Effectiveness Demonstration of Fugitive Dust Control Methods for Public Unpaved Roads and Unpaved Shoulders on Unpaved Roads

Final Report

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EXECUTIVE SUMMARY

Experimental Approach

Experiments were conducted from July 1995 to August 1996 in order to determine the efficiencies of different suppressant materials on unpaved public roads and unpaved shoulders along paved roads. The objectives of these experiments were:

- To review published studies of dust emissions rates and dust suppression, and based on this experience, choose the field measurement and data analysis approaches most promising for the quantification of PM_{10} emission rates and suppressant effectiveness.

- To apply those approaches in order to determine which unpaved road stabilizing substance and practices have a high potential to reduce PM_{10} emissions from public unpaved roads and unpaved shoulders of public paved roads.

- To demonstrate the amount by which contributions to ambient PM_{10} concentrations are reduced by applying these methods and to establish the long-term efficiencies of the suppressant applications.

- To determine the practicality and costs of applying these control measures to reduce fugitive dust emissions in the San Joaquin Valley.

For unpaved roads, the PM_{10} sampling plan involved upwind and downwind measurements that eliminated the most objectionable assumptions associated with previous studies. PM_{10} emission rates were estimated by a profile method including of two overhead samplers to allow a more full characterization of past plumes. Net PM_{10} emissions from suppressant test sections were obtained by subtracting the upwind profile form the downwind source profile, and by combining the resulting PM_{10} mass concentrations with meteorological data. Concurrently, a program of detailed soil surface measurements tracked the mechanical properties of the treated surfaces. The PM_{10} emissions were combined with detailed records of the vehicle traffic in order to provide: 1) the emissions rates as PM_{10} mass produced per vehicle-kilometer traveled for each of the suppressant test sections; 2) the efficiencies of the different suppressants in reducing PM_{10} emissions.

For the unpaved shoulder study, a different approach was required because the dust plumes were much more localized and short-lived. In addition to upwind and downwind PM_{10} sampling, fast response observations from light scattering and turbulence sensors were used to characterize the dust events. The full compliment of surface measurements was also performed in order to characterize the mechanical properties of the shoulder surfaces. This broad approach gave: 1) two measures of PM_{10} emissions, one which summed all emissions over several hours, and one which responded to and measured each dust plume created by one vehicle; 2) a three-dimensional measurement of the turbulence caused by each passing vehicle, because this air motion initiates the dust plumes; and 3) the mechanical behavior of the suppressant measurements.

For both the unpaved road and unpaved shoulder test sites, the PM_{10} emission rates, surface properties, and suppressant efficiencies were measured over a period of about one year, so that the effects of weather and aging could be evaluated.

In an initial survey, more than 60 specific suppressant products were identified. These fell into categories of: 1) salts; 2) asphalt or petroleum emulsions; 3) emulsions of other materials; 4) polymers; 5) surfactants; 6) bitumens; 7) adhesives; 8) solid materials; fibers and mulches; 9) hydroseed vegetation; and 10) miscellaneous products.

Four suppressant products were applied to one-third mile test sections of Fields Road, near Merced, California: 1) “Non-Hazardous Crude-Oil-Containing Materials”; 2) “EMC Squared”, a biocatalyst product; 3) “Soil-Sement” polymer emulsion mixture; and 4) “Coherex PM” petroleum emulsion and polymer mixture. Three suppressants were applied to one-half mile test sections of unpaved shoulders along Bellevue Road, a suburban thoroughfare near Merced: 1) “Enduraseal” organic emulsion; 2) “Hydroshield” endosperm hydrate; and 3) “DSS-40” acrylic co-polymer.

Conclusions were drawn with respect to: 1) efficiency and durability of each suppressant; 2) fugitive dust emissions rates; and 3) zones of influence of fugitive dust emissions.

Suppressant Efficiency

Suppressant efficiency is defined as the percent reduction in emission achieved on the suppressant-treated test section, as compared to a nearby untreated test section.

