FINAL REPORT

CONTROL OF DUST EMISSIONS

FROM UNPAVED ROADS

by

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PROJECT SUMMARY

The alternatives for suppressing traffic generated dust on unpaved roads are paving, reducing speed limits and chemical stabilization. Paving roads for the purposes of dust suppression becomes a viable alternative if the traffic intensity is large enough. Reducing the speed limit for the purposes of reducing dust emissions from unpaved roads is hard to impose and increases travel time. The most widely used traffic generated dust control measure is the use of chemical suppressants. The primary types of these suppressants are fresh or salt water with a wetting agent; hygroscopic and deliquescent chemicals; organic binders; petroleum-derived binders; and some waste products. Relevant information concerning the applicability of these suppressants in controlling traffic generated dust is summarized in the appendix.

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INTRODUCTION

Unpaved roads are a major source of dust. The dust generation potential of a given unpaved road is dependent on several factors including nature of surface (gavel or dirt) and traffic volume. The source of dust from unpaved surfaces is largely from road bed material. In instances where the road is narrow and ineffectively curbed, the unpaved road shoulders can be another significant source.

For the purposes of this study, road dust is defined as road aggregates that become airborne as a result of the abrasive action of traffic. The particle size distribution of dust from unpaved roadways depends on the type of the road surface. Table 1 gives the size distribution of road dust by surface type (Orlemann et al., 1983; EPA, 1977).

TABLE 1. TYPICAL SIZE DISTRIBUTION OF FUGITIVE DUST PARTICLES BY SURFACE TYPE a (ADAPTED FROM ORLEMANN ET AL., 1983)
(percentages)

Size range	Gravel Roads	Dirt Roads
<5 µm	23	8
5-30 µm	39	24
>30 µm	38	68

The need to control road dust is illustrated by exploring some of the social and environmental impacts of dust. Road dust has an impact on safety, aesthetics, health, vegetation, soils, and aquatic resources as described below (Techman Engineering Limited, 1982).

1. Impact of Road Dust on Safety

Accident potential is greater on unpaved as opposed to paved surfaces. This increase in accident potential is due to loss of visibility, skidding and swaying of vehicles, less positive steering response, longer stopping distance, and broken windshields from flying aggregates. The fatality rate on unpaved roads in the United States is 2.3 times the rate on paved primary systems (Hoover, 1971).

2. Impact of Road Dust on Aesthetics

Dust generated by unpaved roads produces an immediate visual impact which affects the residents living adjacent to these roads.

3. Impact of Road Dust on Health

Small dust particles (less than 2 microns) are trapped in the lungs due to the inability of the respiratory system to filer all particulates (Battigelli, 1969; United Nations, 1979). This could be potentially dangerous to people, especially the elderly (Weisskopf, 1991).

4. Impact of Road Dust on Vegetation

During hot weather, a coating of dust on leaves could increase solar heat absorption and decrease transpiration causing a heat build-up in these leaves. This could result in reduction in leaf water content, chlorophyll content and carbon uptake as well as an increase in plant water temperature, mineral ion concentration and PH.

5. Impact of Road Dust on Soils

Chemical element enrichment of soils could result from dust fallout from neighboring roads.

6. Impact of Road Dust on Aquatic Sources

Increased dust fall into water systems will increase sedimentation within these systems. This could lead to a reduction in fish growth rate and condition.

ROAD DUST GENERATION MECHANISMS

Traffic tends to reduce both the clay and water content of a road surface, leaving it more susceptible to dust generation. The possible mechanisms for dust generation under these conditions are vortex entrainment, slippage entrainment, and saltation and creep. These mechanisms are discussed briefly below (Techman Engineering Limited, 1982).

1. Vortex Entrainment

Dust is pumped into the air as a result of air compression and expansion caused by the passage of a vehicle over unpaved roads. This mechanism of dust generation is known as vortex entrainment. It constitutes a very small percentage of generated dust on unpaved roads.

2. Slippage Entrainment

Slippage between the tire and road is the largest contributor to road dust generation. This mechanism of road dust generation is known as slippage entrainment and is responsible for about 90% of traffic-generated dust. Slippage entrainment involves three phases as shown in Figure 1.

3. Saltation and Creep

Aggregates of large size (>10 microns) may become suspended via saltation and surface creep. These mechanisms are illustrated in Figure 2 (Cannessa, 1977). Saltation involves the bouncing of particles, which could lead to damage to windshields. Also, when a particle bounces at the road surface, it could hit smaller particles getting them into suspension. Creep involves the slow movement of the orad surface caused mainly by the direct impact of saltation grains that are too heavy to be dislodged into the air.

