
Labor Cost =	$21.60	/day

Baseline Emissions:

Worst Case Cost-Effectiveness Scenario

Pile Surface Area =	915	ft2
=	0.021	acre
Windblown Emission Factor =	0.0206	ton PM10/acre-hr @ 25 mph (Development of Vacant Land PM-10 Emission Factors in the Las Vegas Valley, D. James/UN Las Vegas, November 2001)
=	41.2	lb PM10/acre-hr
Duration of High Winds =	2.0	hr (D. James/UNLV, November 2001)
Uncontrolled High Wind Emissions =	1.73	lb PM10/high wind day

Typical Emission/Cost Scenario

Pile Surface Area =	915	ft2
=	0.021	acre
Windblown Emission Factor =	0.0206	ton PM10/acre-hr @ 25 mph (Development of Vacant Land PM-10 Emission Factors in the Las Vegas Valley, D. James/UN Las Vegas, November 2001)
=	41.2	lb PM10/acre-hr
Duration of High Winds =	6.0	hr (M. Zeldin email, 1/6/03)
Uncontrolled High Wind Emissions =	5.19	lb PM10/high wind day

Controlled Emissions:

Watering Control Efficiency = 90% (CCERT, April 2000)

Worst Case Cost-Effectiveness Scenario

Controlled Emissions = 0.17 lb PM10/high wind day

Typical Emission/Cost Scenario

Controlled Emissions = 0.52 lb PM10/high wind day

Emission Reduction:

Worst Case Cost-Effectiveness Scenario

Emission Reduction = 1.56 lb PM10/high wind day

Typical Emission/Cost Scenario

Emission Reduction =	4.68	lb PM10/high wind day

Cost-Effectiveness:

Worst Case Cost-Effectiveness Scenario

Cost-Effectiveness =	$13.86	/lb PM10
	$27,720	/ton PM10

Typical Emission/Cost Scenario

Cost-Effectiveness =	$4.62	/lb PM10
	$9,240	/ton PM10