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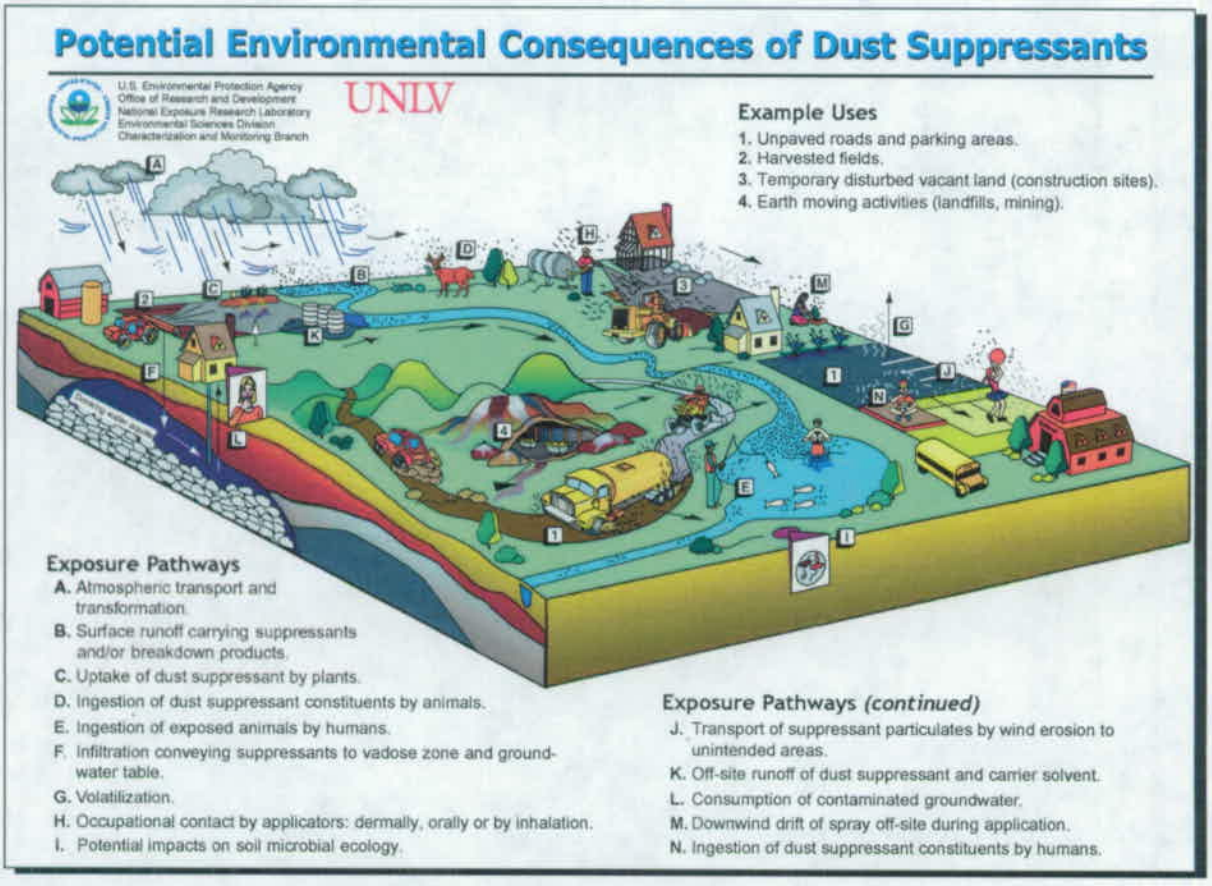
MOL.20050615.0511

Potential Environmental Impacts of Dust Suppressants: "Avoiding Another Times Beach"

An Expert Panel Summary

Las Vegas, Nevada

May 30 – 31, 2002



EPA/600/R-04/031
March 2004

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The information in this document has been funded by the United States Environmental Protection Agency under EPA Assistance Agreement #CR829526-01-0 to the University of Nevada, Las Vegas. It has been subjected to the Agency's peer and administrative review and has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation by EPA for use.

Executive Summary

A.1 Background

In the past decade, there has been an increased use of chemical dust suppressants such as water, salts, asphalt emulsion, vegetable oils, molasses, synthetic polymers, mulches, and lignin products. Dust suppressants abate dust by changing the physical properties of the soil surface and are typically used on construction sites, unpaved roads, and mining activities. The use of chemical dust suppressants has increased dramatically due to rapid population growth and increased emphasis on the need to control particulates in the interest of air quality. In the United States, there are over 2,500,000 km of public unpaved roads, of which 25% (625,000 km) are treated with chemical dust suppressants. A critical problem in the arid southwestern U.S. is dust suppression on land disturbed for residential construction.

Recognizing that it is important to achieve and maintain clean air, the concern that prompted this report is that application of dust suppressants to improve air quality could potentially have other adverse environmental impacts. Times Beach, Missouri is a classic example where the resolution of dust emissions from unpaved roads leads to the creation of a Superfund site. In 1972 and 1973 waste oil contaminated dioxin was sprayed on unpaved roads and vacant lots for dust control in Times Beach. After realizing the adverse situation that had occurred, the costs to relocate the residents and clean up the site was over $80 million. Much more stringent regulations are now in place to avoid another Times Beach; however, there is still concern over the use of dust suppressants since most products used as dust suppressants are by-products and their exact composition is unknown.

The purpose of this report is to summarize the current state of knowledge on the potential environmental impacts of chemical dust suppressants. Furthermore, the report summarizes the views of an Expert Panel that was convened on May 30-31, 2002 at the University of Nevada, Las Vegas to probe into the potential environmental issues associated with the use of dust suppressants.

A.2 Current State of Knowledge

There are several major categories of dust suppressants: hygroscopic salts, organic petroleum-based, organic nonpetroleum-based, synthetic polymer emulsions, electrochemical products, mulches of wood fiber or recycled newspaper, and blends that combine components from the major categories. Dust suppressants are frequently formulated with waste products recycled from other industries.

Most of the research on dust suppressants has been conducted by industry and has focused on the effectiveness (or performance) of dust suppressants, that is, the ability to abate dust. Little information is available on the potential environmental and health impacts of these compounds. Potential environmental impacts include: surface and groundwater quality deterioration; soil contamination; toxicity to soil and water biota; toxicity to humans during and after application; air pollution from volatile dust suppressant components; accumulation in soils; changes in hydrologic characteristics of the soils; and impacts on native flora and fauna populations.

The major known effects of salts in the environment relate to their capacity to move easily with water through soils. Water quality impacts include possible elevated chloride concentrations in

streams downstream of application areas and shallow groundwater contamination. In the area near the application of salts, there could be negative impacts to plant growth. For organic non-petroleum based dust suppressants, ligninsulfonate has been shown to reduce biological activity and retard fish growth. Organic petroleum-based dust suppressants have been shown to be toxic to avian eggs; however, the leachate concentrations in other studies were low in comparison to health-based standards. There is also concern with the use of recycled oil waste that may have heavy metals and PCBs.

A.3 View of the Experts

The expert panel was not able to identify specific concerns on the use of dust suppressants due to the high amount of variability associated with site conditions, dust suppressant composition, and application techniques. The experts did agree more attention should be paid to dust suppressant composition and management. The determination of whether a problem might exist in any given case, however, must be based on the assessment of site-specific conditions.

The potential impact of dust suppressants on soils and plants includes changes in surface permeability, uptake by plant roots that could affect growth, and biotransformation of the dust suppressants in the soil into benign or toxic compounds depending on the environmental conditions and associated microbiota. Vegetation adjacent to the area where dust suppressants are applied could be impacted by airborne dust suppressants. This includes browning of trees along roadways and stunted growth. These effects will vary since different plants have different tolerances.

The potential impact of dust suppressants to water quality and aquatic ecosystems include contaminated ground and surface waters, and changes in fish health. Dust suppressants that are water-soluble can be transported into surface waters and materials that are water-soluble but do not bind tenaciously to soil can enter the groundwater. Fish may be affected by direct ingestion of toxic constituents and also by changes in water quality (e.g., BOD, DO, salinity).

A.4 Current Programs/Guidelines

There are no federal regulations controlling the application of dust suppressants; however, some states have developed guidelines for the use of dust suppressants. These include the U.S. Environmental Protection Agency (EPA) Environmental Technology Verification (ETV) program, three state programs in California, Michigan, and Pennsylvania, and a county-level program in Clark County, Nevada. In Canada, there is the Canada ETV national program.

Although there are no specific regulations in place to control dust suppressant application, it is noteworthy that existing regulations promulgated under the Resource Conservation Recovery Act (RCRA), Comprehensive Environmental Response Compensation and Liability Act (CERCLA), Superfund Amendments and Reauthorization Act (SARA), Clean Water Act (CWA) and TOSCA restrict the introduction of harmful substances into the environment. Regardless, there is concern that since no one program addresses the use of dust suppressants, the enforcement of what is used as dust suppressants could "slip through the regulatory cracks."

A.5 Path Forward (Recommendation)

The expert panel and organizing committee identified several important issues related to scientific research and information about dust suppressant, and regulations on the use of the products. Below is a summary of the major issues and recommendations for each of these categories:

Scientific issues

- Develop a comprehensive definition of an "effective" dust suppressant that includes the performance, costs and environmental impacts
- Better understanding of the composition of the dust suppressants and how they change after application
- Better understanding of dust characteristics and development of methods to assist in the selection of the most appropriate dust suppressant for a specific site
- Develop a framework (e.g., decision-making tree, expert system) for dust suppressant selection and assessing potential environmental impacts
- Develop an easily accessible information center, a "clearinghouse", which could help applicators, regulators, and the public acquire the information about dust suppressants. The recommended form of this clearinghouse is as a World Wide Web site
- Conduct field experiments that provide additional information on the "effectiveness" of a dust suppressant with a particular focus on the environmental impacts as well as the performance of the dust suppressants

Regulations

- Establishing an interagency working group that evaluates the cross media and cross jurisdictional issues associated with the use of dust suppressants
- Review existing state and federal regulatory databases to determine if the compounds found in dust suppressants are restricted or prohibited. This should also be done to close regulatory loopholes that allow entry of unlimited industrial waste into the environment when they are classified as dust suppressants
- Evaluate whether existing programs such as Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), RCRA, CERCLA, SARA, CWA, TOSCA and Ecological Soil Screening Level (Eco-SSL) guidance will serve as good models for the development of risk-based regulations
- Develop a standardized assessment methodology that can be used to estimate soil mass fractions of dust suppressant constituents at a particular site. An example is provided in the main part of this report
- Identify standardized environmental tests (e.g., water quality, toxicity) that all dust suppressants manufacturers would have to perform on their products

Foreword

The purpose of this report is to summarize the current state of knowledge of dust suppressants and potential environmental consequences. The material presented here is based on knowledge gained from scientific literature, industry reports, conversations with industry representatives and regulators, and an expert panel hosted by the University of Nevada - Las Vegas (UNLV) and the U.S. Environmental Protection Agency (EPA). The expert panel on the "Potential Environmental Effects of Dust Suppressant Use: Avoiding Another Times Beach" met on the University of Nevada, Las Vegas, campus on May 30-31, 2002 to consider whether or not dust suppressants pose risks to the environment or human health and how they should be used and managed.

Support for the expert panel and preparation of this report was provided by EPA Region 9 who encouraged the EPA's Office of Research and Development in Las Vegas to consider the use of dust suppressants and their potential environmental and human health impacts.

The expert panel considered the potential for unintended consequences from dust suppressants and also if guidelines or regulations on the use of dust suppressants might prevent future problems. Twenty-six (26) experts from varying disciplines were invited to participate in the panel. They represented hydrologists, soil scientists, microbiologists, industry, applicators, and regulators. Several participants had specific knowledge about dust suppressants, but the majority was selected because of their expertise in a specific discipline. They were asked to participate in the panel and use their expertise for discussing the current and future use of dust suppressants in a variety of settings. The specific objectives for this expert panel were to: (1) review, and add to, industrial and scientific knowledge on the composition of dust suppressants; (2) interpret the body of knowledge, and identify physical, chemical, biological, and regulatory issues related to the environmental impacts of dust suppressants; (3) begin to develop a strategy to assist federal, state, and local agencies in regulating the use of dust suppressants; and (4) contribute to a report describing the expert interpretations and a strategy for permitting the use of dust suppressants.

The panel and additional reviewers were asked to review this final report as to whether it fairly reflects the current knowledge of dust suppressants and their applications, potential problems, and a path forward to further resolve those problems and other issues. The report reflects a combination of views of the Expert Panel Organizing Committee and the Expert Panel, and information from the scientific literature and industry. There were many views presented by the group of experts and some of them differed. The statements and/or views of individual members or several members of the Expert Panel are referenced as (Expert Panel 2002), and scientific literature references use a standard reference form (e.g., Bolander, 1999).

The report is written for several audiences. It is intended to be a guidance document for regulators at federal, state, and local levels, scientific researchers, and the environmental community. It serves as a primer to give readers general background information on what dust suppressants are, how they are used, and what potential regulatory issues arise from their use. It provides the local-level employee, who has been given the task of learning about dust suppressants and assessing whether her or his organization should develop regulations, a basic understanding of the issues and kinds of questions that need to be asked about a particular dust suppressant application. It also provides information that could ultimately be used to determine the need for federal regulation of dust suppressants.

Section 1 of the report provides an introduction and frames the potential problems associated with the use of dust suppressants. Section 2 provides an overview of dust suppressants, the various uses, and the current regulations/guidelines. Section 3 summarizes the current state of knowledge on environmental impacts of dust suppressants from the scientific literature and the Expert Panel. Section 4 outlines a framework for assessing the potential environmental impacts of dust suppressants. Finally, Section 5 lists the scientific and regulatory issues that are not resolved at this time and should be considered if guidelines are to be developed for dust suppressant use.

A draft version of this report was submitted to all of the 26 Expert Panelists and 10 outside individuals from government agencies, universities, and industry. A total of 19 individuals provided comments to the Organizing Committee. All comments were considered, and revisions were made to strengthen the report. Following is a list of the external reviewers.

Amy, Penny, Ph.D.	University of Nevada, Las Vegas
Bassett, Scott, Ph.D.	Desert Research Institute, Reno
Bolander, Peter	U.S. Department of Agriculture, Forest Service
Colbert, Woodrow	Pennsylvania State Conservation Commission
Detloff, Cheryl	Midwest Industrial Supply, Inc.
Franke, Deborah	Research Triangle Institute
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Knight, Gaye	City of Phoenix, Office of Environmental Programs
Langston, Rodney	Clark County Department of Air Quality
Lee, G. Fred, Ph.D., P.E.	G. Fred Lee Associates
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Scheetz, Barry, Ph.D.	Pennsylvania State University
Spear, Terry, Ph.D.	Montana Tech of the University of Montana
Starkweather, Peter, Ph.D.	University of Nevada, Las Vegas
Tyler, Scott, Ph.D.	University of Nevada, Reno
Wells, Jason	ILS, Inc., ESAT Contractor for U.S. EPA Region 4
Wierenga, Peter, Ph.D.	The University of Arizona

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Acronyms

APG	Application Practice Guidelines
ASTM	American Society of Testing and Materials
BOD	Biological oxygen demand
CalCert	California Environmental Technology Certification program
CCCP	Clark County Comprehensive Planning
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
COD	Chemical oxygen demand
CWA	Clean Water Act
DO	Dissolved oxygen
Eco-SSL	Ecological Soil Screening Level guidance
ETV	Environmental Technology Verification program
FIFRA	Federal Insecticide, Fungicide and Rodenticide Act
MDEQ	Michigan Department of Environmental Quality
MSDS	Material Safety Data Sheet
PM	Particulate matter
PSCDGRS	Pennsylvania Conservation Commission Dirt and Gravel Roads Maintenance Program
RBCA	Risk Based Corrective Action
RCRA	Resource Conservation Recovery Act
RO	Reverse Osmosis
RTAC	Road and Transportation Association of Canada
SARA	Superfund Amendments and Reauthorization Act
SIPs	State Implementation Plans
TCDD	Tetrachlorodibenzodioxin
TCLP	Toxicity characteristic leaching procedure
TDS	Total Dissolved Solids
TOC	Total organic carbon
TOSCA	Toxic Substance Control Act
TPH	Total petroleum hydrocarbons
TSCA	Toxic Substance Control Act
TPH	Total petroleum hydrocarbons
TS	Total solids

TSS	Total suspended solids
TVS	Total volatile solids
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USDOT	U.S. Department of Transportation
UNLV	University of Nevada, Las Vegas
VOC	Volatile organic compounds

Section 1

Introduction

The use of chemical dust suppressants in the United States is increasing, due to high rates of population growth in arid regions, the need to reduce airborne particulate matter to meet air quality standards, and increased recognition of the value of reducing erosion and maintenance costs on unpaved roads. Dust suppressants are used to control erosion and maintenance costs on unpaved roads, and to abate fugitive dust in mining, on construction sites, agricultural fields, livestock facilities, disturbed vacant land, landfills, and in steel mills. Materials used as dust suppressants include water, salts, asphalt emulsion, vegetable oils, molasses, synthetic polymers, mulches, and lignin products. Dust suppressants abate dust by changing the physical properties of the soil surface. The mechanisms by which suppressants abate dust vary with product type; some form crusts or protective surfaces on the soil, others act as binding agents causing particles to agglomerate together, and some attract moisture to the soil particles.

Across the United States, over 625,000 kilometers of public, unpaved roads are treated with chemical dust suppressants (Midwest Industrial Supply, Inc., personal communication). In Las Vegas, Nevada, and Phoenix, Arizona, degraded air quality from disturbed land and unpaved roads in the extremely arid environment has led to the potential for widespread use of dust suppressants. In spite of the growing use of dust suppressants, there are no agreed upon definitions, standards of performance and almost no regulation of dust suppressant contents, application rates, or management practices. Understanding of direct and indirect effects of dust suppressants on human health and the environment is limited. Frameworks for making meaningful cost benefit analysis of either benefits or risks are not yet developed.

There is concern that the unexamined use of dust suppressants might create future environmental and health liabilities similar to the problems resulting from dust suppressant use in Times Beach, Missouri in the 1970's. In 1972 and 1973 waste oil containing dioxin was sprayed on unpaved roads for dust control in Times Beach (EPA, 1983). A subsequent flood raised fears that dioxin had contaminated homes and yards. In 1983, the 2,800 people of Times Beach were permanently relocated at a cost of approximately $30 million (EPA, 1988) and the town was closed. Costs to excavate and incinerate the contaminated soils were estimated to be an additional $50 million (EPA, 1988). To avoid similar contamination and cost from current uses of dust suppressants, it is important to take an early, comprehensive look at dust suppressants and their application and to develop policies, guidelines, and recommendations for their use.

Although some programs have been developed to evaluate dust suppressant effectiveness and safety, most programs are voluntary; so most dust suppressant use is unregulated. Waste products or industrial by-products are often used as suppressants, with little examination of the product's hazardous constituents. Application practices are also not regulated. The method and frequency of application and amount of material applied varies. While risks to human health and the environment may be taken into consideration, the primary consideration driving the decision to use a particular suppressant is its initial cost. Frequently reliable performance data does not exist to determine true cost-effectiveness.

Several states (California, Michigan, Pennsylvania) and counties (Clark County, Nevada) are developing guidelines for the use of dust suppressants: where, when and which suppressant to use for a given environment. The guidelines (See Section 2.7) developed by the above agencies are based on limited information and are not sufficient for developing standard protocol in determining whether a dust suppressant should be used. These guidelines were developed out of a need to prevent adverse environmental impacts. An extensive testing program would be needed to develop standard protocol for dust suppressant use.