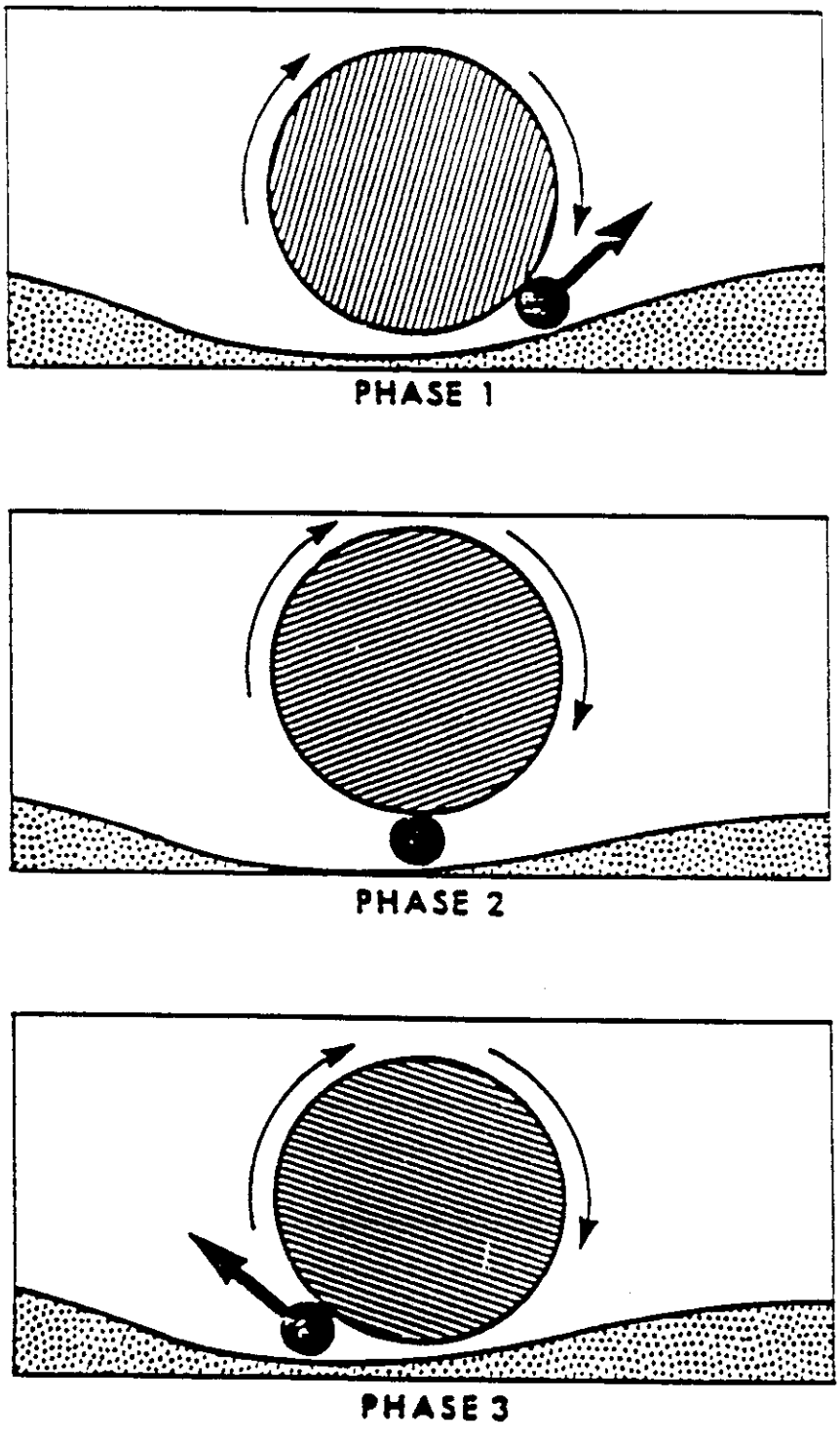
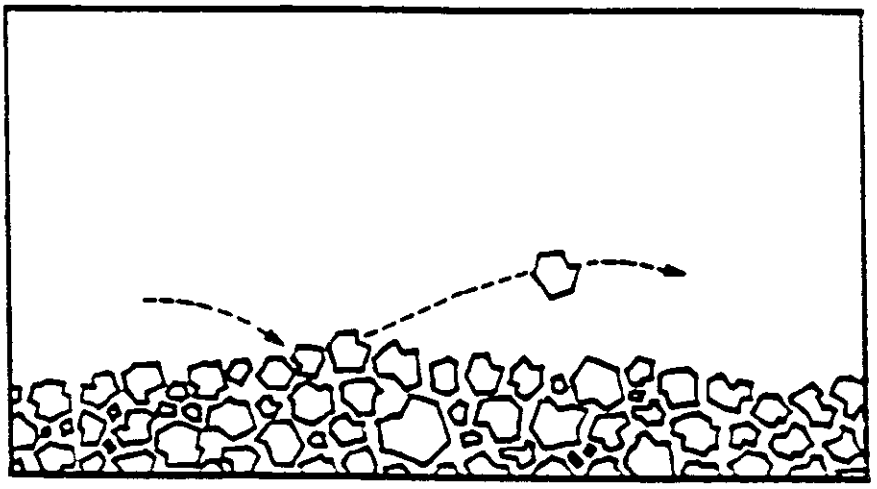
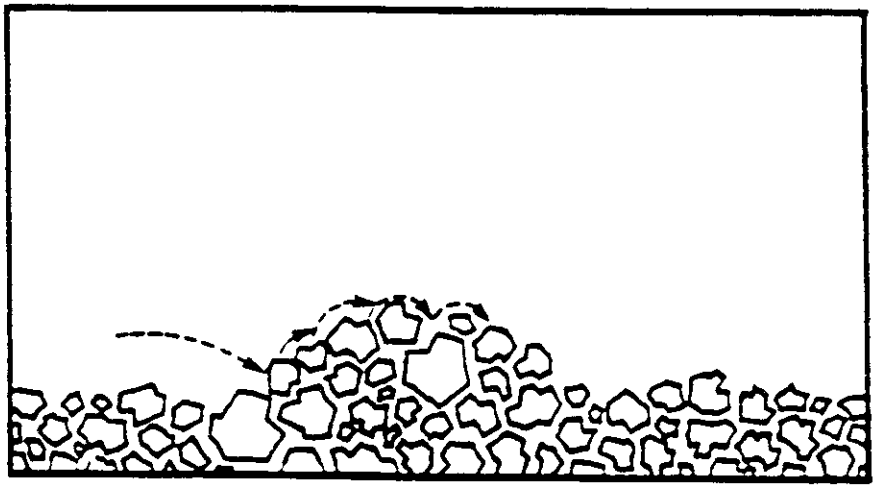


FIGURE 1. Action of Tires on Soil Particles (adapted from Techman Engineering Limited, 1982).



Saltation of Loose Aggregate



Surface Creep of Loose Aggregate

FIGURE 2. Generation of Road Dust by Saltation and Surface Creep of Loose Aggregate (adapted from Techman Engineering Limited, 1982).

Aggregate (adapted from Techman Engineering Limited, 1982).

FACTORS AFFECTING QUANTITY OF ROAD DUST EMISSIONS

The main factors influencing traffic generated dust emissions on unpaved roads include vehicle velocity, number of wheels per vehicle, particle size distribution, road surface moisture, tire width, length of unpaved road, and traffic volume. These factors influence generation in the following fashion (Techman Engineering Limited, 1982).

1. Vehicle Speed

Emissions of particles less than 2 microns in size are proportional to the vehicle speed, while those less than 10 microns in diameter are proportional to the square of the vehicle speed (Monsanto Research Corporation, 1979).

2. Number of Wheels

Dust generated by a vehicle moving on an unpaved road is directly proportional to the number of its wheels (Monsanto Research Corporation, 1979).

3. Road Surface Particle Size Distribution

Open field measurements show that the proportion of particles that are in suspension is approximately equal to the proportion of particles less than 100 microns present in the road surface soil (Monsanto Research Corporation, 1979).

4. Surface Moisture

As the moisture content of road surface aggregates increases, the cohesive force between the soil particles increases and the rate of dust generation decreases (Mansanto Research Corporation, 1979)

5. Tire Width

Vehicles with wider tires cause larger amounts of dust emissions per tire (Orlemann et al., 1983). Under the same loading, dual tires have a much higher loosening effect on road surfaces of straight roadways than do wide single tires. The opposite is true on curved road sections (Ekse, 1965).

6. Length of Unpaved Roads

The influence of length of the unpaved road on dust generation is to increase the quantity of dust emissions as the length of the unpaved road increases.

7. Traffic Volume

The influence of traffic volume on dust generation is to increase the quantity of dust emissions as the traffic volume increases.

METHOD FOR ESTIMATION OF DUST EMISSIONS

The Environmental Protection Agency published an empirical relationship for estimating the amount of road dust emissions. This relationship is shown below (EPA, 1977; Orlemann et al., 1983):

$$EF = 0.81(F)(P)(s)(V/30)((365-D)/365)(T/4) \quad [1]$$

where:

EF = emission factor, lb/VMT;
VMT = vehicle miles travelled;
P = fraction of particulate which will remain suspended (diameters less than 30 μ1m): P = 0.62 for a gravel road bed and 0.32 for a dirt road bed;
S = silt content of road bed material, percent; approximate average value is 12% (values range between 5% and 15%);
V = average vehicle speed;
D = days with 0.01 inches or more of precipitation;
T = average number of tires per vehicle; and
F = 1 for vehicles with normal size tires and 2.5 for vehicles with oversized tires (most wheeled construction equipment).

METHODS OF ROAD DUST SUPPRESSION

The control of dust from unpaved surfaces could be accomplished using one or more of the following procedures: paving, speed control and chemical stabilization. Effectiveness of these procedures is discussed in this section and is summarized in Table 2.

Paving

One of the most efficient methods of controlling dust from unpaved surfaces is to pave the surface. This method of dust suppression has a control efficiency of up to 90% (Orlemann et al., 1983; EPA, 1978). However, it would only be feasible for unpaved roads with high frequency of personal and commercial traffic.

Traffic Control

Traffic generated dust emission from unpaved roads is proportional to vehicle speed. Speed reductions could therefore be used as a dust control measure. This measure would be attractive as the initial implementation cost is minimal. Some of the main disadvantages of this procedure are related to costs associated with increased travel time and enforcement of speed restrictions. The efficiency of speed reduction as a dust control measure increases as the speed is reduced. Based on an initial speed of 40 miles per hour, a reduction in the speed limit to 20 miles per hour results in a 65% reduction in dust emissions; a reduction in the speed limit to 15 miles per hour results in an 80% reduction in dust emissions (EPA, 1977; Orlemann et al., 1983).