- “Soil-Sement” and “Non-Hazardous Crude-Oil-Containing Materials” were effective suppressants , even after vehicular use including about 100 vehicles passes per day during the intensive study periods, and the effects of an unusually wet winter. The efficiencies of “Soil-Sement” and “Non-Hazardous Crude-Oil-Containing Materials” exceeded 80%, on average, during the final measurements period, 12 months after application.

- “Coherex PM’s” average efficiency was 73% after three months, and 49% after 12 months.

- “EMC Squared’s” average efficiency was 33% immediately after application; after 3 and 12 months’ aging, it seemed completely ineffective.

- The major properties that define low-emitting, well-suppressed surfaces are: 1) surface silt loading; and 2) the strength and flexibility of suppressant material as a surface layer or cover.

- Silt loading is the best indicator of suppressant efficiency. Loading of less than 20 grams of loose silt per square meter of surface area (g/m^2) are associated with efficiencies that exceed 90%. Silt loadings that exceed 200 g/m^2 are no different from untreated sections in terms of efficiency.

- None of the shoulder suppressants was effective for any appreciable period. The suppressants applied to Bellevue Road shoulder test sections broke down quickly under the effects of ordinary vehicle traffic such as daily mail deliveries to residences, and random shoulder traffic such as temporary passenger car pullovers. It appeared that these activities caused major deterioration in suppressant efficiencies even without winter weather.

Emission Rates

Emission rates are defined as the total mass of PM10 particulate matter emitted by one vehicle traveling one mile (or kilometer) on the unpaved road, or along the road bordered by the unpaved shoulders. The rate is measured for a certain vehicle speed or range of speeds.

- Emission rates estimated from the untreated and suppressant-treated unpaved road sections ranged from zero to 2.9 pounds of PM_{10} per vehicle-mile-traveled (VMT) (zero to 800 grams per vehicle kilometer-traveled [VKT] for a vehicle speed of 25 mph (40 km/h) and from zero to 5.0 pounds of PM_{10} per VMT (1.4 kilograms per VKT) for a vehicle speed of 35 mph (55km/h).

- Unpaved road emission rates from this study are similar to, but as variable as, those found in other studies. A study conducted on unpaved agricultural roads by the University of California at Davis found emission factors ranging from about 0.1 to about 5 pounds of PM_{10} per VMT at 25 mph. The U.S. EPA "AP-42" Empirical Dust Emission Model underpredicts by as much as a factor of three when applied to the unpaved road conditions pertinent to this study.

- Silt loading, rather than silt content, in the emission rate equation improves the emission rate estimate.

- PM_{10} emission rates from unpaved shoulders are estimated to be 0.03 ± 0.015 pounds per VMT (8 ± 4 grams per VKT) for large vehicles (trucks, semis, vehicles with trailers) traveling from 50 to 60 mph.

- It is doubtful that fugitive dust emission rates from roads and shoulders can ever be estimated by better than a factor of two or three. There will always be large uncertainties in these estimates owing to: 1) problems of natural variability, such as varying wind directions and speeds; and 2) problems involved in using a limited number of samplers to accurately sample turbulent, particle-laden plumes.

Zone of Influence

The "Zone of Influence" is defined in two ways. First, it is the distance from a source at which PM_{10} concentrations have fallen off 10% of their values close to the source. Second, it can also be defined from the receptor's perspective, as the distance at which the source's emissions result in a measured 1 $\mu g/m^3$ increment above the ambient background. The findings concerning the zone of influence of the unpaved road PM_{10} emissions are as follows:

- PM_{10} concentrations decrease exponentially with distance downwind.

- PM_{10} concentrations decrease by 90% from near-road concentrations within 50 meters (165 feet) downwind of the road.

- Extrapolating to 1 $\mu g/m^3$ shows downwind distances of about 150 meters. This is the effective zone of influence for detecting emissions from a single source. Ambient concentrations usually result from the superimposed contributions of many individual sources.