Other agencies are interested in developing regulations for dust suppressant use, but feel there is little guidance available. Thus, the overall goal of this report is to summarize the current state of knowledge on dust suppressants. The material in the following sections focuses on the current state of knowledge about dust suppressants, areas where information is missing, and proposes an assessment framework for making decisions on the use of dust suppressants.

Section 2

Background

2.1 What are Dust Suppressants?

There is no standard definition of a dust suppressant. Dust suppressants are materials used to control particulate matter emissions from land surfaces. They can include physical covers (such as vegetation, aggregate, mulches, or paving) and chemical compounds. This report focuses on chemical dust suppressants and one physical cover (fiber mulch). Chemical products used for dust suppression fall into eight main categories, listed in Table 2-1. They include water, products manufactured specifically as dust suppressants, natural or synthetic compounds, and waste or by-products from other uses and manufacturing processes. In 1991, 75-80% of all dust suppressants used were chloride salts and salt brine products, 5-10% were ligninsulfonates, and 10-15% were petroleum-based products (Travnik, 1991). The products are usually provided as a concentrate. Dilution for application varies from 1:1 to 1:20 (1 part concentrate to 20 parts water) depending on the specific dust suppressant, application type, and site conditions. Since many of the products are mixed with water, non-aqueous phase liquids are not commonly used in dust suppressant formulation (Expert Panel, 2002).

The control of dust emission is closely related to erosion control, but differs slightly. In both cases, the goal is to restrict the movement of soil particles. Dust suppressants are used to prevent soil particles from becoming airborne. Erosion control technologies aim to minimize soil movement on and off a given site. Since erosion control agents counteract the forces of both wind and water, they may have different properties than dust suppressants, which are used primarily to prevent wind erosion. The minor differences in the definition and classification of these materials may become important as decision makers and regulators begin to focus on unintended, negative consequences of these products.

Water alone can be a dust suppressant. It is commonly used on construction sites and unpaved roads where the surfaces are disturbed only for short time periods. Water is probably the most cost effective short-term solution for dust control (Gebhart *et al.*, 1999); however, the cost will vary depending on climatic conditions influencing water availability. The application rate is important since a heavy application may turn the road into mud destroying the soil's structure and damage its ability to perform as the subgrade. In some areas, reclaimed water is used for dust control. In these cases, the quality needs to be considered as well as the potential for human exposure to reclaimed water and environmental and wildlife impacts.

Salts and Brines are the most common type of dust suppressant used (Travnik, 1991). Calcium chloride ($CaCl_2$) and magnesium chloride ($MgCl_2$) are the major products in this category (Sanders and Addo, 1993). Calcium chloride is a byproduct of the ammonia soda (Solvay) process and a joint product from natural salt brines. Magnesium chloride is derived from seawater evaporation or from industrial byproducts. These products stabilize the soil surface by absorbing moisture from the atmosphere, so it is critical to have sufficient humidity levels of 20-80% when applying these products (Bolander, 1999a).

Organic Non-petroleum Products include ligninsulfonate, tall (pine) oil, vegetable derivatives, and molasses. Ligninsulfonate is derived from the sulfite pulping process in

the paper industry where sulfuric acid is used to break down wood fiber. Tall oil is a by-product of the wood pulp industry recovered from pinewood in the sulfate Kraft paper process. Vegetable oils are extracts from the seeds, fruit or nuts of plants and are generally a mixture of glycerides. Molasses is the thick liquid left after sucrose has been removed from the mother liquor in sugar manufacturing. It contains approximately 20% sucrose, 20% reducing sugar, 10% ash, 20% organic non-sugar, and 20% water (Lewis, 1993).

Synthetic Polymer Products comprise many different compounds that promote the binding of soil particles. The exact composition of these products is usually not provided in the Material Safety Data Sheets (MSDS) since the makeup of the product is confidential information of manufacturers.

Organic Petroleum Products are derived from petroleum and include used oils, solvents, cutback solvents, asphalt emulsions, dust oils, and tars. Petroleum-based products are not water-soluble or prone to evaporation, and generally resist being washed away (Travnik, 1991).

Electrochemical dust suppressants are typically derived from sulphonated petroleum and highly ionic products. This group of products includes sulphonated oils, enzymes, and ammonium chloride. A disadvantage of these products is that their effectiveness depends on the clay mineralogy of the site and may only work with certain types of soils.

Clay Additives are composed of silica oxide tetrahedra (SiO_4) and alumina hydroxide octahedra ($Al(OH)_6$) (Scholen, 1995). Clay additives provide some tensile strength in warm dry climates, however, their tensile strength decreases as moisture in the soil increases (Bolander, 1999b).

Mulch and Fiber Mixtures are formulated from waste wood fibers or recycled newspapers, a binding agent (for example, plaster of paris) and a carrier solvent (usually water). They generally work by forming a protective layer or crust over the soil surface instead of by binding soil particulates together.

Table 2-1: Most commonly used dust suppressants (modified from Bolander, 1999a).

Suppressant Type	Products
Water	Fresh and seawater
Salts and brines	Calcium chloride, magnesium chloride
Petroleum-based organics	Asphalt emulsion, cutback solvents, dust oils, modified asphalt emulsions
Non-petroleum based organics	Vegetable oil, molasses, animal fats, ligninsulfonate, tall oil emulsions
Synthetic polymers	Polyvinyl acetate, vinyl acrylic
Electrochemical products	Enzymes, ionic products (e.g. ammonium chloride), sulfonated oils
Clay additives	Bentonite, montmorillonite
Mulch and fiber mixtures	Paper mulch with gypsum binder, wood fiber mulch mixed with brome seed

2.2 Uses of Dust Suppressants

Dust suppressants are used on unpaved roads, road shoulders, construction sites, landfills, mining operations, military sites, animal enclosures, vacant lands and agricultural fields (Expert Panel, 2002). Figure 2-1 presents a conceptual model of major dust suppressant uses. The use of dust suppressants is largely driven by air quality regulations, but other concerns can also motivate their use (Expert Panel, 2002). For instance, transportation agencies may use dust suppressants to reduce the maintenance on unpaved roads. Private property owners may use dust suppressants to reduce nuisance dust.

The selection of a dust suppressant varies for the different uses. For example, magnesium chloride and petroleum-based products would not be suitable for agricultural use because they could affect crops grown on the fields after application. A fiber mulch might be more appropriate for use in agriculture areas. For an unpaved road, the dust suppressant needs to be more durable and a fiber mulch would not be appropriate to use. Instead, a petroleum-based product may hold up better under traffic conditions.

There is significant regional variation in the use of dust suppressants (Expert Panel, 2002). In Pennsylvania, the major use is on unpaved roads. In other parts of the eastern United States, dust suppressants are used on landfills, coal fields, steel mills, and mines. They are also used as temporary covers on lands that are disturbed for short periods, such as slopes exposed during road construction that are eventually revegetated. In Texas, dust suppressants are used largely on construction sites with disturbed lands and haul roads. In Clark County, Nevada, and other parts of the southwest, 90% of the use is on disturbed vacant land – land that has been cleared for residential or commercial development but on which construction has not yet begun. In some cases, disturbed land can remain vacant for several years. In eastern Oregon and Washington, dust suppressants are used on fallow agriculture fields. The United States Department of Agriculture (USDA) Forest Service also uses dust suppressants on unpaved roads.

2.3 Current and Potential Magnitude of Use

An important consideration is the current magnitude of chemical dust suppressant usage. An unpublished 2001 analysis by the dust suppressant manufacturer, Midwest Industrial Supply, Inc., summarized existing and potential markets for chemical dust suppressants. Some of the study's key findings are noted below.

1. There are over 2,500,000 km of public unpaved roads in the United States. It is estimated that 25% (625,000 km) of these roads are treated with a chemical dust suppressant. In addition, there are over 340,000 km of private unpaved roads of which 22% (74,000 km) are treated with a chemical dust suppressant.
2. Globally, there are over 8,000,000 km of unpaved roads. On the South American continent, over 2,000,000 km of unpaved roads is estimated to exist. A small portion (less than 1%) of these unpaved roads in South America is currently treated with dust suppressants.
3. The United States constitutes about 63% of the global market for chemical dust suppressants and has a current annual market value of approximately $300,000,000.
4. The existing global annual application rate of chemical dust suppressant concentrate is approximately 483,000 tons. This could increase to over 1,200,000 tons if markets in other regions of the world (particularly South America) are developed to the extent of the U.S. market.

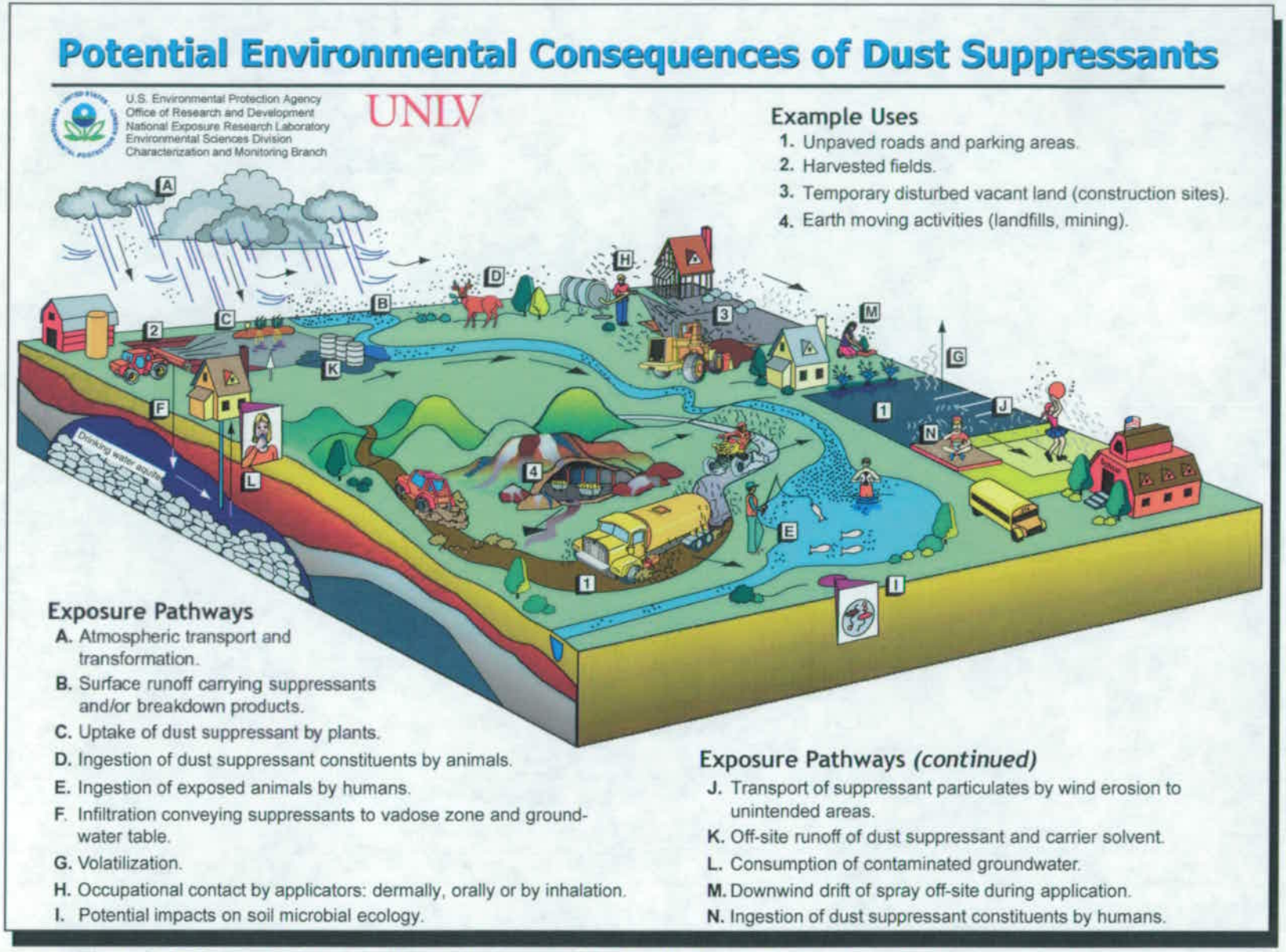

Figure 2-1: Conceptual model of the various uses of dust suppressants and the potential environmental consequences.

It is also important to note the potential uses at a regional scale. Pennsylvania, for example, has over 33,000 km of public unpaved roads that could potentially be treated with dust suppressants (Expert Panel, 2002). In Maricopa County, Arizona, the Department of Transportation applies ligninsulfonate to 92 miles of road shoulders three times a year (Arizona Department of Transportation, personal communication). Clark County, Nevada, has 100-200 km of unpaved roads and approximately 150,000 acres (60,000 hectares) of vacant land in the urban core of the Las Vegas Valley (James *et al.*, 1999). Of these 150,000 acres, 10-20% (15,000-30,000 acres, or 6,000-12,000 hectares) are estimated to have a high potential to emit PM-10 (particulate matter less than 10 μm), and could be stabilized through physical cover (vegetation, aggregate) or via application of chemical dust suppressants. Clark County has decided to pave high-use public roads instead of treating them with chemical dust suppressants (CCCP, 2001). It was reported in Pennsylvania that long term environmental and maintenance costs are set in motion by public pressure to pave roads before a proper road base and drainage system is in place. Paved road failures in even the first year have occurred. However, haul roads at construction and mining sites are often treated with chemical dust suppressants.

2.4 How Dust Suppressants Work

Dust suppressants abate dust by changing the physical properties of the soil surface. When a dust suppressant is applied the soil particles become coated and bound together, making them heavier. Some products form a crust on the surface and others penetrate through the surface. Water and petroleum-based products form a crust by agglomerating the soil particles. The formation of a crust with adequate thickness with petroleum-based products reduces the amount of immediate maintenance that is required on unpaved roads, however, in the long term, when failures such as potholes occur, there is no way to repair them using normal low cost techniques, such as grading. Unless these roads are milled to return them to unsealed status, the structural failures get paved over, again setting in motion the long-term maintenance and environmental costs referenced earlier (Expert Panel, 2002). Many of the synthetic organic materials are derived from petroleum products and are mixed with a binding agent that glues the particles together (Expert Panel, 2002). Salts absorb moisture from the air and retain it by resisting evaporation (Foley *et al.*, 1996). Organic non-petroleum and synthetic polymer products act as a weak cement by binding the soil particles together or weighing down and agglomerating particles. The electrochemical stabilizers work by expelling adsorbed water from the soil, which decreases air voids and increases compaction (Foley *et al.*, 1996).

2.5 How Dust Suppressants are Applied

Dust suppressants are applied either topically or mixed into the top layer of the soil. Topical application is with a spray bar on the back of a truck or through a large hose with a nozzle on the end (See Figures 2-2 and 2-3). On vacant lands, dust suppressants are applied topically. On small plots, application is by hand-directed hoses (Figure 2-2). On larger properties, application is by truck-mounted spray bars (Figure 2-3) and modified water cannons (Figure 2-4). A less common type of application is when the dry products (flakes) are spread on the surface and the product is mixed into the soil (Expert Panel, 2002).

Figure 2-2: Topical application of a dust suppressant using a spray hose.

Figure 2-3: Topical application of a dust suppressant using a spray bar.

Figure 2-4: Topical application of a dust suppressant using a spray gun.

Another application method is to mix the dust suppressant into the travel surface by a sequence of steps comprising, 1) grading the road surface to remove a windrow of earth from the travel lane, 2) application of dust suppressant, 3) grading the earth windrow back onto the travel lane and compaction to maximum density, and 4) a second topical application on top of the graded earth. Mixing the dust suppressant into the soil is more difficult, but it tends to last longer since the product is exposed to more soil particles.

Some dust suppressant vendors have software available to make recommendations to customers based on traffic conditions, vehicle speed, and other site conditions. However, a major factor that impacts the application rate for many situations is the amount of funding available for dust suppression. For instance, a heavier application often increases the durability of the dust suppressant and reduces the need for repeated applications (Expert Panel, 2002). Seldom are analysis made of the soil types, which may change numerous times on one road in some geographic areas.

2.5.1 Typical Application Rates of Dust Suppressants

Typical liquid application rates vary from 0.3 to 1.0 gallons per sq yard (1.4 to 4.5 liter/m^2) and will depend on site-specific conditions (e.g., soil type, land use, weather during application, and weather after application). For liquid emulsions, dust suppressant concentrates are mixed with diluent (usually water) to give the correct mass application rate of solids for the desired application. For example, solids application rates for acrylic polymer emulsions are usually 0.20 to 1.00 pounds per square yard (0.11 - 0.54 kg/m^2) at liquid application rates of 0.50 to 1.00 gallons per square yard (2.26-4.53 liter/m^2). It is generally better to apply multiple light applications rather than a single heavy application, as the light applications generally allow for better penetration into the surface soil and also reduce the fraction of dust suppressant that may run off the target area.

The performance of a dust suppressant is determined by the mass of applied solids per unit volume of treated soil. Mass of applied solids per unit volume of soil will be the product of the mass application rate, and the penetration depth of solids into the soil. The mass application rate of a dust suppressant is computed as the liquid application rate times the mass concentration of bulk suppressant in applied liquid.

For example, if the liquid application rate is 0.50 gallon/yd^2 (2.26 liter/m^2) and the solids concentration is 1.00 lb / gallon (0.120 kg/ liter), then the mass application rate of the dust suppressant is 0.50 gallon / yd^2 x 1.00 lb/gallon = 0.50 lb/ yd^2 (0.271 kg/m^2). If the penetration of the suppressant material was uniform to a depth of 2 inches (0.05 meters), then the bulk concentration of the suppres-

sant in the surface layer of soil would be 0.50 lb/yd^2 / (9 ft^2/yd^2) / 0.167 ft = 0.336 lb/ft^3 (or, 2.71 kg/m^2 / 0.05 meters = 5.40 kg/m^3). This bulk concentration is about 1/300 the mass density of typical soils (~100 lb/ft^3 or ~1,560 kg/m^3), so the suppressant solids are present in the soil at a mass fraction of about 1/300. Mass and liquid rate data for typical application rates of dust suppressants are shown in Table 2-2 (James *et al.*, 1999).

Table 2-2: Typical dust suppressant use rates for unpaved roads and vacant lands based on industry data. English and (SI units).