Chemical Stabilization

A variety of chemical stabilizers may be used as suppressants to control traffic generated road dust. Effective use of these suppressants depends on the relative use of the roadway, road surface soil properties, frequency of application of suppressant, type of suppressant, and local weather conditions. Dust control efficiency of chemical stabilizers could be as high as 90% to 95% (Orlemann et al., 1983; EPA, 1978). A summary of chemical suppressants used in road dust control, their costs, and environmental impact is presented in Tables 2 through 4 (Techman Engineering Limited, 1982; Orlemann et al., 1983). Suppressant application rates as practiced in Northern and Western Canada are given in Table 5 (Techman Engineering Limited, 1982). A detailed summary of suppressant information relevant to rad dust control is given in the appendix (Techman Engineering Limited, 1982; Orlemann et al., 1983; Manufacturer supplied information).

Chemical suppressants used in road dust control may be either wetting or binding agents. The primary types of these suppressants are fresh or salt water in combination with a wetting agent; hygroscopic and deliquescent chemicals; organic binders; petroleum-derived binders; and some waste products. A brief description of these types is given below (Techman Engineering Limited, 1982; Orlemann et al., 1983).

Water and Wetting Agents

Watering is often used as a dust suppressant on unpaved roads. Wetting agents are often mixed with water to extend the effect of roadway watering. These agents reduce surface tension of water and therefore increased water penetration and subgrade wetting. The subgrade will then act as a reservoir, providing replacement to evaporated water through capillary action. An example of a wetting agent is Alchem 8808. No adverse environmental effects have been reported in the literature from the use of this wetting agent (Midwest Research Institute, 1981).

Hygroscopic and Deliquescent Chemicals

Deliquescent chemicals attract water from the atmosphere, helping to maintain a moisture film around soil particles which binds these particles together. Dust suppression using this method is therefore effective if the humidity of the air is high enough to provide the water. Examples of these chemicals are Calcium Chloride and Sodium chloride (Bell, 1976). Little information is available on the environmental impact of hygroscopic and deliquescent chemicals when used as dust suppressant agents. However, it is known that salts applied for dust suppression initially penetrate a road to a depth of several centimeters and then rise to the surface by capillarity action, making them susceptible to being washed off by rain. The environmental impact of the resulting runoff will be similar to that of the particular salt used and is dependent on the concentration of salt in this runoff.

Note that Calcium Chloride has been used extensively in the Yukon Territory on higher traffic roads, on city streets in Haines, and on some parts of the Dalton and Alaska Highways (Reckard, 1983; 1988).

Organic Binders

Almost all organic binders that are used as dust suppressants are lignosulfonate compounds. These are water soluble liquid chemical by-products of the sulfite pulping process. There are five types of lignosulfonate compounds: crude lignosulfonate, Calcium lignosulfonate; sodium lignosulfonate; magnesium lignosulfonate; and ammonium lignosulfonate. The environmental impact of lignosulfonate compounds is not well studied.

Petroleum-based Suppressants

Petroleum-based products are the most commonly used suppressants in unpaved road dust control. Different petroleum products are available and the choice of which product to use is dependent on porosity of the road surface, evaporation temperature and intended results. Generally, roads with larger aggregates and less fines dictate the use of lower viscosity petroleum products while higher viscosity products are usually applied on roads comprised of smaller particles.

Petroleum suppressants are either sprayed on the surface of an unpaved road or mixed with the road material so that penetration will occur to a design depth coating particles of gravel, sand and dust with a thin oil film. Depending on the speed by which as suppressant cures, either concentration of the soil particles (rapidly-curing petroleum based suppressants) or prolonged coating with the oil film (medium to slow-curing petroleum suppressants) will occur.

The environmental impact of commercially available petroleum-based suppressants is unknown. Environmental impact information has been for the most part, inferred from oil

pollution research which is mainly concerned with environmental emergencies or bioassay studies and cannot be directly related to the small amount of oil found within a petroleum-based suppressant. Further research is required to investigate this impact.

Waste Products Suitable for Road Dust Suppression

There are a number of waste products that are available (and some are currently being used) for road dust suppression. Some of these products like lignosulfonates (a waste product from the pulping industry which glues soil particles together), used lubricating oil, salt brines (from natural gas wells), and whey are currently being used. Others like fly ash (waste generated by the burning of coal in thermal power plants), sulphur (waste generated by the petroleum industry), rubber latex (waste generated during the manufacture of synthetic rubber), and calcium or magnesium carbonate (waste precipitated from water softening operations) are good candidates for future use. Further research into the applicability of these products, including their environmental impact is needed.

TABLE 2. SUMMARY OF TECHNIQUES, EFFICIENCIES AND COSTS FOR CONTROLLING FUGITIVE DUST FROM UNPAVED SURFACES (ADAPTED FROM ORLEMANN ET AL., 1983)

Control Method	Estimated control efficiency, %	Initial cost, 1980 dollars	Annual operating cost, 1980 dollars
Unpaved surfaces			5,000-12,000/mile
• Chemical stabilization[a]	90-95	6,000-13,000/mile	5,000-12,000/mile[b,c]
• Road oiling[a]	75	1,200-2,500/mile	(Re-oil once a month)
• Watering[a]	50	12,000	4,000/mile [c,d]
• Surface improvements			
- Aggregate	30	NA	NA
- Oil and double chip	80	11,000/mile	2,500-5,000/mile[c,e]
- Paving	90		
• Speed reduction[f]			
- 30 mph	25	NA	NA
- 20 mph	65	NA	NA
- 15 mph	80	NA	NA

[a] Applies to both unpaved roadways and road shoulders.
[b] Frequency of application was unspecified.
[c] Based on a plant having 6.3 miles of unpaved roads, this average was determined from unpaved road mileage at four steel plants.
[d] Represents a frequency of two waters per day.
[e] Value based upon resurfacing once a year.
[f] Assumes an uncontrolled speed of 40 mph.

TABLE 3. ENVIRONMENTAL AND SOCIAL IMPACTS OF ROAD DUST SUPPRESSANT ALTERNATIVES (Adapted from Techman Engineering Limited, 1982)

Suppression Alternative	Potential Environmental Impacts	Social Impacts
Traffic Controls	• None Apparent	• Travel time loss.
Paving	• None Apparent	• Travel time reduced. • Decreased accident potential from poor visibility. • Less vehicle maintenance.
Water and Wetting Agents		
Water (Fresh or Salt)	• Salt water may have impacts similar to calcium or sodium chloride.	• None apparent. • Short-term dust suppressant life. • Salt water may have impacts similar to calcium or sodium chloride.
Alchem 8808	• Apparently incurs none of the environmental problems often associated with waste-oil use.	• None apparent--short-term dust suppressant life. • Skin irritant.
Deliquescent and Hygroscopic Chemicals		
Calcium Chloride Sodium Chloride Natural Brines	• Generally nontoxic due to rapid dissolution in the environment. • Toxic to some plants such as fruit trees if concentrated.	• May be concentrated in groundwater. • Surface "crust" may be slippery in wet weather. • Possible corrosion to vehicles.
Organic, Nonbituminous Binders		
Calcium Lignosulfonate Sodium Lignosulfonate Magnesium Lignosulfonate Pead Chemicals Lignosulfonate Ammonium	• Biodegradation slow--persistent in the environment. • Moderately toxic to rainbow trout and aquatic plants.	• Molasses-like smell. • Road surface may become slippery in wet weather.
DC-M18	• Initial tests by manufacturer indicate DC-M18 is nontoxic, nonacidic and biodegradable.	• No strong odor.
NALCO 89WF030	• None apparent.	• No strong odor.
Petroleum-Based Suppressants		
Used oil, Waste oil	• Used oil may impose an environmental threat because of contaminants such as heavy metals (especially lead), PNAs and PCBs. • Potential of hydrocarbons and contaminants entering surface water or groundwater in high water table areas--should not be applied near these areas.	• Hydrocarbon taste problem in water if it leaches to the water table. • Use of used oil for dust suppression has been discouraged at the provincial level due to economic and environmental concerns.
Bunker Oil	• Potential hydrocarbon contamination of nearby watercourses and groundwater. • Full environmental implications of use not well researched. • Contains hydrocarbons that may be potentially toxic.	• Use of petroleum products for dust suppression is generally discouraged at the provincial level due to economic and environmental considerations. • Smell or appearance may be less desirable than other dust suppression alternatives.
DL-10	• Product generally remains in the roadbed. • Potential hydrocarbon contamination of local waterbodies, particularly if applied excessively.	• Strength of odor unknown.

TABLE 3. ENVIRONMENTAL AND SOCIAL IMPACTS OF ROAD DUST SUPPRESSANT ALTERNATIVES (Adapted from Techman Engineering Limited, 1982)

Suppression Alternative	Potential Environmental Impacts	Social Impacts
Emulsified Asphalt Primer	• Product generally remains in the surface course. • Potential hydrocarbon contamination of local water bodies, particularly if applied excessively.	• Strength of odor unknown.
Coherex	• Apparently noninjurious to plant growth • Some impacts have been noted in the U.S., details unavailable at time of printing.	• Strength of odor unknown. • Yellow color only while product cures.
Resinex 60	• None apparent.	• None apparent.
Other		
Soil Sement	• None apparent.	• None apparent.

TABLE 4. DUST SUPPRESSANT INFORMATION MATRIX[1] (ADAPTED FROM TECHMAN ENGINEERING LIMITED,1982)

Suppressant	Application Life[2]	Climatic Limitations	Optimum Road Surface Gradation (% Fines)	Comments
Water and Wetting Agents				
Water (Fresh or Saltwater)	Short-Term	Drier climates require considerably more frequent applications.	10-25% Fines	Short-term life limits usefulness for public road dust suppression.
Alchem 8808	Short-Term	Drier climates require more frequent applications but not as much as for water alone.	10-25% Fines	Short-term life limits usefulness for public road dust suppression.
Deliquescent and Hygroscopic Chemicals				
Calcium Chloride	Long-term	Loses effectiveness in dry periods with low daily relative humidities. Minimum relative humidity required ranges with temperature from 20 to 40%. Easily leached from road in heavy rain.	10-15% Fines	Generally ineffective in surface courses with lower fines' contents.
Organic Nonbituminous Binders				
Calcium Lognosulfonate	Long-term	Superior to calcium chloride in long dry periods. Leached from road in heavy rain but generally not as much as calcium chloride.	10-25% Fines	Dilution and application instructions must be strictly followed. Generally ineffective in surface courses with lower fines' contents.
DC-N18	Long-term	New product--initial results encouraging in both long dry periods and heavy rainfall.	10-25% Fines and up. Apparently effective in higher fines' contents.	New product still undergoing research.
Nalco 89WF030	Variable	Should be applied when temperature > 32◦F	-	
Petroleum Based Suppressants				
Used oil, Waste oil	Long-term	Generally effective, regardless of climatic conditions. May pot-hole in wet periods.	10-25% Fines. High clay content may require greater applications.	Used oil use discouraged in favor of energy conservation and environmental protection.
Bunker Oil	Long-term	Generally effective, regardless of climatic conditions. May pot-hole in wet periods and if cures hard.	10-25% Fines. High clay content may require greater applications.	May be difficult to rework surface course if cures hard.
DC-10	Long-term	Generally effective regardless of climatic conditions. May pot-hole in wet periods.	10-25% Fines. High clay content may require greater applications.	Apparently remains reworkable.
Emulsified Asphalt Primer	Long-term	Generally effective regardless of climatic conditions. Cures hard and will pot-hole in wet periods if too many fines in road surface.	Best performance noted with low fines' and high sand content surface courses.	Cures hard, most likely difficult to rework surface course.
Coherex	Short to Long-term	May be favored in locations that are too dry for calcium chloride.	10-25% Fines	Contradictory results with use appear in the literature.
Slow Curing Liquid	Long-term	Generally effective regardless of climatic conditions. May pot-hole in wet weather.	10-25% Fines	Hardened crust makes road difficult to rework and promotes pot holing.
Liquid Asphalt, NC30	Long-term	Generally effective regardless of climatic conditions. May pot-hole in wet weather.	10-25% Fines	Hardened crust makes road difficult to rework and promotes pot holing.
Emulsified Asphalt, SS1	Long-term	Generally effective regardless of climatic conditions.	10-25% Fines	Hardened crust makes road difficult to rework

TABLE 4. DUST SUPPRESSANT INFORMATION MATRIX[1] (ADAPTED FROM TECHMAN ENGINEERING LIMITED,1982)

Suppressant	Application Life[2]	Climatic Limitations	Optimum Road Surface Gradation (% Fines)	Comments
		May pot-hole in wet weather.		and promotes pot holing.
Asphalt Road Primer	Long-term	Generally effective regardless of climatic conditions. May pot-hole in wet weather.	10-25% Fines	Hardened crust makes road difficult to rework and promotes pot holing.
Decant Oil	Long-term	Generally effective regardless of climatic conditions. May pot-hole in wet weather.	10-25% Fines. High clay content may require greater applications.	Use discouraged in northern and western Canada in favor of energy conservation and environmental protection.
Re-refined Oil	Long-term	Generally effective regardless of climatic conditions. May pot-hole in wet weather.	10-25% Fines. High clay content may require greater applications.	Use discouraged in northern and western Canada in favor of energy conservation and environmental protection.
Heavy Crude Oil	Long-term	Generally effective regardless of climatic conditions. May pot-hole in wet weather.	10-25% Fines. High clay content may require greater applications.	Use discouraged in northern and western Canada in favor of energy conservation and environmental protection.
Resinex 60	Long-term	Generally effective	-	-
Other				
Soil Sement	Long-term	Generally effective regardless of climatic conditions. Should be applied when temperature > 32°F	-	-

NOTES: 1. All dust suppressants, especially water and wetting agents, may require more frequent applications with higher traffic volumes and/or heavier vehicles.

2. Short-term application life refers generally to less than one week of initial extended dust control being attainable following suppressant application, under most common conditions. Long-term application life refers generally to several weeks of initial extended dust control being attainable following suppressant applications, under most common conditions.

TABLE 5. APPLICATION DATA FOR MOST COMMON DUST SUPPRESSANTS AVAILABLE IN NORTHERN AND WESTERN CANADA* (Adapted from Techman Engineering Limited, 1982)

Suppressant	Application Range	Application Strength	Number of Applications
Water and Wetting Agents			
Alchem 8808	Add 2-3% concentration to water which would usually be applied. (0.5% Once base built-up)	-	Every 2-3 days
Deliquescent and Hygroscopic Chemicals			
Calcium Chloride	0.5-5.0 L/m^2	generally 35%	Minimum of one application per season
Sodium Chloride	0.5-5.0 L/m^2	-	Usually more than calcium chloride in same area
Salt Brines	0.5-5.0 L/m^2	Full Strength (>7% Calcium Chloride)	2 or more applications per season
Organic Non- Bituminous Binders			
Calcium Lignosulfonate	1.9-2.2L/m^2	1:1 water	minimum of one application per season
Sodium Lignosulfonate	1.9-2.2L/m^2	1:1 water	minimum of one application per season
Ammonium and Sodium Lignosulfonate	1.9-2.2L/m^3	1:1 water	minimum of one application per season
Reed Chemicals Lignosulfonate	1-2% solid mixed into windrow	-	-
Spent Sulfite Liquor	1.9-2.2L/m^2	Full strength to 1:1 water	-
DC-N18	1L/22-55m^2	1 part in 85-100 parts water	2-3 applications/year
Nalco 89WF030	-	-	Variable
Petroleum Based Suppressants			
Used Lubricating Oil, Waste Oil	1.1-1.7 L/m^2	-	2 applications first year 1-2 thereafter
Bunker Oil	1.1-1.3 L/m^2	-	-
DL-10	1.8 L/m^2	-	3 in first season, 2 in each season thereafter
Emulsified Asphalt Primer	1/8 L/m^2	-	1 application per year
Coherer	2.0-3.0 L/m^2	1:4 water	-
Slow Curing Liquid Asphalt, SC30	1.35-1.65 L/m^2	-	minimum of one application first year
Liquid Asphalt, NC30	1.1-1.4 L/m^2	-	1 application per year
Emulsified Asphalt SS1	1.1-1.4 L/m^2	-	1 application per year
Asphalt Road Primer	1.1-1.4 L/m^2	-	-
Decant Oil	1.1-1.65 L/m^2	-	-
Re-refined Oil	1.1-1.65 L/m^2	-	-
Heavy Crude Oil	1.1-1.65 L/m^2	-	-