	Unpaved Roads			
	Low Rate		High Rate	
Liquid application rate	0.50 gallon/yd^2	(2.26 l/m^2)	1.00 gallon/yd^2	(4.53 l/m^2)
Solids concentration	0.40 lb/gallon	(0.05 kg/l)	1.00 lb/gallon	(0.12 kg/l)
Solids application rate	0.20 lb/yd^2	(0.11 kg/m^2)	1.00 lb/yd^2	(0.54 kg/m^2)
10 foot (3.05 m)-wide travel lane:				
Topical 1 layer (solids)	1,173 lb/lane-mile	(330 kg/lane-km)	5,867 lb/lane-mile	(1,653 kg/lane-km)
Topical 1 layer (liquid)	2,933 gal/lane-mile	(6,898 l/lane-km)	5,867 gal/lane-mile	(13,799 l/lane-km)
Graded 2 layer (solids)	2,347 lb/lane-mile	(661 kg/lane-km)	11,733 lb/lane-mile	(3,306 kg/lane-km)
Graded 2 layer (liquid)	5,867 gal/lane-mile	(13,799 l/lane-km)	11,733 gal/lane-mile	(27,596 l/lane-km)

	Vacant Lands			
	Low Rate		High Rate	
Liquid application rate	0.50 gallon/yd^2	(2.26 l/m^2)	1.00 gallon/yd^2	(4.52 l/m^2)
Solids concentration	0.40 lb/gallon	(0.05 kg/l)	1.00 lb/gallon	(0.12 kg/l)
Solids application rate	0.20 lb/yd^2	(0.11 kg/m^2)	1.00 lb/yd^2	(0.54 kg/m^2)
Application rate:				
per 100 ft^2 (solids)	2.2 lb/100 ft^2	(10.7 kg/100m^2)	11.1 lb/100 ft^2	(54.2 kg/100 m^2)
per 100 ft^2 (liquid)	5.6 gal/100 ft^2	(228.1 l/100m^2)	11.1 gal/100 ft^2	(452.1 l/100 m^2)
per acre (solids)	968 lb/acre	(1,085 kg/ha)	4,840 lb/acre	(5,426 kg/ha)
per acre (liquid)	2,420 gal/acre	(22,637 l/ha)	4,840 gal/acre	(45,273 l/ha)

2.6 Effectiveness of Dust Suppressants

The majority of research on dust suppressants has been on the effectiveness of the products, where "effectiveness" reflects the ability of the product to keep soil particles on the soil surface when subjected to some erosive force, such as wind. Effectiveness varies with type of use, site condition, and climate. Water has been found to be between 40% and 85% effective in suppressing the suspension of soil particles for short time periods, but not effective over longer time periods (Thompson, 1990; Travnik, 1991; Foley *et al.*, 1996; Kestner, 1989; Cowherd *et al.* 1989). Salts are more effective than water in controlling dust if sufficient moisture is available (Bolander, 1999a). Ligninsulfonates remain effective during long, dry periods with low humidity. They also tend to remain plastic, allowing reshaping and traffic compaction when applied to soils with high amounts of clay. The effectiveness of ligninsulfonates may be reduced or completely destroyed in the presence of heavy rain because of the solubility of these products in water (Bolander, 1999a). Synthetic polymer emulsions increase the tensile strength of clays on typical roads and trails up to ten times. Tests have shown that synthetic polymers applied in wet climates tend to break down if

exposed to moisture or freezing for an increased time (Bolander, 1999a). Petroleum-based products generally resist being washed away, but oil is not held tightly by most soils and can be leached away by rain. Under the right conditions, these products can remain 90% effective after a year (Gilles *et al.*, 1997).

The length of time that a dust suppressant is effective varies according to variables such as the type of product, soils, weather, application rate, and traffic conditions. However, many manufacturers advertise that the products will be effective from 6-12 months. Some products will last up to 24 months under certain conditions.

2.7 Current Regulations/ Guidelines

At least six programs in the United States and one in Canada are directly or indirectly developing, or have developed, guidelines for dust suppressant use. Appendix B includes fact sheets for the programs and following is a summary of the key program elements. In the United States, there is the Environmental Protection Agency (EPA) Environmental Technology Verification (ETV) program, three states programs in California (CalCert), Michigan, and Pennsylvania, and a county level program in Clark County, Nevada. In Canada, there is the Canada ETV national program. The Canada ETV, CalCert, and EPA ETV programs are voluntary and available to any developer/vendor of environmental technology, including dust suppressants. All three verification programs (ETV, CalCert, and Canada ETV) were created by partnerships between regulatory environmental agencies and either the private sector or non-profit organizations, with an emphasis on the performance claims and some environmental tests of the products. Other programs that are ancillary to dust suppressants are those that provide specifications for the use of snow and ice control products such as the Pacific Northwest Snowfighters (www.wsdot.wa.gov/partners/pns/default.htm).

The testing program in Pennsylvania was developed by joint efforts of conservation interests, academia and industry and, is used, for all materials, including suppressants, for projects funded by the Dirt and Gravel Roads Maintenance Program under the State of Pennsylvania Conservation Commission (PSCDGRS, 2003). The stringent specifications require product testing by a certified lab and manufacturer guaranteed product uniformity, delivery, application and cure. Results in the program have been so positive, and reception by industry so strong, it has been used voluntarily by others. The Michigan Department of Environmental Quality created specific regulations for the application of oil field brine as a dust suppressant (MDEQ, 2000). Clark County, Nevada has issued detailed interim guidelines for the use of dust suppressants on disturbed lands (CCCP, 2001). The guidelines were drafted by a working group composed of air and water quality professionals from state and local agencies, as directed by the Clark County Commissioners.

In all three voluntary certification programs and in the Pennsylvania Dirt and Gravel Road regulations, it is the responsibility of the technology vendor/developer to provide sufficient performance data and documentation to support the claims of the technology under consideration. While the other programs do not specify what data should be provided to support the technology claim, the Environmental Protection Agency (EPA) ETV and the Pennsylvania programs note specific tests that have to be performed to evaluate the environmental impacts of the products under consideration. In the EPA ETV, ETV Canada, and CalCert voluntary programs, scientists and engineers from regulatory agencies, universities, research laboratories, and the private sector examine the supporting documentation for product verification. However, ETV Canada maintains a list of approved expert entities (e.g. universities, private consultants) to be used to conduct tests to support the verification. An agreement is reached with the vendor/ developer regarding the expert entity to be used in the technology verification process.

In the case of Pennsylvania, the data supporting the claim, issued by EPA certified labs, are evaluated by the State Conservation Commission for authenticity. All three voluntary verification programs, as well as Pennsylvania's, issue a report or certificate as proof of verification. Only the Canada ETV and the California CalCert programs require renewal of the verification after three years.

Michigan's regulations for brine application as a dust suppressant do not specify any specific test methods. Instead, it establishes acceptable application rates and methods, and types of areas where it can and cannot be applied. It also requires the property owner or contractor to maintain detailed record keeping of the specific locations, amount, and source of brine applied. Clark County, Nevada guidelines specify types of areas where the application of specific dust suppressants are discouraged. In addition, they contain recommendations on the types of suppressants, dilution, and application rates to be used in different types of dust control areas (e.g. roads, construction sites). In general, the Clark County guidelines discourage the application of products known to potentially contain specific pollutants near lakes, streams, channels, and flood control channels.

The EPA ETV program requires acute and chronic toxicity tests (EPA/600/4-90/027F and EPA/600/4-91/002), and analyses of biological oxygen demand (BOD), chemical oxygen demand (COD), volatile organic compounds (VOC), toxicity characteristic leaching procedure (TCLP) [EPA Method 1311], inorganics/metals (EPA 6010B), semi-volatile organics (EPA 8270D), volatile organics (EPA 8260B), pesticides/herbicides (EPA 8270D), and PAHs. The Pennsylvania program requires bulk analysis of products using EPA SW-846 tests (originally designed for testing RCRA wastes), leach analysis by EPA Method 1312 (includes metals, volatiles, and semi-volatiles), 7-day survival and growth test for rainbow trout and *Ceriodaphinia dubia*, BOD, and COD.

In addition to the programs noted above, the United States Department of Agriculture (USDA) Forest Service is developing the "Forest Service Specifications for the Construction of Roads and Bridges" that will have new requirements for dust suppressants. These requirements will include a certificate that states that the dust suppressant meets the chemical requirements of the Pacific Northwest Snowfighters, that a toxicity test (ASTM E 729) be submitted, and that the pH of the product be on the certificate as well.

Section 3

What is Known About Potential Environmental Effects

The majority of research on dust suppressants has been by industry and has focused on the effectiveness (or performance) of dust suppressants to abate dust, however, little information is available on the potential environmental and health impacts of these compounds. The numerous pathways of exposure to dust suppressants for humans, flora, and fauna and how suppressants may migrate through the environment to potentially sensitive recaptors are shown in Figure 2-1. Impacts will depend upon their composition, application rates, and interactions with other environmental components. Potential environmental impacts include: surface and groundwater quality deterioration; soil contamination; toxicity to soil and water biota; toxicity to humans during and after application; air pollution; accumulation in soils; changes in hydrologic characteristics of the soils; and impacts on native flora and fauna populations.

This conceptual model and all of the potential pathways and receptors of concern were presented to the expert panel for their consideration. Following is a brief summary of the literature on known potential effects of dust suppressants. A complete description of the studies is provided in the literature review presented in Appendix A. The views of the Expert Panel on potential environmental effects of dust suppressants are then presented Section 3.2.

3.1 Overview of Scientific Literature

Although there are several noteworthy studies on the effects of dust suppressants to water quality, plants, and fish, the majority of the studies have focused on salts and brines, ligninsulfonates, and a few organic petroleum-based products.

3.1.1 Salts and Brines

The major known effects of salt in the environment relate to its capacity of moving easily with water through soils. Water quality impacts include possible elevated chloride concentrations in streams downstream of application areas (Demers and Sage, 1990) and shallow groundwater contamination (Heffner, 1997). In the area near the application of salts, there have been negative impacts to the growth of fruit trees (RTAC, 1987), pine, poplar, and spruce (Foley *et al.*, 1996, Hanes *et al.*, 1976, and Hanes *et al.*, 1970), and alterations in the plant nutrition due to increases in the osmotic pressure of soils (Sanders and Addo, 1993). Chloride concentrations as low as 40 ppm have been found to be toxic to trout, and concentrations up to 10,000 mg/L have been found to be toxic to other fish species (Foley *et al.*, 1996, Golden, 1991). Salt concentrations greater than 1,800 mg/L have been found to kill daphnia and crustaceans (Sanders and Addo, 1993), and 920 mg/L of calcium chloride has been found to be toxic to daphnia (Anderson, 1984).

3.1.2 Organic Non-petroleum Products

The majority of research in this category has focused on the impacts of ligninsulfonate. The toxicity of ligninsulfonates to rainbow trout and other biota has been investigated (Heffner, 1997). The 48-hour LC_{50} (concentration of ligninsulfonates which would be lethal to 50 percent of the tested population within 48 hours) value for ligninsulfonates was found to be 7,300 mg/L (Roald, 1977a and 1977b). A mortality of 50% was achieved for rainbow trout exposed to 2,500 mg/L ligninsulfonate for 275 hours. For concentrations equal to or higher than 2,500

mg/L, rainbow trout showed loss of reaction to unexpected movements, rapid and irregular breathing, and finally loss of co-ordination before death. It has been found that calcium and sodium ligninsulfonate negatively affect the colon of guinea pigs causing weight gain and producing ulceration in those animals (Watt and Marcus, 1976).

High levels of ligninsulfonate in water bodies have high coloring effects, increase biochemical oxygen demand, reduce biological activity, and retard growth in fish (Raabe, 1968, Heffner, 1997, RTAC, 1987, Bolander, 1999a, Singer *et al.*, 1982). However, ligninsulfonate compounds do not impact seed germination in the areas where applied (Singer *et al.*, 1982).

3.1.3 Organic Petroleum Products

Potential environmental impacts are highest from organic petroleum products. The chemical characteristics of the oil deposit from which the petroleum product originated, results in varied impacts with the potential for high levels of heavy metals from specific oil deposits. Several studies have shown that waste oils may contain known toxic and carcinogenic compounds (e.g. PCBs); therefore EPA prohibits the use of these materials (RTAC, 1987; Metzler, 1985, and USEPA, 1983).

The accidental introduction of a petroleum-based dust suppressant (Coherex) into a stream in Southern Pennsylvania affected fish and benthic macroinvertebrate communities and killed a large number of fish (Ettinger, 1987). Organic petroleum-based products have also been found to be toxic to avian mallard eggs. When the eggs were exposed to a concentration of 0.5 μL/egg, 60% mortality was observed by 18 days of development (Hoffman and Eastin, 1981).

3.1.4 Water Quality Impacts from University of Nevada, Las Vegas (UNLV) Study

A recent UNLV study, funded by several local agencies in the Las Vegas Valley, generated preliminary data highlighting the potential of the major dust suppressant categories. The research focused on the quality of urban runoff and on the changes in the chemical composition of soils where suppressants were applied (Piechota *et al.*, 2002 and Singh *et al.*, 2003). Rainfall events were simulated on the dust-suppressant treated plots and the changes in soil composition and the quality of the runoff emanating from the plots were examined.

In the study, a site was graded and divided into several individual plots. Each plot was 2.4 meters x 2.4 meters. Six categories of dust suppressant (11 individual products) were topically applied to the plots by local dust suppressant applicators. The dust suppressants applied included acrylic polymer emulsion, ligninsulfonate, petroleum-based organic, non-petroleum based organic, fiber mulch, and magnesium chloride salt. Rainfall was simulated using water treated by a reverse osmosis (RO) system. The water supply characteristics were designed to be similar to those of the rainfall in the Las Vegas Valley. An approximate rainfall of 20 mm was generated for a 1-hour period. The first five gallons of runoff emanating from the plots were combined to form a composite sample that was divided into aliquots, preserved, and analyzed for chosen parameters. In addition, the top two-inches of soil from each plot were sampled after the rainfall events to determine remaining levels of different compounds. The soil samples were leached using the EPA Synthetic Precipitation Leaching Procedure (Method 1312). Parameters evaluated in the runoff and soil leachate include 67 toxic volatile and 76 semi-volatile organic compounds, organic pesticides, PCBs, 11 metals, nutrients, biochemical oxygen demand (BOD), total solids (TS), total volatile solids (TVS), total suspended solids (TSS), total dissolved solids (TDS), turbidity, total organic carbon (TOC), pH, alkalinity, chemical oxygen demand (COD), hardness, nitrate, ammonia, phosphate, sulfide, sulfate, cyanide, chloride, and coliform bacteria.

The results show that petroleum-based products had a higher number of potentially

toxic contaminants with concentrations greater than the control plot, followed by acrylic polymers and ligninsulfonate. Magnesium chloride presented the lowest number of contaminants with concentrations greater than the control. The majority of the dust suppressants created a surface that is more impermeable than the natural soil surface. This increased the runoff volume similar to that emanating from a developed land surface.

Although several compounds that affect water quality have been detected in the runoff of plots to which dust suppressants were applied, this information alone should not be used to evaluate the impacts of dust suppressants to water quality. The data generated in this study and others should be combined with information on dust suppressant effectiveness, the frequency of application, proximity to water bodies, and cost to thoroughly evaluate the feasibility of using these compounds when water quality is a concern.

3.2 View of the Experts

This section summarizes the expert panel views on potential environmental impacts of dust suppressants, presented during the panel discussions. It is problematic to attribute specific views to a specific expert; therefore, the major points of consensus are noted below and collectively these represent the views of the experts as captured in the Expert Panel and through their review of the document.

3.2.1 Potential Factors Affecting Environmental Impacts of Dust Suppressants

On-site and off-site environmental effects of dust suppressant application depend on many factors including the physical characteristics of the suppressant, its chemical composition, concentration, the form it takes when it migrates, soil composition, and the climate conditions during and after application. From all the aforementioned factors, the lack of knowledge on the chemical composition of the suppressants is of critical importance to the evaluation of the environmental impacts of these compounds.

There is a need to improve information about the chemical composition of suppressants. Although Material Safety Data Sheets (MSDS's) for suppressants include the major components of the dust suppressants, they do not always include adequate details on toxic compounds that may be present and are of environmental concern. Because the vast majority of compounds used as dust suppressants are waste products from the manufacturing industry, their chemical composition is often unknown and complex and may vary widely for each batch. Organic suppressants sometimes contain surfactants or foaming agents that can cause environmental effects. One applicator cited an instance in which they unexpectedly found benzene, a carcinogenic hydrocarbon, in an off-spec water-based paint product sold as a dust suppressant. The compound was detected in tests performed on the dust suppressant prior to application. However, testing of the dust suppressants prior to application is expensive and not a common practice.

3.2.2 Unintended Off-site Environmental Impacts

Dust suppressants can potentially affect the environment beyond the application site. Overspray during application affects land, plants and fauna adjacent to the site. In addition, dust suppressants can be transported onto adjacent lands by surface flow or air. Material can be spilled from application trucks during transport to or from the application site, and commonly during off-loading from tankers to distributor trucks. It is a concern that trucks applying suppressants to roads have been observed to continue spraying when they cross bridges, resulting in dust suppressants being sprayed directly into streams below.

After the application of the dust suppressants it must be borne in mind that suppressants attached to soil particles covered with dust suppressants can be transported due to wind or erosion to off-site

areas. In Pennsylvania it has been observed that a farmer's machinery kept under an open-sided shelter was completely rusted from salts carried on the dust from a nearby brine application demonstration.

Humans who are on the site during application (e.g., applicators) or after application could also come in direct contact with the dust suppressant. Road applications bear the additional exposure of suppressant product becoming embedded under the skin of errant runners or cyclers. In addition, there is the potential for deleterious effects of pumping water from remote streams to construction sites for dust control. One instance was reported in Pennsylvania where the contractor pumped a stream dry.

3.2.3 Effects on Soils

Dust suppressants may cause undesired dissolution of some soil constituents. In the simplest case, even water used as a suppressant may cause chemical dissolution of compounds bound to soil particles. In soils from arid regions, which have high salt content, water used as a suppressant can mobilize the salts, increasing the salt concentration in nearby waterbodies or groundwater. In more complex scenarios, the chemical constituents of the suppressant can react with and leach toxic components out of the soils at the application site. The issue of leaching is particularly relevant where dust suppressants are used on coalfields, landfills, and mine tailings piles, which may contain hazardous material.

The constituents of the suppressants may be taken up by plant roots and systemically affect plants. In addition, soil microorganisms may biotransform the suppressants into benign or more toxic compounds depending on the environmental conditions on the site of application.

The application of dust suppressants will have secondary effects on the characteristics of soils to which suppressants are applied including a decrease of surface permeability. Depending on precipitation, the change in surface permeability can lead to increased runoff from the site to adjacent sites and decreased soil moisture. Changes in surface flow can then change patterns of erosion on and off the application site.

3.2.4 Effects on Air Quality

Dust suppressant use can affect air quality characteristics in a number of ways. In arid areas, for example, the use of water may add moisture to air fostering the proliferation of microorganisms. Dust suppressants that adhere to soil particles can be re-entrained into the air with strong winds, potentially adding contaminants to the air in addition to particulate matter. It is noteworthy that dust suppressants have little efficacy at suppressing small respirable dust that have the potential to be inhaled directly into lung parenchyma and cause lung disease (Reilly *et al.*, 2003). Dust suppressants are generally used to comply with PM10 regulations and improve visibility; but could be potentially harmful since smaller dust particles (less than 10 μm) can be inhaled. Lastly, some dust suppressants may have volatile organic compounds in the products that may be dispersed into the air when the product is applied. This is a particular concern in the formation of ozone.

3.2.5 Effects on Flora and Fauna

Dust suppressant application is not limited to the soils on the site. Since dust suppressants are generally applied over the surface, any vegetation or fauna on the site, including soil microorganisms, may also come into direct contact with the suppressant. Application of dust suppressants, especially magnesium chloride, has been associated with the browning of trees along roadways and stunted vegetation growth in forestlands. Effects vary, because different plants have different tolerances.

Aquatic ecosystems are affected by direct contamination from spills or runoff from offsite applications of dust suppressants. Fish may be affected by direct ingestion of toxic constituents or their degradation products. They are also sensitive to increased salinity resulting from salts and brine applications.

Dust suppressants that result in an increase in biochemical oxygen demand (BOD) can result in decreased DO concentrations in nearby streams, which may affect fish health and survival. Dust suppressants that affect macroinvertebrates could cause a decrease in food supplies for fish. Dust suppressants that result in increased suspended solids concentration, either directly or indirectly, via erosion, can potentially degrade aquatic habitat. At the micro level, suppressants can potentially be toxic to soil and water micro-organisms.

There is a chance that reproductive effects for fauna could also be found in these areas. An example of adverse impact of dust suppressants in animals relates to using finely chopped asphalt in feedlots to suppress dust. With time, the animals started having convulsions and high levels of lead were found in their blood. When the animals were moved to another feedlot, the symptoms were reduced.