TABLE 5. APPLICATION DATA FOR MOST COMMON DUST SUPPRESSANTS AVAILABLE IN NORTHERN AND WESTERN CANADA* (Adapted from Techman Engineering Limited, 1982)

Suppressant	Application Range	Application Strength	Number of Applications
Resinex 60	-	-	-
Other			
Soil Sement	0.2-1 L/m^2	-	-

* Based on Canadian DOT and manufacturer-supplied information.

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APPENDIX

The information presented in this appendix is mainly adapted from a report by Techman Engineering Limited (1982). The book by Orlemann et al. (1983) and some manufacturer supplied literature were also used in producing this appendix.

Product:	Alchem 8808
Manufacturer/Distributer:	Alchem, Inc.
Application/Effectiveness:	• Not recommended for long-term public road dust suppression • Suitable for mine haul road dust suppression. • Not easily leached from roadbed.
General Application Procedures:	• Added at 2 to 3% concentration directly to the amount of water that would usually be applied. • Once a base is built up, the frequency of application and solution concentration is reduced to maintain the desired level of control. (Generally requiring only a 0.5% solution every 2 to 3 days. • Alchem representative will recommend the proper dust control program for each situation.
Men & Equipment (Storage) Requirements:	• Standard equipment. • Recommended maximum in-plant storage of drums is 12 months.
Preparation of Suppressant:	1. Fill tank one-half full with water. 2. Add desired amount of Alchem 8808 to tank. 3. With water hose under the liquid surface, fill the tank.
Preparation of Road Bed:	As for normal watering
Precautions/Problems:	• If water is allowed to cascade when mixing, a foaming problem may occur. • Inhalation of mist, eye contact, ingestion, or prolonged or repeated contact with skin should be avoided. • Keep container closed and away from heat or open flame. • Recommended maximum in-plant storage of unopened drums is 12 months.
Toxicity:	Contains aliphatic hydrocarbons that may be potentially toxic.
Environmental Considerations:	• Precautions for human contact suggest that some environmental implications may exist. • Apparently induces none of the environmental problems often associated with waste oil use.
Social Considerations:	None apparent.

Product:	Calcium Chloride ($CaCl_2$)
Manufacturer/Distributer:	• Allied Chemical • Dow Chemical
Application/Effectiveness:	• Generally 2 applications per dust suppression season. • May require occasional watering in dry periods. • Generally excellent effectiveness in drier climates; however, less effective than lignosulfonates when very dry. • Cannot be relied upon to carry over to next dust season. • Optimum road surface gradation 10-15% fines.
General Application Procedures:	• Ranges from 2 to 8 tons of solid $CaCl_2$ per kilometer (2 lane road). • Ranges from 0.5 to 5.0 liters per square meter for liquid $CaCl_2$. • Most commonly 2.2 liters of liquid per square meter or 6 tons of solid per kilometer (2 lane road). • Second application generally one-half of the first.
Men & Equipment (Storage) Requirements:	• Grader needed for roadbed preparation.
Preparation of Suppressant:	None, unless making liquid from flake is desired.
Preparation of Road Bed:	• Ranges from scarifying and applying suppressant between 2 to 3 passes of the grader to simple pass of grader and top application. • Most commonly, road is graded and suppressant applied. • Compaction of final surface is recommended.
Precautions/Problems:	• Poor quality soils take longer to recover from wetting. • Progressively leached from road by rainfalls causing suppression loss and roadbed deterioration. • Complaints from taxpayers on excess rusting of vehicles have been reported. • Fresh calcium chloride causing drying and cracking of leather, workers should wear rubber boots. • Surface "crust" which is created by $CaCl_2$ may be slippery in wet weather.
Toxicity:	• Mildly toxic to some plants such as fruit trees.
Environmental Considerations:	• No build-up of components has been measured in the field. • Mildly toxic to some plants such as fruit trees.
Social Considerations:	• May cause hardening of local water. • Use near fruit tree orchards may warrant initial testing due to potential toxicity.

	• Road surface may be slippery when wet. • May cause corrosion of vehicles.

Product:	Salt Brines
Manufacturer/Distributer:	
Application/Effectiveness:	• If contain greater than 7% calcium chloride may be considered cheaper than commercially available calcium chloride. • May not be effective in very dry conditions. • Low content brines (ie., 7 to 15% $CaCl_2$) are generally not recommended for heavily traveled roads but are considered very good for low traffic volume roads where maintenance and service demands are not high. • It may not be possible to concentrate low content brines much further by successive passes due to the relatively large quantities of water involved.
General Application Procedures:	• Applied the same as liquid Calcium chloride although more passes are necessary to achieve the same road surface concentration, if desired. • May not be possible to achieve significant road surface concentrations.
Men & Equipment (Storage) Requirements:	• Same as for liquid calcium chloride. • More time may be required per site for extra passes if similar road surface concentrations as for commercial calcium chloride are desired and possible.
Preparation of Suppressant:	• None required. • If desired, it may be possible to evaporate off some of the water in storage lagoons to achieve a more concentrated solution.
Preparation of Road Bed:	• Standard preparation
Precautions/Problems:	• May not be possible to achieve greater road surface concentrations of calcium chloride by increasing the number of passes. • May only be suitable for low traffic volume roads. • Use on heavier traveled roads may require more frequent applications. • Progressively leached from road by rainfalls causing suppression and road surface deterioration.
Toxicity:	• Mildly toxic to some plants such as fruit trees.
Environmental Considerations:	• No build-up has been measured in the field for calcium chloride. • Mildly toxic to some plants such as fruit trees.

	• May cause corrosion of vehicles
Social Considerations:	• May cause hardening of local water • Use near fruit tree orchards may warrant initial testing due to potential toxicity. • Road surface may be slippery when wet.

Product:	Modified Calcium Lignosulfonate
	Georgia Pacific, Bellingham, Washington
Application/Effectiveness:	• Generally 2 applications of 2 liters per square meter, per dust suppression season. • Most successful form of lignosulfonate to date in northern and western Canada. • Superior to calcium chloride in long periods of dry weather. • Heavy rain can lead to product leaching but apparently less than from calcium chloride.
General Application Procedures:	Generally 1.9 - 2.2 liters per square meter applied in 1 or 2 passes.
Men & Equipment (Storage) Requirements:	• Standard equipment. • Specialized storage equipment not required. • Traffic control may be desired as product cures.
Preparation of Suppressant:	Always a 1:1 dilution with water.
Preparation of Road Bed:	• Tightly blade, shoving excess over side slope to be retrieved if surface becomes slippery in rain. • Compact after product application. • Final surface should be firm and smooth with a good cross section.
Precautions/Problems:	• Suppressant preparation and application instructions must be strictly followed. • Road surface may become slippery when wet. • Rapid drying of application should be avoided. • Requires a minimum of road surface fines similar to calcium chloride. • May foam severely if water allowed to cascade in mixing.
Toxicity:	• Essentially nontoxic: generally very low toxicity. • Moderately toxic to rainbow trout.
Environmental Considerations:	• Biodegradation slow--persistent in the environment. • Moderately toxic to rainbow trout.

Social Considerations:	• Molasses-like smell not considered offensive. • Road surface may become slippery when wet.

Product:	Sodium Lignosulfonate, Rayliq (Rayobinder)
Manufacturer/Distributer:	ITT Rayonier, Shelton, Washington
Application/Effectiveness:	• Generally 2 applications of 2 liters per square meter per dust suppression season. • Most likely superior to calcium chloride in long periods of dry weather. • Heavy rain can lead to product leaching but most likely less than from calcium chloride.
General Application Procedures:	Generally 1.9 - 2.2 liters per square meter applied in 1 or 2 passes.
Men & Equipment (Storage) Requirements:	• Standard equipment. • Specialized storage equipment not required. • Traffic control may be desired as product cures.
Preparation of Suppressant:	Generally a 1:1 dilution with water is most successful.
Preparation of Road Bed:	• Tightly blade, shoving excess over side slope to be retrieved if surface becomes slippery in rain. • Compact after product application. • Final surface should be firm and smooth with a good cross section.
Precautions/Problems:	• Suppressant preparation and application instructions must be strictly followed. • Road surface may become slippery when wet. • Rapid drying of application should be avoided. • Requires a minimum of road surface fines similar to calcium chloride. • May foam severely if water allowed to cascade in mixing.
Toxicity:	• Essentially nontoxic: generally very low toxicity. • Moderately toxic to rainbow trout.
Environmental Considerations:	• Biodegradation slow--persistent in the environment. • Moderately toxic to rainbow trout. • Sodium based lignosulfonates may change local soil properties if contamination of local soils occurs.
Social Considerations:	• Molasses-like smell not considered offensive. • Road surface may become slippery when wet.

Product:	Ammonium and Sodium Lignosulfonate, Orzan GL-50
Manufacturer/Distributer:	Crown Zellerbach, Seattle, Washington
Application/Effectiveness:	• Generally 2 applications of 2 liters per square meter per dust suppression season. • Most likely superior to calcium chloride in long periods of dry weather. • Heavy rain can lead to product leaching but most likely less than from calcium chloride.
General Application Procedures:	Generally 1.9-2.2 liters per square meter applied in 1 or 2 passes.
Men & Equipment (Storage) Requirements:	• Standard equipment. • Specialized storage equipment not required. • Traffic control may be desired as produce cures.
Preparation of Suppressant:	• Generally a 1:1 dilution with water is most successful. • Dilutions up to 1:3 and as low as 2.25:1 have been used in the U.S.
Preparation of Road Bed:	• Tightly blade, shoving excess over side slope to be retrieved if surface becomes slippery in rain. • Compact after product application. • Final surface should be firm and smooth with a good cross section.
Precautions/Problems:	• Suppressant preparation and application instructions must be strictly followed. • Road surface may become slippery when wet. • Rapid drying of application should be avoided. • Requires a minimum of road surface fines similar to calcium chloride. • May foam severely if water allowed to cascade in mixing.
Toxicity:	• Essentially nontoxic: generally very low toxicity. • Moderately toxic to rainbow trout.
Environmental Considerations:	• Biodegradation slow--persistent in the environment. • Moderately toxic to rainbow trout. • Sodium-based lignosulfonates may change local soil properties if contamination of local soils occurs.
Social Considerations:	• Molasses-like smell not considered offensive. • Road surface may become slippery when wet.

Product:	DC-M18
Manufacturer/Distributer:	United International Industries Ltd.
Application/Effectiveness:	• A new product that was first tested in 1981 with encouraging results--available commercially. • U.I.I.L. is continuing experimenting and testing under various conditions to determine effectiveness and applications for potential users. • Apparently good for excessive fines. • Generally 2 to 3 applications per year totaling 280 to 340 liters of suppressant per kilometer. • Does not provide total dust control but provides safe visibility for an extended length of time.
General Application Procedures:	• Generally applied with water at a rate of one liter of suppressant per 22 to 55 m^2. • Object is to achieve 2.0 cm penetration, check to ensure that this is, in fact, occurring and adjust application rate as necessary.
Men & Equipment (Storage) Requirements:	Standard equipment.
Preparation of Suppressant:	Presently 140 to 170 liters of DC-M18 is mixed with 22,730 liters of water for application to a 9 m road in 2 passes.
Preparation of Road Bed:	Tight blade the surface--removing loose material, potholes, and washboard.
Precautions/Problems:	• This is a new product with successful results, however, testing for local condition applicability encouraged before larger scale endorsement. • Always add DC-M18 to the water to avoid excessive foaming.
Toxicity:	Initial tests indicate DC-M18 is nontoxic and nonacidic.
Environmental Considerations:	Manufacturer says product is completely biodegradable and none of the ingredients are toxic.
Social Considerations:	No strong odor.

Product:	Used oil, waste oil
Manufacturer/Distributer:	
Application/Effectiveness:	• Very effective as a dust suppressant--generally more effective than calcium chloride or lignosulfonates and longer lasting. • However, leached by rain leading to eventual deterioration of performance. • Generally 2 applications the first year and 1 or 2 each year thereafter.
General Application Procedures:	• Generally applied at 1.1 to 1.7 liters per square meter either directly to prepared surface or mixed into windrows. • Heavy applications may be as high as 2.7 liters per square meter.
Men & Equipment (Storage) Requirements:	• Standard equipment. • No specialized storage requirements.
Preparation of Suppressant:	• Generally none, applied as collected from sources such as gas stations. • Possibly distilled by contractor.
Preparation of Road Bed:	• Standard preparation. • May be mixed into windrows during road preparation.
Precautions/Problems:	• Used oil imposes a considerable environmental threat because of heavy metals (especially lead), PNAs and PCBs which it may contain. • Should not be used where surface runoff enters nearby water course or body, or in high water table areas. • Use of used oil containing significant amounts of used transformer oil is strongly discouraged due to PCB contamination potential. • Under certain conditions, such as a wet spring, it may be necessary to supplement the first application with a second or third later in the season. • May be prone to potholing in very wet weather. • Roads with high clay content need greater applications.
Toxicity:	• Common contaminants potentially very toxic and carcinogenic.
Environmental Considerations:	• Used oil imposes a considerable environmental threat because of heavy metals (especially lead), PNAs, and PCBs, which it may contain.

Social Considerations:	• Smell or appearance may be less desirable than other dust suppression alternatives such as calcium chloride or lignosulfonates.

Product:	Bunker Oil, Road Oil, Medium Curing Oil (M.C.0., M.C.2)
Manufacturer/Distributer:	
Application/Effectiveness:	• Very effective as a dust suppressant--generally more effective than calcium chloride or lignosulfonate and longer lasting. • Generally costlier than other alternatives such as calcium chloride or lignosulfonates. • Commonly develops potholing problems. • May cure hard, making road surfaces difficult to rework.
General Application Procedures:	Generally applied at 1.1 to 1.35 liters per square meter.
Men & Equipment (Storage) Requirements:	• Standard equipment. • No specialized storage requirements.
Preparation of Suppressant:	Usually applied as supplied.
Preparation of Road Bed:	Standard preparation.
Precautions/Problems:	• Roads with high clay content need greater applications. • Prone to potholing in very wet weather.
Toxicity:	Contains hydrocarbons that may be potentially toxic.
Environmental Considerations:	• Potential hydrocarbon contamination of nearby water courses, bodies, or ground water. • Full environmental implications of use not well researched.
Social Considerations:	• Smell or appearance may be less desirable than other dust suppression alternatives such as calcium chloride or lignosulfonates.