3.2.6 Effects on Surface and Groundwater

Dust suppressant use can potentially affect both surface and groundwater. Spills directly affect surface water and can impact groundwater depending on site characteristics. Dust suppressants that are water-soluble can be transported into surface waters and materials that are water-soluble but do not bind tenaciously to soil can enter the groundwater. If the soil surface is not bound together well (i.e., chlorides, lignin) or if the rain event is extreme, dust suppressant treated soil particles can be carried by overland flow into streams, rivers, and ditches. Sedimentation and uptake of soil particles could adversely affect aquatic or marine life, if sufficient numbers of treated particles have significant and mobile concentrations of hazardous compounds. Settled particles can also change the composition of the ecological community and the dominant species (Sanders *et al.*, 2003).

3.2.7 What can be done to Avoid Another Times Beach?

To further engage the experts and to work through the scientific and policy issues associated with dust suppressant use, the experts were posed the above question and asked to respond individually. Following is a compilation of the responses.

Primarily, materials that fail existing regulatory thresholds for toxicity and those containing FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act), TSCA (Toxic Substance Control Act), and RCRA (Resource Conservation and Recovery act) regulated compounds should not be used as dust suppressants. Chlorinated compounds and materials containing any paints should be carefully evaluated if used in a dust suppressant. Food products (e.g. soy oil, molasses) could be used, when possible, for they are likely to contain less toxic compounds than the industrial materials and waste products currently used as dust suppressants. Natural products are likely to biodegrade in the environment and therefore toxic effects are expected to be minimal. However, the make up of these products needs to be considered since some biodegradable products can be toxic before degradation occurs.

Application of all types of chemical dust suppressants should not be ruled out or permitted under all conditions. Instead, guidelines should be drafted to indicate where specific dust suppressants should be applied. Application of chemical dust suppressants should be avoided near sensitive environments, near water bodies and fractured rock, in areas with a shallow groundwater table, and other areas where water could quickly reach the saturated zone. Site-specific characteristics should be considered when approving the use of dust suppressants. All of these recommendations would require the screening of suppressants via a certification program, and a proper monitoring program of product make up over time. This would eliminate suppressants that do not meet expected standards. Alternatively, the number of dust suppressants to be

applied could be limited to specific types; that would facilitate regulation and monitoring of the environmental impacts.

The public perception of toxicity may be an important component of the acceptance of dust suppressants as a dust abatement technology notwithstanding the actual threat the suppressant may pose. Factors such as the smell and the visual impact of dust suppressants should be considered. Finally, information on environmental impacts and effectiveness of dust suppressants should be used together when determining the type of suppressant to be used. If only environmental concerns are used as guidance to select dust suppressants, one could end-up with the most environmentally friendly suppressants instead of the best suppressant for the application with the least potential environmental risks. Before adopting new regulations, the advantages (e.g., improved air quality) and disadvantages (e.g., contaminated soils) associated with dust suppressant should be considered in risk management analysis.

3.2.8 What would be a Significant Concern that would Limit Use?

The Expert Panel was also presented with the above question on what would constitute a concern for them. The following items would cause the experts to limit the use of dust suppressants:

1. Data indicating a potential ecological impact (e.g., plant stress, isolation of animal communities, habitat disruption).
2. Data indicating carcinogens, toxins in levels that would cause negative impacts in human health.
3. Industrial waste by-product containing potential toxic contaminants.
4. Suppressant containing significant amounts of products regulated under FIFRA, TSCA, and RCRA.
5. Potential or observed negative impacts to adjacent landowners.

3.3 User and Agency Survey Results

To further probe into the current practices used for dust suppressant selections, several agencies and dust suppressant applicators were asked what characteristics in a dust suppressant they felt were important when deciding on the use for a particular situation, and what other factors influence their decisions. The main considerations include:

- Environmental impacts, especially near detention basins/waterways
- Toxicity such as LC50 test of dust suppressant on fish
- Cost of dust suppressant per acre
- Application costs
- Warranty time and durability
- Availability of product
- Type of equipment needed to apply product
- Penetration characteristics
- Past history of dust suppressant use
- Traffic impacts (i.e., different products for different conditions)
- Long term maintenance costs
- Category of dust suppressant

Section 4

Framework for Assessing Potential Environmental Effects

To make decisions about dust suppressant use, managers must evaluate the potential level of concern that use will generate. The level of concern about a given dust suppressant depends on a number of site-, use-, and composition-specific factors. These factors are highly variable and information about many of them is uncertain. The diagram shown in Figure 4-1 presents a framework for assessing the level of concern about the use of a particular dust suppressant. This is not meant to be a comprehensive decision-tree model. Instead, it outlines it identifies the type of information needed to evaluate the product. It also summarizes the relationship between the purpose of application, type of dust suppressant, site conditions, and level of concern. This is intended for managers and/or policy-makers who would use this framework to make a decision about the use of a particular dust suppressant on a specific site. This would guide the person on what information would need to be collected for each of these categories specific to the suppressant and the site in question. An explanation of the diagram from the bottom (endpoint) to the top is provided below.

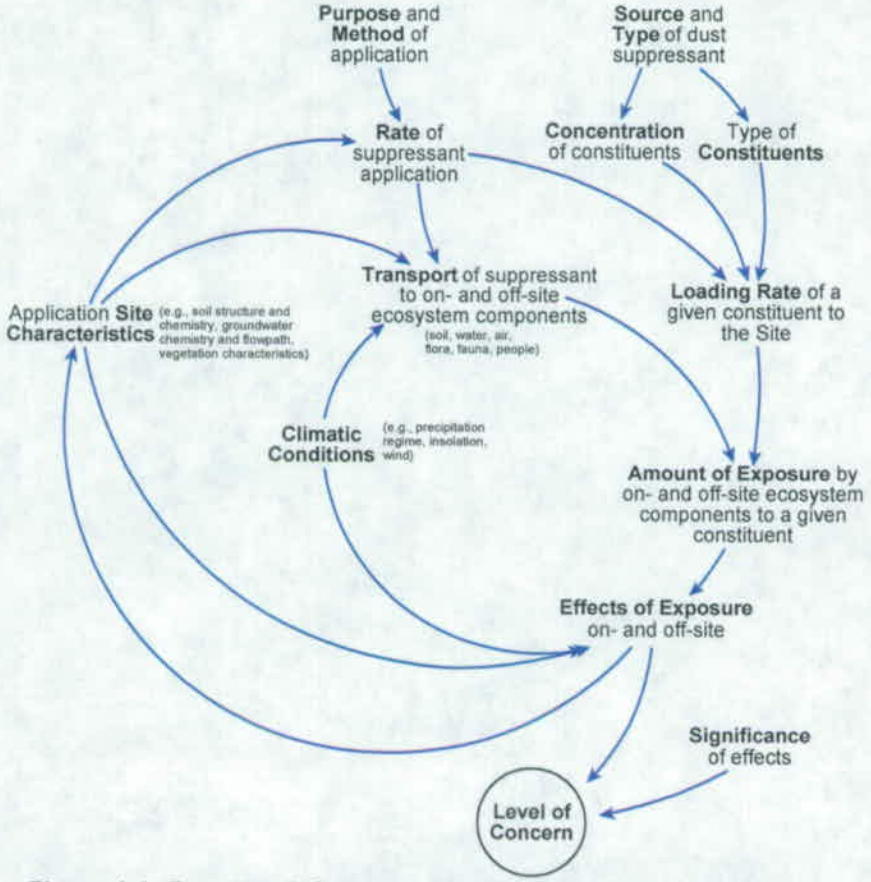

Figure 4-1: Framework for assessing the potential environmental impacts of dust suppressants.

To determine the *level of concern* about a given use, both the *effects of exposure* of the suppressant on a range of ecosystem components and the *significance* of those effects must be considered. If a suppressant applied to a given site were carried off the site and into an adjacent stream, for example, the level of concern would depend on the effect of that suppressant on the aquatic ecosystem – an algal bloom caused by an input of phosphorus, for example – and the significance of that effect. The same effect could be critical in one system and insignificant in another. An algal bloom might be unacceptable in a water body used for swimming but unremarkable in a wastewater treatment plant outfall. The significance of the effect might also be determined by comparing the effect of use with the effect of *not* using the suppressant. Any decision to use or not use a suppressant should be based on an assessment of benefits and risks (Expert Panel, 2002).

The effects of dust suppressant exposure on and off the application site are a function of the *site characteristics*, *amount of exposure* the different ecosystem components receive, and *climatic conditions* at the site. Site characteristics such as topography, soil texture and chemistry, groundwater flow path, vegetation and wildlife types, and distribution set the parameters for environmental responses to dust suppressant exposure. A basic set of ecosystem components whose response to the dust suppressant should be evaluated, include air, soil, water, soil microbes, aquatic organisms, vegetation, fauna, and people (Expert Panel, 2002). Different categories might be more or less important at different sites. One site may contain species sensitive to a particular compound while another may not. Site characteristics can also affect the ecosystem response to a suppressant. Alkaline soils may buffer acidic constituents of a suppressant. Dense vegetation may take up excess nutrients in organic suppressants. Soil microbes may break down potentially toxic suppressant constituents. Climatic conditions at the site, including the precipitation regime, wind exposure, and temperature, also affect the response of ecosystem components to the suppressants. Dust suppressant constituents might react differently under different moisture and temperature conditions, for example. The degradation rates of some constituents of dust suppressants may vary with exposure to ultraviolet radiation. The ecosystem response also depends on the amount of exposure to a given suppressant constituent received by the ecosystem component. The response of any given ecosystem component may be non-linear, or involve thresholds.

The *amount of exposure* received by a given ecosystem component to a given suppressant constituent depends on the rate at which it is applied to the site (*loading rate)* and the *transport* of constituents to each ecosystem component. The constituent loading rate depends on the rate at which the suppressant is applied, the type of constituents in the suppressant, and their concentration. Once the suppressant is applied to the site, its constituents may migrate within the site, from the soil surface to the sub-surface, for example, or to the groundwater or into the air. The pathways and rate at which any given constituent moves within the site or off the site are a function of the site characteristics, climatic conditions, and the characteristics of the constituents. The amount of precipitation a site receives affects the transport of water-soluble constituents, as do its topography, soil, and geologic characteristics. Some constituents are more mobile than others. They may be more soluble, or more likely to be volatilized. Depending on soil chemistry, some may be adsorbed to soil particles. Constituents may be transformed after application, reacting chemically with each other or with components at the site, or being degraded.

The *rate* of suppressant application depends on the *purpose and method* of application. The purpose of application – to stabilize disturbed vacant land or agricultural land or to reduce the dust generated from travel over unpaved roads, for example – together with specific site characteristics and climatic conditions, determine the amount and fre-

quency at which the suppressant is applied. The purpose and site characteristics also influence the method of application. If the surface to be stabilized is not expected to be disturbed, the suppressant may be applied topically. If the surface must withstand vehicle traffic, the suppressant may be mixed into the soil by grading.

The *type* and *concentration* of constituents in the suppressant are a function of the *type and source* of the suppressant. Dust suppressants can be water, brines, lignin-sulfonates, petroleum-based products, or other types, as discussed in Section 2.1. Dust suppressants may contain components other than the primary suppressant, depending on the source of the suppressant (Expert Panel, 2002). Most suppressants are derived from waste materials from manufacturing processes. Even the source water (e.g., reclaimed water, groundwater) may contain additional constituents. The composition of the suppressant, together with the rate of application determines the amount (mass) of each constituent applied to the site.

Section 5

Path Forward – Issues and Potential Solutions

There are a significant number of "data gaps" that need to be filled to more adequately address environmental and regulatory issues (Expert Panel, 2002). Research questions range from "What is the national scale of the problem?"; "How much is being applied and where?"; "What tests should one run to determine the chemicals leached into soil and the biological impacts of dust suppressants after they are applied?" These types of questions must be answered before a decision can be made about whether or not more federal regulation is needed. This section focuses on the scientific and regulatory issues, and then provides suggestions for a path forward.

5.1 Scientific Issues

5.1.1 Better Definition of What is Meant by "Effective" Dust Suppressant

As noted earlier, there is no standard definition of a dust suppressant. Current usage of the term "dust suppressant" implies that it can be any chemical formulation applied to the ground to control emission of dust. Furthermore, the term "effective" dust suppressant is not well defined. Currently, the definition of an effective dust suppressant focuses on the ability (efficiency) of the product to suppress particulate matter from becoming air borne over a period of time (Expert Panel, 2002). To support this, Industry has developed data on the performance of dust suppressants on various types of land surfaces (see Literature Review in Appendix A).

A more comprehensive definition of an effective dust suppressant is needed to consider the overall impacts of using the products. A comprehensive definition of an "effective" dust suppressant might consider the following (Expert Panel, 2002):

1. The efficiency and durability of the product
2. The costs and benefits associated with the use of the product
3. The potential environmental impacts

In making the determination of what dust suppressant to use, it is also important to select the proper dust suppressant based on soil characteristics. Soil characterization tests are not always performed on sites when selecting a dust suppressant; however, several experts were asked what tests they would recommend. Recommendations included gradation tests (AASHTO T-11 and T-27), plasticity tests (AASHTO T-89 and T-90), pH tests of the soil, tests for the ability of soil to attract of bind a particular dust suppressant, particle size distribution, moisture content, and a visual survey of the site (Expert Panel, 2002). A thorough description of soils tests necessary to determine the optimum product performance has been prepared by the US EPA ETV Generic Verification Protocol for Dust Suppression and Soil Stabilization Products.

5.1.2 Better Understanding of Dust Characteristics as an Air Pollutant

To properly evaluate the impacts of dust suppressants one must understand the characteristics of dust. One key factor is the size of the particle matter. Airborne particle size fractions are classified as either Particulate Matter (PM) 2.5 or PM10, based on their aerodynamic diameter, when they are regulated under the Clean Air Act. Airborne fugitive dust entrained from road surfaces

and wind-eroded from construction sites, agricultural fields and vacant lands span a physical size range from less than 1 micron to about 100 microns; this range includes (and exceeds, on the large end) the PM2.5 and PM10 size fractions. There is a need for proper characterization of particle size distribution and mineralogy related to variables such as vehicle tire loading and speeds on unpaved roads in different regions (Expert Panel, 2002). As noted earlier, the smaller PM2.5 particles may be more harmful from a human health perspective if inhaled.

The soil surface chemistry, moisture content, and shapes of dust particles can affect the ability of different suppressant formulations to adhere to the particles. The particle size, shape, surface chemistry, and soil moisture content are seldom used to assist in the selection of an appropriate suppressant. In some cases, the soil silt content (given as percent passing a #200 screen) and moisture content may be obtained prior to dust suppressant application. Many of the standard soil characterization tests are time-consuming and not well suited to the daily exigencies of field operations. Development of simple, robust field apparatus and rapid methods for characterization of relevant soil properties could assist in the selection of the right type of suppressant and the appropriate application rate for a particular region.

5.1.3 Better Understanding of How Dust Suppressants Change After Application

The fundamental mechanisms of how the dust suppressants work, break down, degrade, and move in the environment are not well understood at this time. "Degradation" includes effects of solar radiation, abiotic oxidation, biological transformations, dissolution, and physical weathering. In addition, the soils characteristics will influence how the suppressants are degraded (Expert Panel, 2002). Mechanisms of how dust suppressants work are well established and based on research and industry development. However, it is not known what happens to the products after they are applied and weathering occurs. What daughter products are produced as dust suppressants break down? Are they benign or toxic, mobile or immobile? Answers to these questions can only be obtained from long-term testing of dust suppressants under field conditions.

5.1.4 Better Definition of Current and Potential Problems/Uses

Preliminary data was provided in Section 2.3 on the current and potential uses of dust suppressants; however, this issue should be further explored. If national regulations/ guidelines are considered for the use of dust suppressants, then there needs to be a better understanding of the scale of current and potential usage of dust suppressants. Answers to the following questions are needed:

1. In what regions of the United States are dust suppressants currently being applied?
2. How much dust suppressant is being applied nationwide?
3. Have there been adverse environmental impacts in regions where dust suppressants were applied?
4. What is the potential use of dust suppressants on unpaved roads and disturbed lands?
5. Do local and state agencies track the use of dust suppressants?

5.1.5 Source of Dust Suppressants and Dilution Water

A major concern is the current lack of information on the chemical composition of dust suppressants. Material Safety Data Sheets (MSDS's) are commonly provided for dust suppressant products; however, since proprietary information may be involved, MSDS's do not necessarily provide information about all the chemicals present in the products. Major manufacturers (e.g., Midwest Industrial Supply and Pennzoil Products) will provide results of environmental tests if the customer asks for the information, or post the information on the Internet (Expert Panel, 2002). Manufacturers' environmental testing data, while

valuable, is currently not standardized. As an example, several vendors provide reports containing bioassay data, but it is sometimes difficult to compare results among different products because different test species (e.g. fathead minnows or water fleas) and different test protocols may be used.

Chemical properties, particularly toxic contaminants, can vary significantly depending on the product. Constituents can also vary from batch to batch (Expert Panel, 2002). The environmental impacts of dust suppressants cannot be adequately identified until concentration ranges for major and trace chemical constituents are known for the most common products. Most experts in soil science, ecology, and biology can estimate potential environmental impacts in their field of expertise if they know the chemical composition of the product and the site-specific conditions (Expert Panel, 2002). However, that information is not fully available.

There is also a concern regarding the sources of the products used in the dust suppressants. Although some manufacturers formulate suppressants from virgin materials, a majority of commercial products are reformulated by-products or brines from industries that would otherwise dispose of these materials as wastes. Several examples of waste products reformulated as dust suppressants include lignin sulfonates and magnesium chloride brines. In effect, unpaved roads have become disposal system for these by-products that are reformulated and used as dust suppressants. The chemical composition of broad categories of by-products, such as lignin sulfonates, oils, and brines will depend on the original source of the by-products and also on the chemical processes that generated them. For example, the waste oils originating from California crude oils may contain more metals than waste oils originating from Pennsylvania crudes (Expert Panel, 2002). Used oils and solvents may have even higher toxic concentrations.

It is also noteworthy that the use of toxic by-products in dust suppressants is a recycling process. The recycling of non-hazardous waste products into dust suppressants reduces the cost of the dust suppressant and eliminates the need for disposal in landfills. Depending on the by-product, recycling and reuse into dust suppressants may be the best way to dispose of some non-hazardous wastes (Expert Panel, 2002). For example, some mulch-type suppressants are formulated with non-hazardous wood fiber or paper pulp, and large volume use of mulch-type suppressants can significantly reduce the volume of waste pulp that must either be landfilled or incinerated.

The sources of the water used for dust suppressants should also be considered in assessing the potential impacts. The majority of suppressants require dilution and typically applicators will use the water that is most readily available. Tap water, untreated surface or ground water or reclaimed municipal or industrial wastewater could all be used. Reclaimed wastewater may have higher levels of nutrients and pathogens than ordinary tap water or some surface or groundwaters. In some areas, contaminated groundwater could inadvertently be used for mixing of the dust suppressants (Expert Panel, 2002). Minimum quality standards for water used directly as a dust suppressant or as a dilution product should be established to prevent inadvertent contamination of lands treated with dust suppressants.