Product:	DL-10 Asphalt Emulsion
Manufacturer/Distributer:	
Application/Effectiveness:	• Does not harden, remaining workable for standard grader maintenance. • Not leached in rain like calcium chloride or lignosulfonates. • Generally 3 applications for the first year then 2 each year thereafter.
General Application Procedures:	Generally applied in one pass at a rate of 1.8 liters per square meter.
Men & Equipment (Storage) Requirements:	• Standard Equipment. • Traffic control may be desired as product cures.
Preparation of Suppressant:	• None, applied as supplied. • If large quantity ordered, may be supplied in more concentrated form which would have to be diluted with warm water (22◦C) which was not too hard (low in calcium levels).
Preparation of Road Bed:	• Standard preparation. • Small windrow may be left to serve as blotter during application and smoothed out after to ensure positive roadbed drainage.
Precautions/Problems:	• Traffic control may be desired as product cures. • If concentrated form used, dilution water must not be too hard.
Toxicity:	Contains hydrocarbons that may be potentially toxic.
Environmental Considerations:	• Product generally remains in the roadbed. • Potential hydrocarbon contamination of local water bodies, particularly if applied excessively.
Social Considerations:	Strength of odor unknown.

Product:	Emulsified Asphalt Primer, EAP
Manufacturer/Distributer:	
Application/Effectiveness:	• Successfully used on sandy soils in northwest Ontario. • Cures harder than DL-10 making it less desirable for finer roadbed due to probable pothole problem. • Generally only one application per year.
General Application Procedures:	Generally applied in one pass at a rate of 1.8 liters per square meters.
Men & Equipment (Storage) Requirements:	• Standard equipment. • Traffic control may be desired as product cures.
Preparation of Suppressant:	None, applied as supplied.
Preparation of Road Bed:	• Standard preparation. • Small windrow may be left to serve as blotter during application and smoothed out after to ensure positive roadbed drainage.
Precautions/Problems:	• Hardened crust makes road surface more difficult to rework and promotes potholing in most surface courses. • Traffic control may be desired as product cures.
Toxicity:	Contains hydrocarbons that may be potentially toxic.
Environmental Considerations:	• Product generally remains in the roadbed. • Potential hydrocarbon contamination of local water bodies, particularly if applied excessively.
Social Considerations:	Strength of odor unknown.

Product:	Coherex
Manufacturer/Distributer:	Witco Chemical
Application/Effectiveness:	• Available reports reveal differing results with use, varying from bad to good. • Witco notes that Coherex is a suitable alternative to calcium chloride in very dry conditions. • Variable application rate to suite local conditions.
General Application Procedures:	Generally a 1:4 dilution with water applied in 2 passes of 2 to 3 liters per square meter.
Men & Equipment (Storage) Requirements:	• Standard equipment. • A glyceride should be added to Coherex to make it freeze-thaw stable and prevent coagulation of resins in storage.
Preparation of Suppressant:	Dilute with water (dilutions range from 1:4 to 1:7--most commonly 1:4).
Preparation of Road Bed:	• Witco recommends scarification to 15 cm followed by successive applications with windrow mixing followed by compaction of the final surface. • Some users employ standard preparation procedures.
Precautions/Problems:	• Testing of product recommended before large scale use. • Creates handling problems if coagulates due to improper storage. • Skinning has been reported in surface applications which may make road surface reworking impractical.
Toxicity:	Witco states Coherex is practically nontoxic and not considered an eye irritant or primary skin irritant.
Environmental Considerations:	• Apparently noninjurious to plant growth. • Coherex in storm water run-off results in virtually no oxygen decrease in waterways.
Social Considerations:	• Virtually no odor added to road surface. • Yellow color only while product cures.

Product:	Slow Curing Liquid Asphalt, SC30
Manufacturer/Distributer:	
Application/Effectiveness:	• Effective as a dust suppressant although surface may pothole. • Generally 2 applications the first year followed by 1 or 2 applications per year thereafter. • Generally can be rebladed fairly successfully. • May cure hard making it less desirable due to potential pothole problem and by it becoming difficult to rework. • Generally only one application per year.
General Application Procedures:	• Generally applied in one pass at a rate of 1.35 to 1.65 liters per square meter.
Men & Equipment (Storage) Requirements:	• Standard equipment. • Traffic control may be desired as product cures.
Preparation of Suppressant:	None, applied as supplied.
Preparation of Road Bed:	• Standard preparation. • Small windrow may be left to serve as blotter during application and smoothed out after to secure positive roadbed drainage. • May be mixed into windrow and laid over surface.
Precautions/Problems:	• If hardened, crust may make road surface more difficult to rework and promotes potholing. • Traffic control may be desired as product cures.
Toxicity:	Contains hydrocarbons that may be potentially toxic.
Environmental Considerations:	• Product generally remains in the roadbed. • Potential hydrocarbon contamination of local water bodies, particularly if applied excessively.
Social Considerations:	Strength of odor unknown.

Product:	Liquid Asphalt, MC30 (medium curing)
Manufacturer/Distributer:	
Application/Effectiveness:	• Effective as a dust suppressant, however generally not recommended. • Surface will usually pothole eventually, deteriorating rideability. • Cures hard making it less desirable due to potential pothole problems and becomes difficult to rework. • Generally only one application per year.
General Application Procedures:	• Generally applied in one pass at a rate of 1.1-1.4 liters per square meter.
Men & Equipment (Storage) Requirements:	• Standard equipment. • Traffic control may be desired as product cures.
Preparation of Suppressant:	• None, applied as supplied.
Preparation of Road Bed:	• Standard preparation. • Small windrow may be left to serve as blotter during application and smoothed out after to ensure positive roadbed drainage. • May be mixed into windrow and laid over surface.
Precautions/Problems:	• Hardened crust makes road surface more difficult to rework and promotes potholing. • Traffic control may be desired as product cures.
Toxicity:	• Contains hydrocarbons that may be potentially toxic.
Environmental Considerations:	• Product generally remains in the roadbed. • Potential hydrocarbon contamination of local water bodies, particularly if applied excessively.
Social Considerations:	Strength of odor unknown.

Product:	Emulsified SS1
Manufacturer/Distributer:	
Application/Effectiveness:	• Effective as a dust suppressant, however generally not recommended. • Surface will usually pothole eventually, deteriorating rideability. • Cures hard making it less desirable due to potential pothole problems and by its becoming difficult to rework. • Generally only one application per year.
General Application Procedures:	• Generally put down in 2 or more passes with increasingly stronger solutions to concentrate the asphalt in the surface. • Total application generally 1.1 to 1.4 liters per square meter.
Men & Equipment (Storage) Requirements:	• Standard Equipment • Traffic control may be desired as product cures.
Preparation of Suppressant:	Needs to be applied in a very dilute form to get good penetration or to mix well.
Preparation of Road Bed:	• Standard preparation. • Small windrow may be left to serve as blotter during application and smoothed out after to ensure positive roadbed drainage. • May be mixed into windrow and laid over surface.
Precautions/Problems:	• Hardened crust makes road surface more difficult to rework and promotes potholing. • Traffic control may be desired as product cures.
Toxicity:	Contains hydrocarbons that may be potentially toxic.
Environmental Considerations:	• Product generally remains in the roadbed. • Potential hydrocarbon contamination of local water bodies, particularly if applied excessively.
Social Considerations:	Strength of odor unknown.

Product:	Asphalt Road Primer
Manufacturer/Distributer:	
Application/Effectiveness:	• Effective as a dust suppressant, however generally not recommended. • Surface will usually pothole eventually, deteriorating rideability. • Cures hard making it less desirable due to potential pothole problems. • Generally only one application per year.
General Application Procedures:	Generally applied in one pass at a rate of about 1.1-1.4 liters per square meter.
Men & Equipment (Storage) Requirements:	• Standard equipment. • Traffic control may be desired as product cures.
Preparation of Suppressant:	None, applied as supplied.
Preparation of Road Bed:	• Standard preparation. • Small windrow may be left to serve as blotter during application and smoothed out after to ensure positive roadbed drainage.
Precautions/Problems:	• Hardened crust makes road surface more difficult to rework and promotes potholing. • Traffic control may be desired as product cures.
Toxicity:	Contains hydrocarbons that may be potentially toxic.
Environmental Considerations:	• Product generally remains in the roadbed. • Potential hydrocarbon contamination of local water bodies, particularly if applied excessively.
Social Considerations:	Strength of odor unknown.

Product:	Decant Oil
Manufacturer/Distributer:	
Application/Effectiveness:	• Quite effective as a dust suppressant--may be more effective than calcium chloride or lignosulfonate and longer lasting. • May be costlier than other alternatives such as calcium chloride or lignosulfonates. • Commonly develops potholing problems. • May cure hard making road surface difficult to rework.
General Application Procedures:	Generally applied at 1.1 to 1.65 liters per square meter.
Men & Equipment (Storage) Requirements:	• Standard equipment. • No specialized storage requirements.
Preparation of Suppressant:	Usually applied as supplied.
Preparation of Road Bed:	Standard Preparation.
Precautions/Problems:	• Roads with high clay content need greater applications. • May be prone to potholing in very wet weather.
Toxicity:	Contains hydrocarbons that may be potentially carcinogenic.
Environmental Considerations:	• Potential hydrocarbon contamination of nearby water courses, bodies, or ground water. • Full environmental implications of use not well researched.
Social Considerations:	• Smell or appearance may be less desirable than other dust suppression alternatives such as calcium chloride or lignosulfonates.

Product:	Re-refined Oil
Manufacturer/Distributer:	
Application/Effectiveness:	• Quite effective as a dust suppressant--may be more effective than calcium chloride or lignosulfonate and longer lasting. • May be costlier than other alternatives such as calcium chloride or lignosulfonates. • Commonly develops potholing problems. • May cure hard making road surfaces difficult to rework.
General Application Procedures:	Generally applied at 1.1 to 1.65 liters per square meter.
Men & Equipment (Storage) Requirements:	• Standard equipment. • No specialized storage requirements.
Preparation of Suppressant:	Usually applied as supplied.
Preparation of Road Bed:	Standard preparation.
Precautions/Problems:	• Roads with high clay content need greater applications. • May be prone to potholing in very wet weather.
Toxicity:	Contains hydrocarbons that may be potentially carcinogenic.
Environmental Considerations:	• Potential hydrocarbon contamination of nearby water courses, bodies, or ground water. • Full environmental implications of use not well researched.
Social Considerations:	• Smell or appearance may be less desirable than other dust suppression alternatives such as calcium chloride or lignosulfonates.

Product:	Heavy Crude Oil
Manufacturer/Distributer:	
Application/Effectiveness:	• Quite effective as a dust suppressant--may be more effective and longer lasting than calcium chloride or lignosulfonate. • May be costlier than other alternatives such as calcium chloride or lignosulfonates. • Commonly develops potholing problems. • May cure hard making road surface difficult to rework.
General Application Procedures:	Generally applied at 1.1 to 1.65 liters per square meter.
Men & Equipment (Storage) Requirements:	• Standard equipment. • No specialized storage requirements.
Preparation of Suppressant:	Usually applied as supplied.
Preparation of Road Bed:	Standard preparation.
Precautions/Problems:	• Roads with high clay content need greater applications. • May be prone to potholing in very wet weather.
Toxicity:	• A recognized carcinogen.
Environmental Considerations:	• Potential hydrocarbon contamination of nearby water courses, bodies, or ground water. • Full environmental implications of use not well researched.
Social Considerations:	• Smell or appearance may be less desirable than other dust suppression alternatives such as calcium chloride or lignosulfonates.

Product:	Soil Sement
Manufacturer/Distributer:	Midwest Industrial Supply, Inc.
Application/Effectiveness:	• Very effective in reducing dust • Reduces rutting, potholes • Increases load-bearing strength of road • Excellent weatherability to rain and ultraviolet light
General Application Procedures:	0.2 to 1 L/m^2
Men & Equipment (Storage) Requirements:	Standard spraying equipment
Preparation of Suppressant:	Mix with water, 1:40
Preparation of Road Bed:	None; ideal to spray after grading and before rolling
Precautions/Problems:	Avoid skin contact
Toxicity:	Nontoxic
Environmental Considerations:	• Does not wash away or leach out • Does not contaminate soils, streams, or vegetation
Social Considerations:	None

Product:	Resinex 60
Manufacturer/Distributer:	Neyra Industries, Inc.
Application/Effectiveness:	Very effective
General Application Procedures:	Consult with Neyra representative to determine application rates for specific use.
Men & Equipment (Storage) Requirements:	Standard equipment to apply water.
Preparation of Suppressant:	Diluted with water
Preparation of Road Bed:	
Precautions/Problems:	• Do not allow to freeze • Do not apply to wet surface • Do not store in direct sunlight or where temperatures exceed 100◦F.
Toxicity:	Nontoxic
Environmental Considerations:	None
Social Considerations:	None

Product:	Nalco 89WF030
Manufacturer/Distributer:	Nalco Chemical
Application/Effectiveness:	Effective; mainly used to control dust on mine haul roads
General Application Procedures:	1:50 to 1:200 water in decreasing dosage and frequency.
Men & Equipment (Storage) Requirements:	Road sprayers
Preparation of Suppressant:	Mixed with water
Preparation of Road Bed:	-
Precautions/Problems:	-
Toxicity:	Nontoxic
Environmental Considerations:	None
Social Considerations:	None

Product:	Compound SP-301
Manufacturer/Distributer:	Johnson March Company
Application/Effectiveness:	Used on haul roads (mainly used on storage piles)
General Application Procedures:	• Generally applied at 1 gal/100 ft^2. • Application lasts 6 months to 1 year.
Men & Equipment (Storage) Requirements:	Applied using spraying equipment.
Preparation of Suppressant:	Applied without dilution
Preparation of Road Bed:	
Precautions/Problems:	
Toxicity:	Unreactive and nontoxic.
Environmental Considerations:	
Social Considerations:	

Product:	
Manufacturer/Distributer:	
Application/Effectiveness:	
General Application Procedures:	
Men & Equipment (Storage) Requirements:	
Preparation of Suppressant:	
Preparation of Road Bed:	
Precautions/Problems:	
Toxicity:	
Environmental Considerations:	
Social Considerations:	

Product:	
Manufacturer/Distributer:	
Application/Effectiveness:	
General Application Procedures:	
Men & Equipment (Storage) Requirements:	
Preparation of Suppressant:	
Preparation of Road Bed:	
Precautions/Problems:	
Toxicity:	
Environmental Considerations:	
Social Considerations:	
Product:	
Manufacturer/Distributer:	
Application/Effectiveness:	
General Application Procedures:	
Men & Equipment (Storage) Requirements:	
Preparation of Suppressant:	
Preparation of Road Bed:	
Precautions/Problems:	
Toxicity:	
Environmental Considerations:	
Social Considerations:	

Product:	
Manufacturer/Distributer:	
Application/Effectiveness:	
General Application Procedures:	
Men & Equipment (Storage) Requirements:	
Preparation of Suppressant:	
Preparation of Road Bed:	
Precautions/Problems:	
Toxicity:	
Environmental Considerations:	
Social Considerations:	
Product:	
Manufacturer/Distributer:	
Application/Effectiveness:	
General Application Procedures:	
Men & Equipment (Storage) Requirements:	
Preparation of Suppressant:	
Preparation of Road Bed:	
Precautions/Problems:	
Toxicity:	
Environmental Considerations:	

Social Considerations:	
Product:	
Manufacturer/Distributer:	
Application/Effectiveness:	
General Application Procedures:	
Men & Equipment (Storage) Requirements:	
Preparation of Suppressant:	
Preparation of Road Bed:	
Precautions/Problems:	
Toxicity:	
Environmental Considerations:	
Social Considerations:	
Product:	
Manufacturer/Distributer:	
Application/Effectiveness:	
General Application Procedures:	
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