5.1.6 Clearinghouse for Dust Suppressant Information

There is a need for more information about the chemicals and formulations used in dust suppressants (Expert Panel, 2002). Regulators, applicators, and the public don't have easy access to information that would help them to decide which dust suppressant types are safe and effective for specific applications. An easily-accessible information center, a "clearinghouse", could help applicators, regulators, and the public acquire the information needed to make good dust control decisions. The recommended form of this clearinghouse is as a World Wide Web site. EPA maintains several web sites that could serve as models for a dust suppressant clearinghouse. An example is the

CHIEF bulletin board that serves the needs of state and local air quality regulators. The clearinghouse could be maintained by EPA or by another public agency or university. Content categories for this clearinghouse could include (Expert Panel, 2002):

1. Information on composition of dust suppressants
2. Easy to follow guidelines for selection and application
3. List of products not to use
4. Occupational and environmental toxicity information for different types of dust suppressants
5. Applicable state and local ordinances regulating dust suppressant application
6. Information about what happens after application, both in terms of suppressant performance and environmental impacts
7. Information for the affected public as well as for regulators/manufacturers/applicators, including:

   a. Contact information for federal, local, and state agencies regulating use of dust suppressants

   b. Contact information for dust suppressant manufacturers

Complete disclosure by dust suppressant manufacturers, formulators, and vendors would be needed in order to address all the items shown above. Some manufacturers, formulators, and vendors might be reluctant to release exact formulation information, since they could consider the information to be proprietary. The model for disclosure of pesticide formulations, where only "active" ingredients are specifically listed, might prove useful. However, in the case of dust suppressants the definition of an "active" ingredient should include both those constituents that control dust and any other trace constituent, which when applied to the land surface at the intended application rate, has the potential for environmental impact. However, the lack of complete cooperation from vendors should not delay the creation of the clearinghouse.

5.1.7 Risk Assessment and How to Decide What to Test For

When making the determination on which dust suppressant should be used, a robust risk assessment framework is needed along with the identification of which test should be performed. In Section 4, a framework was provided that outlines the considerations that one might use to make an assessment. There are several detailed risk assessment frameworks available to the industry that could be used as models.

- The American Society of Testing and Materials (ASTM)'s Risk-Based Corrective Action (RBCA) is one of the standard frameworks for assessing the extent of petroleum contamination and developing remedial measures for contaminated lands (ASTM, 1999)
- ASTM also publishes guides and standards for ecological considerations for the use of chemical dispersants in oil spill response that may provide insight into development of standards for dust suppressants (ASTM, 2003)
- EPA has also published guidelines for remediation of hazardous waste sites (EPA, 2002)

Unfortunately, these frameworks for risk assessment were developed for cases where contamination had already occurred. One proprietary general guideline exists for evaluating potential environmental impacts of release of chemicals to the environment (see Rohm and Haas Consumer and Industrial Specialties' Risk Assessment Flow Chart for Safe Product Use, available at http://www.rohmhaas.com/rhcis/environmental/safeproduct.html).

There are no relevant guidelines available for minimizing environmental and human health risk from intentional application of dust suppressants to roads construction sites, agricultural fields, and vacant lands. Guidelines do exist for:

- Intentional application of fertilizers to crops and turf, and

- Intentional application of pesticides to croplands, turf, and residences

However, in both of these cases, the active ingredients are well known and impacts have been fairly well studied. The situation with dust suppressants is much more ambiguous, as in many cases, data about their chemical composition and biological impacts are lacking.

It is recommended that tests performed, as part of a risk assessment for dust suppressants should focus on the constituents in the dust suppressant concentrate, in runoff, and in the soil after application. It is very likely that no dust suppressants will be free of every potential harmful chemical; however, it is important that guidance documents and initial recommended threshold levels be developed to reduce risk. Relevant EPA methods, compiled from both Expert Panel recommendations and from the literature review, are summarized in Table 5-1. These tests could be applied to the raw product, the collected runoff, and/or the soils.

Table 5-1: Relevant EPA and Standard test to be considered in assessing impacts of dust suppressants.

	Analytical Method	EPA/ASTM Number
Organic	Volatile organic compounds	8260B
	Semi-volatile organic compounds	8270D
	Pesticides and herbicides	8270D
	Chlorinated hydrocarbons	8121
	Petroleum hydrocarbons	8440
	PAHs	Tentatively identified compounds (TIC)
Inorganics/Metals	Inductively Coupled Plasma-Atomic Emission Spectrometry	6010B
Toxicity	Terrestrial bird toxicity	850.2200
	Insect toxicity	850.3020
	Vegetation toxicity	850.4000
	Algal Toxicity	850.4400
	Acute to fishes and microinvertebrates	ASTM E-1192-88
	Marine and Estuary organisms	EPA/600/4-85-013 and EPA 600/4-87-028
	Chronic to fishes and microinvertebrates	EPA/600/4-89-001
	Dredge material chemical and biological evaluation	U.S. Corps. Engr. Rep-D90
	Bioconcentration	ASTM E-1022-84
Biodegradability	Soluble Chemical Oxygen Demand	410.4
	Biochemical Oxygen Demand	405.1

5.1.8 Example of a Standardized Assessment Methodology

As part of an initial risk assessment for this report, a proposed standardized methodology for estimating soil mass fractions of dust suppressant constituents is shown below in Tables 5-2 and 5-3. The worksheets use known information about a dust suppressant constituent concentration, the application rate, the soil penetration, and soil density to estimate a dust suppressant constituent concentration in soil. Table 5-2 is provided as a blank worksheet for vendors, applicators, regulators, and investigators to use in their risk assessments. Table 5-3 shows an example calculation for a constituent present at a 50 mg/L in a dust suppressant concentrate.

Table 5-2: Blank Worksheet A – Estimation of soil mass fraction from suppressant constituent concentration.

Blank Worksheet A: Calculation of constituent concentration in soil

Fill in shaded blanks with your data and complete calculations in other rows per Calculation Instructions

User-supplied	Row #	Data Entry or Calculation Instruction	Value	Units
*	1	Concentrate constituent concentration		mg/L
*	2	Dilution: volume water/volume concentrate		
	3	Mixed constituent concentration = concentrate concentration / (1 + dilution)		mg/L
*	4	Liquid mixture application rate per pass		gallon/yd2
*	5	Number of passes		
	6	Total liquid mixture application rate/yd2 = rate/pass x number passes		gallon/yd2
	7	Land area conversion	1.20	yd2/m2
	8	Converted total liquid mixture application rate per m2 = row 6 x row 7		gallon/m2
	9	Mixture volume conversion	3.78	liter/gallon
	10	Total Liquid mixture application rate (metric) = row 8 x row 9		liter/m2
*	11	Runoff fraction (fraction leaving site before infiltration into soil)		
	12	Retained liquid application rate = Total rate x (1 - runoff fraction)		
	13	Mixture liquid depth applied to soil = (row 12 x (1 meter3/1000 liter) x 100cm/meter x 1 inch/2.54 cm		inches
	14	Constituent application rate as mass/area soil = mixed constituent concentration (row 3) x liquid mixture rate (row 12)		mg/m2
*	15	Diluted mixture penetration (inches)		inches
	16	Length conversion	2.54	cm/inch
	17	Diluted mixture penetration (centimeters) = row 15 x row 16		centimeters
	18	Diluted mixture penetration (meters) = row 17 / 100		meters
	19	Constituent soil concentration as mass constituent/volume soil = constituent application rate (row 14) / diluted mixture penetration (row 18)		mg/m3
*	20	Soil bulk density		kg/m3
	21	Initial constituent mass fraction in soil = constituent soil concentration (row 19) / soil bulk density (row 20)		mg/kg = ppm

Table 5-3: Example calculation using Worksheet A. Soil mass fraction resulting from application of dust suppressant with constituent concentration of 50 mg/L. Assumes 1,600 kg/m^3 soil bulk density, 0.45 inch (1.14 cm) suppressant penetration into soil, 2 suppressant applications at 0.50 gallon/yd^2, no runoff of liquid suppressant, and mixing of 1 volume of suppressant concentrate with 1 volume of water.

Worksheet A Example 1: Estimation of constituent soil mass fraction based on constituent concentration in suppressant as supplied (concentrate)

User-supplied	Row #	Data Entry or Calculation Instruction	Value	Units
*	1	Concentrate constituent concentration	50	mg/L
*	2	Dilution: volume water/volume concentrate	1	
	3	Mixed constituent concentration = concentrate concentration / (1 + dilution)	25	mg/L
*	4	Liquid mixture application rate per pass	0.50	gallon/yd2
*	5	Number of passes	2	
	6	Total liquid mixture application rate/yd2 = rate/pass x number passes	1.00	gallon/yd2
	7	Land area conversion	1.20	yd2/m2
	8	Converted total liquid mixture application rate per m2 = row 6 x row 7	1.20	gallon/m2
	9	Mixture volume conversion	3.78	liter/gallon
	10	Total Liquid mixture application rate (metric) = row 8 x row 9	4.53	liter/m2
*	11	Runoff fraction (fraction leaving site before infiltration into soil)	0.00	
	12	Retained liquid application rate = Total rate x (1 - runoff fraction)	4.53	liter/m2
	13	Mixture liquid depth applied to soil = (row 12 x (1 meter3/1000 liter) x 100cm/meter x 1 inch/2.54 cm	0.18	inches
	14	Constituent application rate as mass/area soil = mixed constituent concentration (row 3) x liquid mixture rate (row 12)	113	mg/m2
*	15	Diluted mixture penetration (inches)	0.45	inches
	16	Length conversion	2.54	cm/inch
	17	Diluted mixture penetration (centimeters) = row 15 x row 16	1.14	centimeters
	18	Diluted mixture penetration (meters) = row 17 / 100	0.0114	meters
	19	Constituent soil concentration as mass constituent/volume soil = constituent application rate (row 14) / diluted mixture penetration (row 18)	9,900	mg/m3
*	20	Soil bulk density	1,600	kg/m3
	21	Initial constituent mass fraction in soil = constituent soil concentration (row 19) / soil bulk density (row 20)	6.19	mg/kg = ppm

Environmental regulations establish action levels for contaminants or contaminant classes in soils. Remediation is usually required if values above these levels are recorded for a contaminated site. Tables 5-4, 5-5, and 5-6 show a proposed calculation methodology for using an action level in soil to estimate the maximum allowable constituent concen-

tration in a formulated dust suppressant concentrate. Table 5-4 is provided as a blank worksheet for interested parties to use in risk assessments involving suppressants. Table 5-5 shows a sample calculation for a RCRA-based action level of 100 ppm for total petroleum hydrocarbons (TPH). Table 5-6 shows a sample calculation for a CERCLA-based action level of 1 ppb for tetrachlorodibenzodioxin (TCDD). The final result computed at the bottom of Tables 5-5 and 5-6 should not be considered as a fixed "not to exceed" value for TPH or TCDD, as the numerical result depends on dust suppressant liquid application rate, penetration depth into the soil, fraction suppressant retained on the target surface, suppressant dilution, and soil bulk density. However, the results are instructive, and the accompanying blank worksheet (Table 5-4) could be used with site-specific data to compute maximum allowable constituent (or contaminant) concentrations for other combinations of site conditions, suppressant dilutions, and application rates.

Table 5-4: Blank Worksheet B – Estimation of maximum allowable dust suppressant constituent concentration from risk-based limit in soil.

Blank Worksheet B: Calculation of maximum suppressant contaminant concentration based on maximum allowed soil contaminant mass fraction

Fill in shaded blanks with your data and complete calculations in other rows per Calculation Instructions

User-supplied	Row #	Data Entry or Calculation Instruction	Value	Units
*	1	Initial constituent mass fraction in soil		mg/kg = ppm
*	2	Soil bulk density		kg/m3
	3	Constituent soil concentration as mass constituent/volume soil = constituent soil mass fraction (row 1) x soil bulk density (row 2)		mg/m3
*	4	Diluted mixture penetration (inches)		inches
	5	Length conversion	2.54	cm/inch
	6	Diluted mixture penetration (centimeters) = row 4 * row 5		centimeters
	7	Diluted mixture penetration (meters) = row 6 / 100		meters
	8	Constituent application rate as mass/area soil = constituent soil concentration (row 3) x diluted mixture penetration (row 7)		mg/m2
*	9	Liquid mixture application rate per pass		gallon/yd2
*	10	Number of passes		
	11	Total liquid mixture application rate/yd2 = row 9 x row 10		gallon/yd2
	12	Land area conversion	1.20	yd2/m2
	13	Converted total liquid mixture application rate per m2 = row 11 x row 12		gallon/m2
	14	Mixture volume conversion	3.78	liter/gallon
	15	Total liquid mixture application rate (metric) = row 13 x row 14		liter/m2
*	16	Runoff fraction (fraction leaving site before infiltration into soil)		
	17	Net liquid application rate = row 15 x (1 - row 16) as volume/ area soil		liter/m2
	18	Mixture liquid depth applied to soil = (row 17 x (1 meter3/1000 liter) x 100cm/meter x 1 inch/2.54 cm		inches
	19	Max allowed concentration in diluted mixture = row 8 / row 17		mg/L
*	20	Intended dilution: volume water / volume concentrate		
	21	Maximum allowed concentration in suppressant concentrate as supplied = row 19 x (1 + row 20)		mg/L

Table 5-5: Example calculation of maximum allowable suppressant concentration based on RCRA 100 ppm action level for Total Petroleum Hydrocarbons (TPH) in soil as determined using EPA Method 8015. Assumes 1,600 kg/m^3 soil bulk density, 0.45 inch (1.14 cm) suppressant penetration into soil, 2 suppressant applications at 0.50 gallon/yd^2, no runoff of liquid suppressant, and mixing of 1 volume of suppressant concentrate with 1 volume of water.

Worksheet B Example #2: Calculation of maximum allowable suppressant contaminant concentration based on maximum allowed soil contaminant mass fraction. RCRA soil limit of 100 ppm maximum allowable TPH in soil from EPA Method 8015

User-supplied	Row #	Data Entry or Calculation Instruction	Value	Units
*	1	Initial constituent mass fraction in soil	100.00	mg/kg = ppm
*	2	Soil bulk density	1,600	kg/m3
	3	Constituent soil concentration as mass constituent/volume soil = constituent soil mass fraction (row 1) x soil bulk density (row 2)	160,000	mg/m3
*	4	Diluted mixture penetration (inches)	0.45	inches
	5	Length conversion	2.54	cm/inch
	6	Diluted mixture penetration (centimeters) = row 4 * row 5	1.14	centimeters
	7	Diluted mixture penetration (meters) = row 6 / 100	0.0114	meters
	8	Constituent application rate as mass/area soil = constituent soil concentration (row 3) x diluted mixture penetration (row 7)	1829	mg/m2
*	9	Liquid mixture application rate per pass	0.50	gallon/yd2
*	10	Number of passes	2	
	11	Total liquid mixture application rate/yd2 = row 9 x row 10	1.00	gallon/yd2
	12	Land area conversion	1.20	yd2/m2
	13	Converted total liquid mixture application rate per m2 = row 11 x row 12	1.20	gallon/m2
	14	Mixture volume conversion	3.78	liter/gallon
	15	Total liquid mixture application rate (metric) = row 13 x row 14	4.53	liter/m2
*	16	Runoff fraction (fraction leaving site before infiltration into soil)	0.00	
	17	Net liquid application rate = row 15 x (1 - row 16) as volume/ area soil	4.53	liter/m2
	18	Mixture liquid depth applied to soil = (row 17 x (1 meter3/1000 liter) x 100cm/meter x 1 inch/2.54 cm	0.18	inches
	19	Max allowed concentration in diluted mixture = row 8 / row 17	404	mg/L
*	20	Intended dilution: volume water / volume concentrate	1	
	21	Maximum allowed concentration in suppressant concentrate as supplied = row 19 x (1 + row 20)	808	mg/L

Table 5-6: Example calculation of maximum allowable suppressant concentration based on CERCLA 1 ppb action level for TCDD. Assumes 1,600 kg/m^3 soil bulk density, 0.45 inch (1.14 cm) suppressant penetration into soil, 2 suppressant applications at 0.50 gallon/yd^2, no runoff of liquid suppressant, and application of undiluted suppressant to land surface.

Worksheet B Example #3: Calculation of maximum allowable suppressant contaminant concentration based on maximum allowed soil contaminant mass fraction. CERCLA limit of 1 ppm maximum allowable dioxin in soil.

User-supplied	Row #	Data Entry or Calculation Instruction	Value	Units
*	1	Initial constituent mass fraction in soil	0.001	mg/kg = ppm
*	2	Soil bulk density	1,600	kg/m3
	3	Constituent soil concentration as mass constituent/volume soil = constituent soil mass fraction (row 1) x soil bulk density (row 2)	1.60	mg/m3
*	4	Diluted mixture penetration (inches)	0.45	inches
	5	Length conversion	2.54	cm/inch
	6	Diluted mixture penetration (centimeters) = row 4 * row 5	1.14	centimeters
	7	Diluted mixture penetration (meters) = row 6 / 100	0.0114	meters
	8	Constituent application rate as mass/area soil = constituent soil concentration (row 3) x diluted mixture penetration (row 7)	1.83E-02	mg/m2
*	9	Liquid mixture application rate per pass	0.50	gallon/yd2
*	10	Number of passes	2	
	11	Total liquid mixture application rate/yd2 = row 9 x row 10	1.00	gallon/yd2
	12	Land area conversion	1.20	yd2/m2
	13	Converted total liquid mixture application rate per m2 = row 11 x row 12	1.20	gallon/m2
	14	Mixture volume conversion	3.78	liter/gallon
	15	Total liquid mixture application rate (metric) = row 13 x row 14	4.53	liter/m2
*	16	Runoff fraction (fraction leaving site before infiltration into soil)	0.00	
	17	Net liquid application rate = row 15 x (1 - row 16) as volume/ area soil	4.53	liter/m2
	18	Mixture liquid depth applied to soil = (row 17 x (1 meter3/1000 liter) x 100cm/meter x 1 inch/2.54 cm	0.18	inches
	19	Max allowed concentration in diluted mixture = row 8 / row 17	4.04E-03	mg/L
*	20	Intended dilution: volume water / volume concentrate	0	
	21	Maximum allowed concentration in suppressant concentrate as supplied = row 19 x (1 + row 20)	4.04E-03	mg/L
	22	Maximum allowed concentration (ppb) = row 21 x 1000	4.04	µg/L (ppb)

5.2 Regulatory Issues

5.2.1 Gaps in Existing Regulations

At present, few specific regulations for dust suppressants exist. Decision-makers currently rely on emerging voluntary certification programs (Section 2.7), and a limited number of state and local guidelines to screen the different types of dust suppressants for a variety of application scenarios. Current state, local, and national guidelines are not uniform. While current voluntary certification programs have merit, they need to be expanded to incorporate a majority of dust suppressants in commerce. Dust suppressants should be evaluated not only for their effectiveness in suppressing dust but also for their potential toxicological and environmental effects.

Regulations to support existing environmental laws (e.g., RCRA, CERCLA/SARA guidelines, as were used to clean up the Superfund site at Times Beach) may apply at some point after a dust suppressant has been applied. However, existing regulations are not applicable to the production and application of dust suppressant. RCRA rules were not written with dust suppressants in mind. Although they allow for waste exchanges and other waste reprocessing steps, their principal intent is to regulate the treatment, storage, and disposal of municipal and hazardous wastes. CERCLA/SARA rules are intended to finance and guide the clean up of contaminated sites. In contrast, the major regulatory need for dust suppressants is to develop guidelines that will prevent the creation of hazardous waste sites from the inappropriate use of dust suppressants. The Toxic Substance Control Act (TOSCA) is intended to regulate hazardous substances prior to them becoming hazardous waste.

5.2.2 Filling the Regulatory Gaps – What's Available in Existing Regulations?

Is the current regulatory environment for dust suppressants adequate to ensure that the risks have been considered and their use is acceptable? It was the opinion of the Expert Panel that it is not adequate. The Expert Panel generally agreed that more research is needed to answer questions about the potential environmental impacts of dust suppressants, but also agreed that development of regulations should not wait for all the science to be completed (Expert Panel, 2002).

A complication in developing new regulations is that the composition of dust suppressants may not be adequately known and components or byproducts of the suppressants may have potentially harmful environmental impacts. Although existing regulations are not intended to regulate the flows of Industrial wastes into the formulation of dust suppressants and thence to the environment, the existing regulations do contain limits on contaminant concentrations in soil that could be used as a starting point for regulations and guidelines for dust suppressants. For instance, a similar approach may be considered as that for the land application sludges. The regulations currently in place for the land application of sewage sludge and wastewater on agricultural fields limits the loading rate of metals based on land use.

The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), Resource Conservation Recovery Act (RCRA), Comprehensive Environmental Response Compensation and Liability Act (CERCLA), Superfund Amendments and Reauthorization Act (SARA), Ecological Soil Screening Level (Eco-SSL) guidance with supporting regulations and guidelines collectively restrict the environmental concentrations of hundreds or thousands of chemicals. Many of these programs are good models for identifying potential problems; however, they need to be followed up with site-specific studies. It is recommended that:

1. State and federal regulatory databases for these compounds be reviewed, and the results organized to produce a database of compounds whose use would be restricted or prohibited in dust suppressants (Expert Panel, 2002).
2. Contaminant concentrations of modeled dust suppressant constituents and by-

products in water should be compared against action levels used in the Clean Water Act and Safe Drinking Water Act since dust suppressants could eventually be transported into surface and ground waters. Any dust suppressant compound that could reasonably be expected to exceed existing regulatory-based action levels or thresholds would need to be examined in detail to determine whether additional regulatory controls were needed to prevent unreasonable risks to human health and the environment.

Regarding regulating dust suppressant application practices, some guidance might be found in U.S. Department of Agriculture (USDA) regulations that control the application of chemical fertilizers and also in regulations that control the application of pesticides under FIFRA. As noted earlier, there are also state programs being developed. These state programs may be the most appropriate since they can better address regional issues related to dust suppressant use than a "one size fits all" federal program.

5.2.3 What's Next for Regulations?

New regulations must be developed to deal with the variety of compounds, application scenarios, and potential receptors that are involved with the growing use of dust suppressants. A variety of potential regulatory approaches specifically focused on dust suppressants exist, ranging from extending the current patchwork approach of local and state regulations to development of a comprehensive national program enforcement of which would likely be delegated to the states. An alternative to a comprehensive national program might be a basic national program that specifically makes dust suppressant products subject to other existing regulatory thresholds for toxicity and requires some type of testing and/or certification to validate that these limits are met. States could be encouraged to develop a more comprehensive regulatory program for dust suppressant products and their use based on regional topography, hydrology, soil types, ecosystems, and material availability.

The range of regulatory topics could include:

1. Limiting the types and number of suppressants allowed, and
2. Regulating the locations and application practices of specific types of dust suppressants (Expert Panel, 2002).
3. Regulating the exposure of workers to dust suppressants.

An effort to limit and specify which dust suppressants could be applied for dust control would be challenging because of the broad variety of products used as dust suppressants, their complex chemistry, and the increasing number of products and industrial by-products regularly introduced to the market. However, limiting the types of dust suppressants allowed for use would make enforcement of environmental regulations much simpler (Expert Panel, 2002). A regulatory-derived list of acceptable dust suppressants would bar access of several vendors to the market and would not be well received. In addition, there was concern that such an approach would discourage the development of more effective and more environmentally benign suppressants (Expert Panel, 2002).

Regulating dust suppressant application locations and application practices, rather than the types and number of suppressants, would allow for the varying sensitivities of different ecosystems to different dust suppressant formulations (See framework proposed in Section 4). For example, a dust suppressant with relatively insignificant impacts in one area (an arid flatland system with no perennial surface water flows and deep groundwater) might have significant impacts in another area (a humid mountainous system with significant perennial surface water flows and shallow groundwater). In the flat arid land case, the suppressant is likely to stay put in the soil for a long time, with minimal aquatic impacts. In the mountainous humid case, significant portions of the suppressant may rapidly reach surface and ground waters and could have significant aquatic impact.

Also, application rates and practices are important since dust suppressants with seemingly benign characteristics when applied at a rate of 1,000 mg/kg soil might produce significant impacts on the environment or human health if it is applied at 10 times the rate (10,000 mg/kg soil) or if the surrounding environment and individuals are particularly sensitive. High soil mass fractions could inadvertently develop if there is significant overspray onto previously treated surfaces during application.

The effectiveness of a suppressant should be considered in any evaluation of the application and potential impacts of dust suppressants. A short-lived, easily weathered dust suppressant requiring frequent re-application could have more significant environmental impacts than a long-lived, weather-resistant suppressant, when both contain the same concentration of a mobile trace contaminant. Frequent reapplication of the easily weathered suppressant would produce higher soil and aquatic concentrations of the trace contaminant than infrequent applications of the weather-resistant suppressant. If effectiveness is not considered, decision-makers might choose the "most environmentally friendly suppressant" rather than select a more effective dust suppressant that is just as environmentally benign for one application and more benign over the long term (Expert Panel, 2002).

The evaluation and/or certification of specific dust suppressants should not be a one-time process, but should instead be subject to periodic renewal. Waste products that are recycled into dust suppressants can vary in composition through time, and this variability must be considered in any comparison of a dust suppressant batch to a fixed set of environmental criteria. Out-of-specification products should not be considered bad, but they should be scrutinized (Expert Panel, 2002).

If additional regulations are developed for dust suppressants, certain criteria should be met (Expert Panel, 2002):

1. Regulations should be practical.
2. A regulatory program to track dust suppressants should not be overwhelming in amount of required information.
3. Regulatory guidelines should benefit governments who rely on dust control in preparing State Implementation Plans (SIPs) for PM10.
4. Training needs to accompany the regulations.
5. A model, decision-tree, or expert system is needed to help decide: what to use, how much to use, for different dust applications and environmental situations (e.g., Figure 4-1).
6. Sufficient EPA-approved and standard analytical testing methods to evaluate suppressant chemical characteristics exist (Table 5-1); however, as part of the regulatory process, the types of tests to be used should be specified. Tests should be carefully selected to provide the information that is necessary to assess potential exposures to critical receptors through those media that are of concern in the area where the suppressant will be applied. The EPA's Data Quality Objective process provides the framework for assessing the type of information that is critically needed to assess the data that are required to evaluate potential exposures.
7. In addition to the tests to determine the potential environmental impacts, the regulations should contain Application Practice Guidelines (APGs). Application Practice Guidelines should include information about the types of areas where specific suppressants can be applied (predominant biota and soil types), wind velocity limitations at the time of application, specific limitations on application in proximity to water bodies, runoff channels, and residential areas, regulations on the types of containers that may be used to transport suppressants [some of this may already be in place in RCRA-inspired rules promulgated by EPA and the U.S. Department of Transportation (DOT)].

Among the questions that applicators and regulators would need answered in order to establish a list of prohibited categories of dust suppressants are (Expert Panel, 2002):

1. What formulated and in-soil concentrations should not be exceeded for specific compounds?
2. If some formulations are already known to contain harmful contaminants (such as TCDD), one could start by prohibiting or restricting suppressant formulations containing those harmful compounds. Additional detailed discussion of this approach, using restrictions found in existing environmental regulations, can be found in Section 5.2.2 above.
3. Can obviously ineffective chemical formulations, passed off as dust suppressants, be prohibited? For example, could a 5% sodium hydroxide NAOH solution in water, be applied to soil and be labeled as a dust suppressant? What can be done to prevent this? Does any existing legislation cover this situation?
4. Should there be a required consistency of dust suppressant composition? A public right-to-know may lead to a requirement for batch-to-batch consistency of composition.
5. How does one develop a reliable testing process to determine if industrial wastes or byproducts, not originally formulated for use as dust suppressants, can be effective suppressants and safely applied? Currently, manufacturers do "in-house" or contracted testing of performance and toxicity.

Additional Recommendations by the Expert Panel included the following:

1. Regulatory exclusions for certain classes of compounds should be re-examined. For example, the RCRA petroleum exclusion allows reintroduction of oily wastes into the marketplace and some of these could cycle back into the environment in dust suppressant formulations (Expert Panel, 2002).
2. Information contained in the MSDS is not sufficient to evaluate the potential environmental impacts of suppressants. Manufacturers should transparently and completely report the chemical compositions of their dust suppressant formulations. (Expert Panel, 2002). Regulations requiring more information on an MSDS should be considered.
3. Finally, regulations should prevent entry of "rogue" dust suppressants into the marketplace. A reputable dust suppressant should have a consistent formulation and independently verifiable test results demonstrating product effectiveness and low environmental impacts, and will be made by manufacturers with consistent track records in the dust suppressant business. Rogue products will typically come without test results from one-time manufacturers that are looking to get rid of a waste product. Certification and regulation are the best ways to prevent entry of rogue products into the marketplace and the environment. Reputable manufacturers would welcome a certification program (Expert Panel, 2002).

5.2.4 Response to Regulatory Uncertainty – Risk Driven Regulatory Response

While current certification and testing protocols focus on evaluating the effectiveness of a dust suppressant, more needs to be done to assess potential adverse impacts from dust suppressants and to estimate risks. Regulatory efforts should be focused first on those compounds and applications that pose the greatest risks to human health and the environment.

A risk assessment model combined with a transport and fate model is required to evaluate potential exposures and adverse risks. For the decision-maker or regulator, a decision-making model or expert system to assist in making site-specific decisions would be of value. Without these models or tools, a decision-maker could either make decisions or develop regulations that are very conservative in the use of dust suppressants. Excessively conservative regulation may not maximize the benefits to be gained from

using dust suppressant products and could be challenged in the courts. Conversely, the decision-maker could allow widespread use of dust suppressants with the potential for unintended consequences. Sufficient information already exists to make a start at preventing either of the above two scenarios. After 25 years of environmental remediation efforts, risk-based concentration limits have been established for a number of compounds and compound classes. Additionally, risk assessment frameworks, such as ATSM's RBCA guidelines, may prove instructive.

An example of this approach would be a risk-benefit analysis to determine how much PM10, and PM2.5 dust is suppressed with each suppressant. Information that would be needed include the potential environmental impacts, the costs associated with the using or not using dust suppressants, the potential environmental benefits associated using dust suppressants. There also needs to be a consideration that many regions are rapidly moving toward a PM2.5 standard and away from a PM10 standard. This is due to the emerging cancer issues and cardiopulmonary disease. However, tighter standards will raise the quality of the environment and the cost associated with that environment.

5.3 Final Recommendations

The additional environmental regulations that have been developed since the 1970's when the Times Beach situation occurred have reduced the chances that dioxin-contaminated waste oil be used as dust suppressants. However, dust suppressants are not specifically regulated under any major federal legislation and there is still significant potential for other environmentally hazardous materials to be used.

1. In the SHORT TERM, the chances that hazardous materials are used can be reduced by:
    a. Establishing an interagency working group that evaluates the cross media and cross jurisdictional issues associated with the use of dust suppressants.
    b. Closing regulatory loopholes that allow entry of unlimited industrial wastes into the environment when they are classified as dust suppressants. All industrial waste must be sampled prior to use.
    c. Requiring complete disclosure of all dust suppressant constituents through independent standardized testing of dust suppressant formulations. Testing should recur periodically and whenever the formulation changes manufacturers using waste products must test each batch.
    d. Developing and employ a risk-based expert system (or decision tree) to prohibit or severely restrict the concentrations of environmental contaminants known to be persistent and harmful.
    e. Developing conservative guidelines (APGs) for application of different types of dust suppressants in major broad ecosystem categories.
    f. Requiring standardized biological toxicity testing for major dust suppressant types.
    g. Requiring training for all personnel who use and regulate dust suppressants.
2. The risks associated with dust suppressant use can be reduced in the LONG TERM by:
    a. Encouraging the development of dust suppressant formulations that are long-lived and environmentally benign.
    b. Continuing to develop scientific information about the environmental impacts of dust suppressants.
    c. Using information developed in 2a and 2b to update risk-based regulations and application and management practices.

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Appendix A

Literature Review

university of nevada, las vegas unlv

Literature Review

Dust Suppression and Its Environmental Impacts

Prepared for the Expert Panel on

Potential Environmental Impacts of Dust Suppressants:

"Avoiding Another Times Beach"

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Dust Suppression and Its Environmental Impacts

In recent years, studies on fugitive dust control have significantly increased in the United States. This literature review summarizes the current status of the use of dust suppressants with respect to types of materials used, application rates, effectiveness, environmental impacts, and costs. In 1991, 75-80% of all dust suppressants used were chlorides and salt brine products, 5-10% were ligninsulfonates, and 10-15% were petroleum-based products (Travnik, 1991). There has been much research on the effectiveness of dust suppressants; however, little information is available on the potential environmental impacts and costs of these compounds. The categories of dust suppressants most frequently used to control fugitive dust are listed in Table 1.

Table 1 – Most commonly used dust suppressants (modified from Bolander, 1999a)

Suppressant Type	Products
Water	Fresh, reclaimed, and seawater
Salts and brines	Calcium chloride, and magnesium chloride
Petroleum-based organics	Asphalt emulsion, cutback solvents, dust oils, modified asphalt emulsions
Non-petroleum based organics	Vegetable oil, molasses, animal fats, ligninsulfonate, and tall oil emulsions
Synthetic polymers	Polyvinyl acetate, vinyl acrylic
Electrochemical products	Enzymes, ionic products (e.g. ammonium chloride), sulfonated oils
Clay additives	Bentonite, montmorillonite
Mulch and fiber mixtures	Paper mulch with gypsum binder, wood fiber mulch mixed with brome seed

Water

Surface watering is an immediate, inexpensive short-term solution to control dust (Gebhart *et al.*, 1999). Water suppresses dust by agglomerating surface particles. However, the effectiveness depends upon temperature and humidity. Water can be effective for a period as short as half an hour and as long as twelve hours (Foley *et al.*, 1996, Schwendeman, 1981). Thompson (1990) found water was 85% effective in controlling dust in coal mines. Water effectiveness in controlling dust in roads and dirty beds has been estimated to be 40% (Travnik, 1991, Foley *et al.*, 1996). Water has little residual effect. Once applied it evaporates quickly, especially in hot, dry climates (Kestner, 1989a). Cowherd *et al.* (1989) reports that dust suppression efficiency decays from 100% to 0% in a very short time. Water is most efficient on sites where vehicular traffic is limited. Seawater is more effective than fresh water as a suppressant owing to the presence of salts.

Salts and Brines

The most widely used compounds in this category of suppressants are magnesium chloride ($MgCl_2$), and calcium chloride ($CaCl_2$) (Sanders and Addo, 1993). Salts suppress dust by attracting moisture from the air, which keeps the surface humid (Foley *et al.*, 1996). Sodium chloride is not a very useful suppressant in arid regions because it only absorbs water when the humidity exceeds 75%.

Calcium chloride is a by-product of the ammonia-soda (Solvay) process and a joint product from natural salt brines. The ability of calcium chloride to absorb water from the air is a function of the relative humidity and ambient temperature. Calcium chloride is more effective in places that have high humidity and low temperatures (Foley *et al.*, 1996). Bolander (1999a) reports that calcium chloride at a temperature of 25°C, for example, starts to absorb water at 29% relative humidity, and at 38°C it starts to absorb water at 20% relative humidity.

Magnesium chloride is created either from seawater evaporation or from industrial by-products prepared from magnesium ammonium chloride hexahydrate in the presence of HCl. It is a more effective salt than calcium chloride because it increases the surface tension and has a harder surface when it is dry (Foley *et al.*, 1996). It has a low freezing point (-34°C) and serves as a de-icing agent. Magnesium chloride needs a minimum of 32% humidity to absorb water from the air independent of the temperature. It remains more hygroscopic at higher temperature than calcium chloride and is therefore more suitable to dry climates (Langdon and Williamson, 1983). Compared to water, salts are more effective in controlling dust if sufficient moisture is available. The effectiveness of salts to control dust significantly decreases with time. The dust abatement properties of magnesium chloride have been found to last about 12 weeks (Monlux, 1993). Another problem with salts is that they migrate readily in the environment. DeCastro *et al.* (1996) modeled the movement of road stabilization additives of road surface to determine how long the additives remained effective. They found that calcium and magnesium chlorides are easily carried from the soil. Table 2 summarizes several studies on the effectiveness of salts in minimizing fugitive dust.

Table 2 - Effectiveness of salts as dust suppressants

Suppressant Type	Effectiveness	Reference
Calcium chloride	55% aggregate retention as compared to control.	Sanders and Addo, 1993
Magnesium chloride	Compared to control, retained 77% of the aggregates.	Sanders and Addo, 1993
Magnesium chloride sprayed during street sweeping	26% $MgCl_2$ solution reduced dust by 92%. 60% $MgCl_2$ solution reduced dust by 58%.	Satterfield and Ono, 1996
Calcium chloride, magnesium chloride, and ligninsulfonate	Reduced fugitive dust by 50-70% Increased aggregate retention by 42-61%. Under low humidity and high temperatures ligninsulfonate was more effective than salts.	Sanders *et al.*, 1997
Petro-tac, Coherex, Soil-Sement Generic Petroleum Resin, and Calcium chloride	95% effective after application to control dust particles < 15, 10, and 2.5 μm. Over a 30-day period, effectiveness decreased as much as 50% and as little as 10%.	Muleski and Cowherd, 1987

Organic Non-Petroleum Products

Organic non-petroleum products include ligninsulfonate, tall (pine) oil, vegetable derivatives, and molasses. Table 3 lists major studies performed on the effectiveness of non-petroleum based products and polymers to abate dust.

Ligninsulfonate is derived from the sulfite pulping process in the paper industry where wood is processed using sulfuric acid to break down the wood fiber. Lignin is a complex amorphous aromatic polymer that acts as a binder for the cellulose fibers in wood. It represents 17-33% dry weight of the wood and is resistant to hydrolysis (Kirk *et al.*, 1980). In the wood pulping process, the wood fiber is the valuable product and the pulp liquor, which contains lignin, is wasted. This waste liquor is processed further and neutralized prior to being used as a dust palliative. Ligninsulfonates act as a weak cement by binding the soil particles together. Ligninsulfonates remains effective during long dry periods with low humidity. They also tend to remain plastic, allowing reshaping and traffic compaction when applied to soils with high amounts of clay. The effectiveness of ligninsulfonates may be reduced or completely destroyed in the presence of heavy rain because of the solubility of these products in water (Bolander, 1999a).

Table 3 – Effectiveness of non-petroleum based and polymer products as dust suppressants

Suppressant Type	Effectiveness	Reference
Sprinkling of 40 ml/m^2/day of canola oil on swine barns	Reduction of 84% in dust concentration	Senthilselvan *et al.*, 1997
Lignin used on unpaved roads	63% more aggregates retained as compared to untreated sections.	Sanders and Addo, 1993
Ligninsulfonate used to control dust fungi and endotoxins in livestock housing facilities	Mass of dust, fungi, and endotoxins were reduced 6, 4, and 3 fold respectively, when ligninsulfonate solutions (27-39%) were applied.	Breum *et al.*, 1999
Synthetic polymer and tall oil	Increased tensile strength of soil. Strength dependent upon curing time.	Bolander, 1999b
Polymer emulsion (PE)	Initial = 94%, After 3 months = 96% After 11 months = 85%	Gilles *et al.*, 1997
Polymer Emulsion (PEP)	Initial = 99%, After 3 months = 72% After 11 months = 49%	Gilles *et al.*, 1997
Biocatalyst stabilizer (BS)	Initial = 33% - 5%, After 3 months = 0% After 11 months = 0%	Gilles *et al.*, 1997

Tall oil is a by-product of the wood pulp industry recovered from pinewood in the sulfate Kraft paper process. It contains rosin, oleic and linoleic acids. Tall oil is used in flotation agents, greases, paint alkyd resins, linoleum, soaps, fungicides, asphalt emulsions, rubber formulations, cutting oils, and sulfonated oils (Merck Index, 1989). Tall oil promotes adherence between soil particles, however, its surface binding actions can be limited or destroyed if this product is exposed to long–term rainfall. Increasing the residual content of tall oil was found to promote an increase in the tensile strength and resistance to periodic wetting or wet freeze of these products (Bolander, 1999a).

Vegetable oils are extracts from the seeds, fruit, or nuts of plants and are generally a mixture of glycerides (Lewis, 1993). Some examples of vegetable oils are canola oil, soybean oil, cottonseed oil, and linseed oil. Vegetable oils abate dust by promoting agglomeration of the surface particles.

Molasses is the thick liquid left after sucrose has been removed from the mother liquor in sugar manufacturing. It contains approximately 20% sucrose, 20% reducing sugar, 10% ash, 20% organic non-sugar, and 20 % water (Lewis, 1993). This type of dust suppressant provides temporary binding to the surface particles (Bolander, 1999a). Additional applications are necessary during the year, mainly after heavy rains, because molasses will dissolve in water (Sanders and Addo, 1993).

Synthetic Polymer Products

The adhesive property of synthetic polymers promotes the binding of soil particles. Products such as polyvinyl acetate and vinyl acrylic are used in synthetic polymers. In the laboratory, Bolander (1999b) investigated the effect of adding synthetic polymers to dense-graded aggregate. The results show that polymers increased the tensile strength of clays on typical roads and trails up to ten times. Synthetic polymer emulsions did not change the compacted dry density. The tests showed that synthetic polymers applied in wet climates would tend to break down if exposed to moisture or freezing for an increased time.

Organic Petroleum Products

Organic petroleum-based materials consist of products derived from petroleum. These include used oils, solvents, cutback solvents, asphalt emulsions, dust oils, and tars. These products agglomerate fine particles, generally forming a coherent surface that holds the soil particles in place. Petroleum-based products are not water-soluble or prone to evaporation (Travnik, 1991). They generally resist being washed away, but oil is not held tightly by most soils and can be leached away by rain. Langdon and Williamson (1983) divided petroleum based products into different categories: cutbacks (e.g. DO-1, DO-2,

DO-3, and DO-6KF), emulsions (e.g. DO-8, Coherex, and CSS-1), and others (e.g. DO-4, DO-6, DO-6P). Table 4 lists studies on the effectiveness of petroleum-based products.

Table 4 – Effectiveness of petroleum-based products as dust suppressants

Suppressant Type	Effectiveness	Reference
Oiling (petroleum-based)	50 to 98%	Foley *et al.*, 1996
Water (0.44 gal/yd^2), petroleum resin (0.84 gal/yd^2), and emulsified asphalt (0.71 gal/yd^2).	50% reduction in particulate emissions for at least one month. Reapplication increased suppressant lifetime. Lifetime decreased with decreasing particle size.	Muleski *et al.*, 1983
Emulsion of hydrocarbon-based textile oil applied to bulk-stored wheat, corn, and soybeans	50% reduction (0.04%emulsion) 92% reduction (0.07% emulsion) Similar results found for rapeseed and oils.	Jayas *et al.*, 1992
Emulsified petroleum resin, petroleum residue,	In general, an increase in water content during suppressant application improved cohesive strength of the aggregates	Lane *et al.*, 1983
Non-hazardous crude oil (NHCO)	Very effective in suppressing dust for a long period; after 11 months = 92% effective	Gilles *et al.*, 1997

Electro-Chemical Products

These suppressants are usually derived from sulphonated petroleum and highly ionic products. This group of products includes sulphonated oils, enzymes, and ammonium chloride. The electro-chemical stabilizers work by expelling adsorbed water from the soil which decreases air voids and increases compaction (Foley *et al.*, 1996). A disadvantage of these products is the dependence upon the clay mineralogy and therefore they are only effective when specific minerals are present.

Clay Additives

Clay additives are composed of silica oxide tetrahedra (SiO_4) and alumina hydroxide octahedra ($Al(OH)_6$) (Scholen, 1995). This type of dust suppressant agglomerates fine dust particles and increases the strength of the material under dry conditions. Clay additives provide some tensile strength in warm dry climates; however, increasing the moisture contents promotes loss of their tensile strength (Bolander, 1999b).

Others

In addition to the categories listed in Table 1, several other suppressants and technologies have been used to abate dust. Foley *et al.* (1996) reported that dust emissions on unpaved roads could be reduced significantly even with small reductions in vehicle speed. Over 40% of the dust was reduced when vehicle speed was decreased from 47 to 31 miles per hour and over 50% was reduced by decreasing vehicle speed from 40 to19 miles per hour. Applying an asphalt emulsion (sealing) or paving roads has been shown to reduce dust by 95-100%. Table 5 reports various treatments that have been successfully applied to unpaved roads to reduce dust.

Table 5 – Effectiveness of various treatments used to suppress dust

Suppressant Type	Effectiveness	Reference
Sealing or bound paving	95-100%	Foley *et al.*, 1996
Chemical dust suppression	High initial efficiency; it decays to zero after several months.	Cowherd *et al.*, 1989
Clay additive, chlorides, enzymes, and sulfonate	Increased tensile strength for moisture contents less than 5%.	Bolander, 1999b
Chemical dust suppression	40-98%	Foley *et al.*, 1996
Reduction of vehicle speed: from 47 mile/h to 31 mile/h from 40 mile/h to 19 mile/h	 40-75% 50-85%	Foley *et al.*, 1996

Application Rates

Table 6 shows typical application rates for several types of suppressants. Typical application frequency for most suppressants is 1-2 times per year, except for clay additives for which the application rate is every 5 years.

Table 6 – Application rates and frequencies of dust suppressants

Suppressant	Range of Application Rate	Application Frequency	Reference
Calcium chloride	0.8-2.0 lbs/yd^2 (dry salt) 0.2 –0.5 gal/yd^2 (solution)	1-2 times per year	Hoover, 1981; Bolander, 1999a, RTAC, 1987; Heffner, 1997, DeCastro *et al.*, 1996 Sanders and Addo, 1993
Mg chloride	0.3-0.5 gal/yd^2	1-2 times per year	Bolander, 1999a; RTAC, 1987 Heffner, 1997, DeCastro *et al.*, 1996 Sanders and Addo, 1993
Ligninsulfonate	0.2 – 1.5 gal/yd^2 (liquid) 1.0-2.0 lbs/yd ^{2} (powder)	1-2 times per year	Langdon and Williamson, 1983, Hoover, 1981; Bolander, 1999a, RTAC, 1987, Sanders and Addo, 1993
	40-50% residual concentrate applied diluted 1:4 w/water at 5.1 gal/yd^2	every two years	Bolander, 1999a
Vegetable oils	Typically 0.24-0.5 gal/yd^2	1 time per year	Bolander, 1999a
Oils	0.1-1.0 gal/yd^2	1 time per year	Hoover, 1981; Bolander, 1999a RTAC, 1987
Arcadias (DO-1, 2, 3), DO-4, DO-6PA, DO-8, CSS-1	0.2 – 0.5 gal/yd^2	--------	Langdon and Williamson, 1983
Coherex	0.5-1.5 gal/yd^2	--------	Langdon and Williamson, 1983 Hoover, 1981
Organic Binders application rate	Liquid: 0.5 gal/yd^2 Dry powder: 1-2 lb/yd^2	--------	Hoover, 1981
Polybind Acrylic (co-polymer resin emulsion)	40 gal/acre of a 1:20 water dilution.	--------	Hoover, 1981
Synthetic polymer derivatives	40-50% residual concentrate applied diluted 1:9 w/water at 0.50 gal/yd^2.	Once every two years	Bolander, 1999a
Clay additives	Typical application rate is 1-3% by dry weight.	Once every 5 years	Bolander, 1999a
Water	0.5-4% water applied to conveyor belt systems.	As often as needed	Goldbeck, 1997
Bituminous and tars or resinous adhesives	0.1-1.0 gal/yd^2 depending on road surface condition and dilution.	1-2 times per year	Sanders and Addo, 1993

Environmental Impacts

Salts and Brines

The potential environmental impacts of salts and brines include corrosion of vehicles and concrete and creation of a slippery surfaces when wet (Foley *et al.*, 1996). Calcium and magnesium chloride are highly soluble and are capable of moving with water through soil as a leachate contaminating groundwater (Heffner, 1997). They can also move as runoff and the dissociated calcium, magnesium and chloride ions can drain into lakes, rivers, streams, and ponds (Demers and Sage, 1990). High concentrations of salts cause high soil salinity and may be toxic to plants (Hanes *et al.*, 1970 and 1976); Sanders and Addo; 1993, Foley *et al.* 1996; RTAC, 1987). However, no conclusive studies have been performed to evaluate the effects of calcium and magnesium chloride on plants. Salts concentrations greater than 400 ppm have been found to be toxic to trout (Golden, 1991 and Foley *et al.*, 1996). Concentrations greater than 1,830 mg/L killed Daphnia and crustaceans fish (Sanders and Addo, 1993; Anderson, 1984).

Organic Non-Petroleum Products

The toxicity of ligninsulfonates to rainbow trout has been investigated. The 48-hour LC_{50} (concentration of ligninsulfonates which would be lethal to 50 percent of the tested population within 48 hours) value for ligninsulfonates was found to be 7,300 mg/L. A mortality of 50% was achieved for rainbow trout exposed to 2,500 mg/L ligninsulfonate for 275 hours. For concentrations equal to or higher than 2,500 mg/L rainbow trout showed loss of reaction to unexpected movements, rapid and irregular breathing, and finally loss of coordination before death (Roald, 1977a; Roald, 1977b). It has been found that calcium and sodium ligninsulfonate negatively affect the colon of guinea pigs causing weight gain and producing ulceration in those animals (Watt and Marcus, 1974 and 1976). Reduced biological activity has been observed in water due to excessive discoloration caused by the introduction of ligninsulfonates (Singer *et al.*, 1982; Raabe, 1968; Heffner, 1997; Foley *et al.*, 1996). Ligninsulfonate compounds were reported not to prevent seed germination in the areas where it was applied (Singer *et al.*, 1982). It has been suggested that ligninsulfonate is the most environmentally compatible dust suppressant (Schwendeman, 1981).

Organic Petroleum Products

Organic petroleum based products are considered long lasting products for dust suppression. However, since some of them are oil waste, their environmental impacts may be high. Waste oil used as dust suppressant is typically associated with contaminants that are known to be either toxic or carcinogenic (RTAC, 1987; Metzler, 1985; USEPA 1984, Foley *et al.*, 1996). The accidental introduction of a petroleum based dust suppressant (Coherex) into a stream in Southern Pennsylvania was found to affect fish and benthic macroinvertebrate communities and to kill an unknown number of fish (Ettinger, 1987). Organic petroleum-based products have also been found to be toxic to avian Mallard eggs. When the eggs were exposed to a concentration of 0.5 μL/egg of the product 60% mortality was observed by 18 days of development (Hoffman and Eastin, 1981).

Electro-Chemical Product

Electro-chemical products are thought to have minimum impact in the environment when used in their diluted form. However, it has been observed that vegetation could not be established in areas treated with sulfonated petroleum products (Foley *et al.*, 1996).

Costs

Reported costs for bulk dust suppressants and dust suppressant application are shown in Table 7. It is difficult to compare application costs of dust suppressants because of the different materials and dilution ratios used. From the data reported in the literature, bulk ligninsulfonate is about five times less expensive than Arcadias, Coherex, and CSS-1. The reported cost per acre for dust suppressant application reveals a wide range for different products used. In general, Chlortex (magnesium chloride) is the least expensive dust suppressant followed by ligninsulfonate, Pennzsuppress D (petroleum resin), and Plastex (paper mulch + gypsum binder).

Table 7 – Reported dust suppressant costs

Suppressants	Bulk Product Cost	Reference
Calcium Chloride	$114.00/ton-$273.00/ton $195 per dry ton	Langdon and Williams, 1983 Hoover, 1981
Magnesium chloride	$67.00/ton-182 gal/ton	Langdon and Williams, 1983
Ligninsulfonate	$40.00/ton	Langdon and Williams, 1983
Arcadia DO-1 Arcadia DO-2 Arcadia DO-4 Arcadia DO-6KF Arcadia DO-6PA Arcadia DO-8 Coherex (concentrate) CSS-1	$210.00/ton $210.00/ton $175.00/ton $215.00/ton $152.75/ton $150.00/ton $285.60/ton $150.00/ton	Langdon and Williams, 1983 Langdon and Williams, 1983 Langdon and Williams, 1983 Langdon and Williams, 1983 Langdon and Williams, 1983 Langdon and Williams, 1983 Langdon and Williams, 1983 Langdon and Williams, 1983

Suppressants	$ Cost/acre	Reference
Chlorides	$283-$2,023/ acre	Foley *et al.*, 1996
Calcium chloride cost/mile at a 21-ft width and 2 lb/yd^2	£165	Hoover, 1981
Chlortex ($MgCl_2$)	$600/acre	James *et al.*, 1999
ESI-Duster Dustac (Ligninsulfonate) Ligninsulfonate cost/mile length and 21-ft width	$9800 (bag of 50 lbs) $750/acre £350 ($800-$900)	Langdon and Williams, 1983 James *et al.*, 1999 Hoover, 1981
Organic Binders Petroleum Binder PennzsuppressD (petroleum resin)	$1011-$24282/acre $2023-$5261/acre $800/acre	Foley *et al.*, 1996 Foley *et al.*, 1996 James *et al.*, 1999
Surfactants Polymeric Binders Polytex (acrylic polymer emulsion) Soil-Sement (acrylic polymer emulsion)	< $1619/acre $6475/acre $700/acre $1050/acre	Foley *et al.*, 1996 Foley *et al.*, 1996 James *et al.*, 1999 James *et al.*, 1999
Plastex (paper mulch + gypsum binder) Hydroseed (wood fiber mulch + brome seed) Recycled Aggregate	$850/acre $1,200/acre $13,500/acre	James *et al.*, 1999 James *et al.*, 1999 James *et al.*, 1999
Ionic Stabilizers	$1,214-$4,047/acre	Foley *et al.*, 1996
Microbiological Binders	$3,642/acre	Foley *et al.*, 1996

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Appendix B

Fact Sheets for Verification Programs and Guidelines

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Environmental Technology Verification Program

California Environmental Technology Certification Program (CalCert)

May 2002

Responsible Agency

California Environmental Protection Agency

Environmental Technology Certification Program

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References

www.calepa.ca.gov/calcert

Disclaimer: This fact sheet was prepared by the UNLV organizing committee of the "Expert Panel on Environmental Impacts of Dust Suppressants" based on information contained in the above reference.

What are the goals of CalCert?

The California Environmental Technology Certification Program (CalCert) is the umbrella program for all technology certifications within the California Environmental Protection Agency (Cal/EPA). CalCert is a voluntary program for manufacturers seeking independent evaluation and certification of the performance of their environmental technology including dust suppressants. Certification efforts within the California Environmental Protection Agency (Cal/EPA) are authorized under section 71031 of the California Public Resources Code.

Who created CalCert?

In 1993, Cal/EPA and the Trade and Commerce Agency created the California Environmental Technology Partnership (CETP), a public-private partnership comprising of representatives from the financial and legal communities, public interest groups, the technology industry, laboratories, academia, and others. Among several strategies to strengthen California's environmental technology industry, CETP recommended Cal/EPA institute a voluntary statewide certification program for environmental technologies. Following enactment of Assembly Bill 2060 (Chapter 429, Statutes of 1993) and Assembly Bill 3215 (Chapter 412, Statutes of 1994), Cal/EPA implemented two voluntary pilot certification projects: one for hazardous waste-related technologies at the Department of Toxic Substances Control and another for air pollution control at the Air Resources Board. After two successful pilot programs, and enactment of Assembly Bill 1943 (Chapter 367, Statutes of 1996), CalCert expanded to address a broad array of technologies that prevent, treat, or cleanup pollution in air, water, and soil. The program seeks to maintain and advance high environmental standards by assuring that the best possible environmental technology is available to meet those high standards.

Who provides the performance verification?

Technology developers and manufactures define their performance claims and provide supporting documentation; Cal/EPA reviews that information and, where necessary, requires additional testing to verify the claims. Participation in the program generally involves four stages: eligibility request, application and data review, evaluation of test data, evaluation report, certification decision or statement, and certificate issuance.

Who may apply for verification?

Equipment, processes or products eligible for certification must have an environmental benefit, be commonly used or readily available, and not pose a significant potential hazard to public safety and the environment. Furthermore, applicants for the program must demonstrate that they can consistently and reliably produce technologies that perform at least as well as those previously considered in the CalCert evaluations.

What is needed to apply?

To apply to the program the applicant should hold manufacturing rights to the technology. The technology should be commercially ready with available quality testing data to support performance claim. The first step to have a technology certified is to request for a determination of eligibility. After CalCert has received the Eligibility Request and determined that the technology is eligible for California Certification, the applicant will receive an Application for Certification and will be invited to meet the Cal/EPA evaluation team in a scoping meeting. The evaluation team will meet with the applicant to discuss the scope, duration, and cost of the evaluation. The cost of evaluating the technology will vary depending on the scope of effort needed to evaluate it.

Who evaluates the application for verification?

Cal/EPA's staff which consist of scientists and engineers from the Air Resources Board, State Water Resources Control Board, Department of Toxic Substances Control, Integrated Waste Management Board, Department of Pesticide Regulation, and Office of Environmental Health Hazard Assessment evaluate the technologies. When necessary, CalCert also partners with California's universities and laboratories.

What are the criteria for verification?

The products eligible for certification must have an environmental benefit, be commonly-used or ready available, and not pose a significant potential hazard to public safety and the environment. The evaluation is based on a detailed review of validation materials submitted by the manufacturer, including original data generated by independent and in-house laboratories, whose findings are considered reliable by Cal/EPA staff.

What is the proof of verification?

A certificate signed by California's Secretary for Environmental Protection is awarded. The issuance of the evaluation report and certificate authorizes the use of the certified technology seal on certified products. The CalCert's certification is valid for three years. Certification does not imply that the technology has been permitted by any application.

What dust suppressants have been certified by CalCert?

In January, 2001 the California Environmental Protection Agency staff recommended certification of PennzSuppress® D, an organic based product from the Pennzoil–Quaker State Company, as a dust suppressant. The certification is valid for three years.

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Application of Oil Field Brine Regulations

Michigan

May 2002

Responsible Agency

Michigan Department of Environmental Quality Waste Management Division

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References

www.deq.state.mi.us/documents/deq-wmd-gwp-Rule2215OilFieldBrine-1.pdf

Disclaimer: This fact sheet was prepared by the UNLV organizing committee of the "Expert Panel on Environmental Impacts of Dust Suppressants" based on information contained in the above reference.

What are oil field brines?

Brines that are produced at oil and gas well facilities. These brines are used for dust control and soil stabilization.

How does Michigan regulate the application of oil field brines?

The Michigan Department of Environmental Quality through regulation R324.705 (3), Part 615, Supervisor of Wells, of Act 451 requires a permit for the application of brines for ice and dust control and soil stabilization. Pursuant to this general permit, applicant of brine may begin as soon as the conditions of the general permit have been met. All maintenance, operations, and monitoring of brine application must comply with the conditions set forth in this general permit by the Department. Failure to comply with the terms and provisions of this general permit may result in civil and/or criminal penalties as provided in Part 31.

What are the requirements of the Michigan oil field brine regulations?

The requirements for oil field application as a dust suppressant and road stabilizers include:

1. No application can occur until a certificate of authorization of coverage on a form approved by the Department is issued.
2. Only brine that meets the requirements of R 324.705 (3) of Part 615, as amended, may be used for ice and dust control and soil stabilization on land, such as roads, parking lots and other land.
3. To prevent other contaminants from becoming part of the brine discharge, brine shall be applied with vehicular equipment dedicated to this use or hauling fresh water.
4. Brine shall be applied for dust control and soil stabilization in accordance with the following criteria: (a) brine may be applied to the surface of roads, parking lots, and other land up to four applications each year south of the southern county lines of Madison, Lake, Osceola, Clare, Cladwin, and Arenac Counties. Counties north of this line may apply only three times per year; (b) brine may be applied to the surface of roads being used as a detour and on other areas during construction as necessary to control dust up to six applications each year; (c) brine must be applied to roads and parking areas with equipment described by the term "spreader bar". This device shall be constructed to deliver a uniform application of brine over a width of at least eight feet; (d) brine may be applied at a maximum rate of 1,500 gallons per lane mile of road or 1,250 gallons per acre of land, provided runoff does not occur; (e) Brine shall be applied in a manner to prevent runoff.

5. Brine shall be applied for dust control and soil stabilization in accordance with the following criteria: (a) brine may be applied to the surface of roads, parking lots, and other land up to four applications each year south of the southern county lines of Madison, Lake, Osceola, Clare, Cladwin, and Arenac Counties. Counties north of this line may apply only three times per year; (b) brine may be applied to the surface of roads being used as a detour and on other areas during construction as necessary to control dust up to six applications each year; (c) brine must be applied to roads and parking areas with equipment described by the term "spreader bar". This device shall be constructed to deliver a uniform application of brine over a width of at least eight feet; (d) brine may be applied at a maximum rate of 1,500 gallons per lane mile of road or 1,250 gallons per acre of land, provided runoff does not occur; (e) Brine shall be applied in a manner to prevent runoff.
6. Brine shall be applied for ice control in accordance with the following criteria: (a) brine shall be applied only on paved roads or paved parking lots; (b) brine shall be applied at a maximum rate of 500 gallons per lane mile of road or 400 gallons per acre of land; (c) brine must be applied only when the air temperature is above 20°F, unless used for pre-wetting solid salt; (d) brine must be applied with equipment designed to direct the discharge to the center of the pavement or high sides of curves.
7. Brine application measurement methods must be used to ensure that the brine application rates are within described in this general permit.
8. Brine shall not be applied at a location determined to be a site of environmental contamination for chlorides.
9. Records shall be kept of the use of brine and should contain driver's name, location, loading date, source of brine, date of brine, application, and gallons applied. Records should be kept by the application for a period of three calendar years after application and should be available for inspection by the Department or a peace officer.

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Interim Guidelines for Dust Palliative Use in Clark County

Nevada

May, 2002

Responsible Agency

Clark County Department of Air Quality Management

Nevada Department of Environmental Protection (NDEP)

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References

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What are the goals of the Interim Guidelines?

The Interim Guidelines aim to facilitate the implementation of air quality fugitive dust controls in a manner that prevents human exposure to harmful constituents and protects soil and water resources while achieving air quality objectives. The guidelines outline practices and procedures that should be followed to ensure compliance with the new Clark County Air Quality regulations (effective January 1, 2001) in a manner that minimizes environmental impacts.

Who created the Interim Guidelines?

A working group was formed in 2000 to draft interim guidelines for the use of dust palliatives in Clark County, Nevada. The working group, formed in response to direction from the Nevada Legislature to provide recommendations regarding the use of dust suppressants in the Las Vegas Valley, was composed of air and water quality professionals from state and local agencies including the Southern Nevada Water Authority, Clark County Health District, Clark County Comprehensive Planning, Clark County Regional Flood Control District, City of Las Vegas, UNLV Department of Civil and Environmental Engineering and the Nevada Department of Environmental Protection (NDEP).

What were the bases for the guidelines?

The working group considered existing state regulations and codes that could apply to the use of dust palliatives and the protection of human health and environment. However, because the environmental impacts of the various dust suppressant products have not been fully evaluated, the working group decided that it would not be prudent to recommend or deny the use of dust palliatives based solely on these regulations. Thus, the group also considered currently available scientific information. The guidelines are expected to be revised in the future to reflect public comments, advanced thinking of the working group, and changing technology of the construction industry. A research project, currently underway at UNLV and funded by local agencies, will provide additional scientific evaluation of the water quality impacts of dust palliatives. The Dust Palliative Working group will continue to meet on a regular basis to evaluate pertinent information relating to the environmental impacts of dust palliative use. It is envisioned that a permanent policy or set of regulations will be developed if such action is deemed necessary and that this policy/set of regulations will be more comprehensive in scope.

What is the content of the guidelines?

(a) The use of organic petroleum products, deliquescent/hygroscopic salts, and lignin-based palliatives are highly discouraged within twenty (20) yards of open bodies of water, including lakes, streams, canals, natural wastes and flood control channels, and drinking water well-heads. This buffer zone is intended to prevent leachate from these palliatives from reaching an open body of water or a ground water aquifer;

(b) The use of surfactants containing phosphates is highly discouraged because of adverse impacts on water quality. Surfactants by themselves are not allowed for use as a dust palliative because they do not form a durable soil surface. Non-phosphate surfactants may be combined with dust palliatives to assist penetration of dust palliatives into hydrophobic soils;

(c) Any person who applies any pesticide material with a dust palliative is required to hold a valid pesticide applicators license issued by the State of Nevada;

(d) Fiber mulch products should not be used for use as a dust palliative in traffic areas. These products do not hold up well for traffic use;

(e) Use of deliquescent/hygroscopic salts should be limited to magnesium chloride and only used for short-term (less than one year) stabilization of unpaved roads. Treated unpaved roads must be periodically maintained with additional applications of water and magnesium chloride as needed to maintain effectiveness. Magnesium chloride is not effective, even with product reapplication, for periods of more than one year. Magnesium chloride should not be used on trafficked areas within twenty (20) yards of an open body of water, a drinking water well-head, natural or artificial drainage channel, or other surface water feature;

(f) Organic petroleum products, including modified and unmodified asphalt emulsions, should not be used on non-traffic areas;

(g) Use of deliquescent/hygroscopic salts is highly discouraged for non-traffic stabilization. These salts require frequent re-watering to be effective in the Las Vegas Valley;

(h) Lignin-based palliatives are not recommended for non-traffic stabilization. Surface binding action of lignin-based palliatives may be reduced or completely destroyed when heavy rains occur;

(i) Suppressants containing banned pesticides, restricted pesticides, dioxin, PCBs, and asbestos should never be applied.

The guidelines also contain recommendations on the types of suppressants to be applied to specific areas as well as dilution and application rates.

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Dirt & Gravel Roads Maintenance (DGRM) Program

Pennsylvania

Responsible Agency

Center for Dirt and Gravel Road Studies
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What is the DGRP Program?

Pennsylvania's State Conservation Commission Dirt & Gravel Roads Pollution Prevention Program is a grant program. It is an innovative effort to educate the public about pollution problems from roads and fund "environmentally sound" maintenance of unpaved roadways that have been identified as sources of dust and sediment pollution. Signed into law in April 1997 as Section 9106 of the PA Vehicle Code (§ 9106), the program is based on the principle that informed local control is the most effective way to stop pollution. The program created a dedicated, non-lapsing fund - $4 million per year – to provide money to local communities for education and local road maintenance by way of streamlined appropriations to local conservation districts for use by local road maintenance entities under the environmental guidance of a local Quality Assurance Boards (QABs). Section 91060(f) (7) of the Vehicle code requires Quality Assurance Boards to adopt standards that prohibit the use of environmentally harmful materials and practices in dirt and gravel road maintenance. Implicit in these standards, are regulations for the control of dust suppressant application. Local municipalities and state agencies that maintain public dirt or gravel roads are eligible to receive the grant funds.

What are the goals of the DGRM Program?

The Pennsylvania Protocol has four main objectives:

1. To prohibit the use of environmental harmful materials or practices on Dirt and Gravel Roads Maintenance Program projects.
2. To recommend procedures that will satisfy the program's non-pollution requirement with a minimum of paperwork.
3. To provide Conservation Districts with a statewide information exchange system which will allow them to establish eligibility of local products.
4. To employ a product clearance system and notify conservation districts of products determined to be eligible for statewide use.

What are the provisions of the program?

The Interim program's requirements for compliance with the non-pollution criteria are currently in the draft form. In general, the guidelines call for compliance with all existing laws and conditions via a purchase contracting process, rather than a regulatory process. Vendors would comply voluntarily as part of their sales agreement. It is anticipated that such an approach would minimize challenges in court by products manufacturers.

The program places the responsibility of proving that a product meets Pennsylvania's existing laws on the manufacturer. It is expected that the adoption of such practice will minimize paperwork because it will be done once for each covered product. Participants may purchase products, listed as eligible and be reimbursed provided they have an active liability contract with the manufacturer and the conservation districts establishes that the product is approved. The program will be applied statewide to insure that individual QABs will not be sued for refusal to buy certain products.

Who provides the performance verification?

It is the responsibility of the vendor, as a condition of sale, to prove that the commercial product does not degrade the environment or create hazards in accordance with the standards of the DGRP program. The vendor has to have an EPA-Certified laboratory test the product according to the specified test procedures. Laboratory personnel complete the tests, certify the results, and report the eligibility of the product for program funding in writing. The Conservation Commission (SCC) will review the submission to confirm the certificate as authentic. The manufacturer must also (a) certify that the product submitted for testing is representative of the product as marked, (b) provide a copy of the certificate of eligibility to the conservation district, (c) provide the participant with a signed copy of a liability contract assuming all liability for supply, transport, application and curing of the product. The product must also comply with Pennsylvania's environmental laws: 25 PA Code 93.6 - Waste Discharge to Water; 25 PA Code 93.7c - Water Quality Criteria by Substance; 25 PA Code - Criteria by Toxic Substances; 25 PA Code 121.1 – Air Quality Criteria; 25 PA Code 124 - Air Quality Hazardous; 25 PA Code 129.64 Air Quality Cut Back Asphalts. In addition, the program encourages the use of by- and co-products if they are deemed to have non-pollution characteristics. Co-products that have "beneficial use" permits issued are considered as effective as commercial products if they meet the non-pollution criteria.

What tests are required from the applicant?

Labeled products, such as herbicides, do not require further testing and are acceptable according to the label restrictions. Plant and seeds are covered by both, the State and Federal Noxious weed laws. All other commercial products, which are not inert, must be certified. The guidelines divide the products used in dirt and gravel roads into solids (e.g. stone, geotextile, salts as crystals) and aqueous (e.g. brines, emulsions). Aqueous products must undergo the following required tests: a 7-day rainbow trout survival and growth test, and a 7-day cladoceran (*Ceriodaphinia dubia*) survival and reproduction test. Each product tested must report the NOEC, LOEC, LC50 and CHV values for the survival and growth of rainbow trout and one for the survival and reproduction of cladocerans. An MSDS sheet for each product should accompany the application. In addition, the materials have to undergo bulk and leach analysis. Bulk analysis should follow methods established in EPA SW-846 and leach analysis should be performed according to EPA Method 1312. Components analyzed in these tests include: pH, major, minor, and trace components, radionuclides, moisture content, loss of ignition (LOI) at 1000°C, metals, cyanide, volatile, and non-volatile organic compounds. The laboratory has to report each constituent that exceeds the trigger levels (50% of SPLP limits, as set forth in current PA DEP Mining Regulations Module 25). If any trigger level (s) is exceeded, a second sample of the material should be tested.

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Environmental Technology Verification Program

ETV Canada Inc.

May 2002

Responsible Agency

ETV Canada Inc.

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References

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What are the goals of the ETV Canada Program?

The main objective of the ETV Canada Program is to provide validation and independent verification of environmental technology performance, including that of dust suppressants. This program has been developed to promote the commercialization of new environmental technologies into the market place and thus provide industry with a tool to address environmental challenges efficiently, effectively and economically.

Who created the ETV Canada?

Environment Canada was the lead department in the development of the ETV program in cooperation with Industry Canada and with direction from the ETV Steering Committee. ETV Canada, Inc., a private sector company that operates under a license agreement with Environment Canada, was created to deliver the ETV program. The ETV Canada, Inc. is owned by the Ontario Centre for Environmental Technology Advancement (OCETA).

What is needed to apply?

The technology vendor must provide sufficient, acceptable documentation and data to support the performance claim of the technology being verified. ETV Canada reviews the Formal Application for completeness and determines if it can be accepted into the verification process. If the application is not acceptable, the applicant may choose to modify and resubmit it. Similarly, at this application review stage, ETV Canada may determine that the data supporting the claim is inadequate. If the applicant wishes to continue, it is their responsibility to first arrange and pay for the generation of the necessary data. Alternatively, the applicant may choose to modify their claim to align it with supporting data. Although ETV Canada would not be directly involved in the testing to develop additional data, it may outline the data requirements within the context of the General Verification Protocol. The formal application should be accompanied with the supporting data that is to be used in the verification process. Before confidential information or data can be passed to ETV Canada, a Confidentiality Agreement is signed. ETV Canada reviews the information and proposes a verification process for the claim, including identification of a Verification Entity and a cost estimate for the verification program. The cost of verification will include the administration and management of the application process by ETV Canada and the actual validation by the Verification Entity of the claim, using the supporting data. The cost will vary from application to application, and will depend on the scope of effort involved in the verification process. ETV Canada discusses the scope and cost of the proposed program with the applicant, and reaches agreement on the Verification Entity, including resolution of any conflict of interest between the applicant and the Verification Entity. ETV Canada keeps a list of approved Expert Entities, which include private consultants, universities, and research institutes that can conduct tests to support the verification of the technology.

Who provides the performance verification?

A formal application must be submitted to ETV Canada, Inc. for review in order to obtain technology verification. If the technology and performance claim are eligible for the ETV program, the applicant submits a Formal Application and a non-refundable $1,000.00 application fee. The Formal Application requests additional information about the technology, the claim to be verified, and the data and information that is available to support the claim. The Formal Application is available either by regular mail or electronically by e-mail and can be faxed back to ETV Canada with a signature. An original should follow by regular mail or by courier with the $1,000.00 fee.

Who may apply for verification?

Environmental technology vendors can apply to the ETV program for verification of the claims concerning the performance of their environmental technologies. For a technology to be eligible for the ETV program, it must be an environmental technology or an equipment-based environmental service, where equipment performance can be verified. The technology must offer an environmental benefit or address an environmental problem. It must also meet minimum Canadian standards and/or national guidelines for the specific technology or claim, as specified by ETV Canada, and be currently commercially available or commercially ready for full-scale application.

Who evaluates the application for verification?

ETV Canada reviews the Formal Application for completeness and determines if it can be accepted into the verification process. Verification Entities, which are approved by ETV Canada, provide the technical expertise to evaluate the technology.

What are the criteria for verification?

The claim must specify the minimum performance that is achievable by the technology and must be unambiguous. It must meet minimum standards and guidelines for the technology. Where federal standards are not available, the least stringent provincial standard shall apply. Technology must achieve federal, provincial, and/or municipal regulations or guidelines for discharge waters or treated effluents, soils, sediments, sludge or other solid-phase materials. ETV Canada will refer to such appropriate standards when assessing the claim. The claim must be measurable using acceptable test procedures and analytical techniques. It is essential that adequate, relevant, reliable data and information be provided to support the verification of the environmental technology performance claim.

What is the proof of verification?

If the claim is verified successfully, the company is issued three documents: a Verification Certificate, a Technology Fact Sheet, and a Final Verification Report.

What dust suppressants have been certified by ETV Canada?

In March 1999 Soil Sement®, a synthetic polymer emulsion, was certified by ETV Canada. Three years after approval, the verification should be renewed and a license renewal fee should be applied.

Appendix C

Expert Panel Agenda

THURSDAY, MAY 30TH, 2002	
8:00 – 8:30 AM	REGISTRATION
8:30 – 9:00 AM	INTRODUCTIONS Welcome and Logistics (Thomas Piechota, UNLV) Importance of issue to EPA (Jeff van Ee, U.S. EPA)
9:00 – 9:45 AM	FRAMING THE PROBLEM Introduction of Conceptual Model (David James, UNLV) Summary of Literature Review (UNLV) Fact Sheets from other relevant activities, programs, and/or protocols.
9:45 – 10:15 AM	PANEL I: WHAT ARE WE DEALING WITH? What is the composition of the dust suppressant and what are the sources of these compounds? How are the dust suppressants applied and at what rates? Where are dust suppressants applied?
10:15 – 10:30 AM	BREAK
10:30 AM – 12:00 PM	PANEL I (continued) What is the potential for trace levels of contaminants given the source and composition? Does the Conceptual Diagram outline all the possible pathways of exposure? What is known about the fate and transport of various dust suppressants? Are some pathways relatively more significant sources of exposure than others? How does the composition of the various dust suppressants change once they are in the environment? What is the potential magnitude of dust suppressant application in urban or rural areas?
12:00 – 1:00 PM	LUNCH (hosted by UNLV/EPA in Richard Tam Alumni Center)
1:00 – 2:45 PM	PANEL II: WATER PATHWAY How are dust suppressants likely to impact surface waters? What are potential impacts of runoff contaminated with dust suppressants to surface water quality and human health? What are potential impacts of runoff contaminated with dust suppressants to aquatic ecosystems? What is known about movement of dust suppressants in the vadose zone? Are dust suppressants likely to impact groundwater? Does Conceptual Model identify all receptors to water quality?
2:45 – 3:15 PM	BREAK
3:15 – 5:00 PM	PANEL III: SOIL AND LANDSCAPE PATHWAY What are the possible human health or ecological impacts related to soils contaminated with dust suppressants? How might application of dust suppressants alter soil properties and effect runoff and erosion? How might dust suppressants impact ecological patterns? How might different dust suppressants change the microbial ecology of local soils? Does the conceptual model clearly identify all pathways and receptors in the terrestrial environment?
5:00 – 7:00 PM	RECEPTION WITH YUCCA MOUNTAIN BOYS (hosted by UNLV/EPA in Alumni Center)

FRIDAY, MAY 31TH, 2002	
8:30 – 8:45 AM	FRAMING THE DAY
8:45 – 9:45 AM	PANEL IV: MAGNITUDE OF USE (GROUP DISCUSSION)
9:45 – 10:00 AM	BREAK
10:00 – 11:30 AM	WORKING GROUPS (See handout)
11:30 AM – 12:30 PM	PRESENTATION OF WORKING GROUPS Designated spokesperson to summarize working groups findings.
12:30 – 2:45 PM	PANEL V: QUESTION AND ANSWER WITH EXPERTS (What do they think?)
2:45 – 3:00 PM	BREAK
3:00 – 4:00 PM	PANEL VI: DEVELOPING GUIDELINES AND REGULATIONS Are current regulations adequate for permitting dust suppressants? Are existing regulations and test methods adequate to address potential effects of dust suppressants? Who should be responsible for tracking use of suppressants? Should long-term monitoring be conducted to evaluate dust suppressant impacts? PANEL VII: PATH FORWARD Recommendations on how best to summarize meeting. What are the follow-up actions from this meeting?
4:00 PM	ADJOURN

Appendix D

Organizing Committee and Expert Panel

Organizing Committee

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March 2004