ROAD DUST MANAGEMENT AND FUTURE NEEDS
2008 Conference Proceedings

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Federal Highway Administration

CTIP

Federal Lands Highway
Commitment to Excellence

Central Federal Lands Highway Division
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FOREWORD

The Federal Lands Highway (FLH) of the Federal Highway Administration (FHWA) promotes development and deployment of applied research and technology applicable to solving transportation-related issues on Federal lands. The FLH provides technology delivery, innovative solutions, recommended best practices, and related information and knowledge sharing to Federal agencies, Tribal governments, and other offices within the FHWA.

This report provides information to anyone interested in mitigating dust from unpaved roads. While unpaved roads provide important linkages in the overall road network, the dust created from these surfaces creates environmental challenges. Although considerable experimentation on a variety of chemical additives has been carried out in the last 70 years, chemical dust control and unsealed-road stabilization has not progressed to the point that road authorities can implement wide-scale programs with confidence. This report presents the proceedings from the first road dust management conference where issues, road dust best management practices, knowledge gaps, research needs, barriers to implementation, and identification of future needs were discussed. Given the volume of road dust that is generated from the unpaved road network, a cooperative and sustainable mitigation plan is needed. These proceedings serve to bring together stakeholders involved in, or affected by, the road dust issue.

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16. Abstract

The first Road Dust Management and Future Needs Conference in 2008 brought together practitioners, scientists and vendors to review the state of the practice and to determine the future direction of dust suppression and stabilization. The four themes explored at the conference were dust suppression, soil stabilization, environmental impacts of dust suppressants used to control dust, and planning and design for the future. Panel discussions and a group vote were used to identify four priorities for formalizing industry standards in road dust management. A major outcome of the conference was the decision to form an association. These proceedings serve to summarize conference discussions as well as to invite interested parties into the planning for a sustainable future in road dust management.

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GLOSSARY AND ACRONYMS

Additive	A chemical or material applied atop or mixed into a road surface to minimize particulate loss (i.e., dust). Also, something that is added, as one substance to another, to alter or improve the general quality or to counteract undesirable properties; in this case something added to the road surface to suppress dust or stabilize the soil.
Dust Suppressant	A chemical additive applied to an unsealed road surface to temporarily reduce the level of particulate matter entrained from the surface by passing vehicles or wind, but does not influence strength or plasticity characteristics of the natural material. Also, any substance that is applied onto, or into a surface, to prevent or reduce the dispersion of dust into the air.
Soil Stabilizer	A chemical or material additive mixed into an unsealed road surface to permanently increase or improve density, compaction, shear strength, and/or changes plasticity characteristics. Also, a chemical or mechanical treatment designed to increase or maintain the stability of a mass of soil or to otherwise improve its engineering properties.
Palliative:	Something that mitigates or alleviates a condition, in this case dust.
PM_{10}	Air particulate matter less then 10 microns in size.

ADT	Average Daily Traffic
ASTM	American Society for Testing and Materials
BLM	Bureau of Land Management
BMP	Best Management Practice
CFLHD	Central Federal Lands Highway Division
CSIR	Council for Scientific and Industrial Research
CTIP	Coordinated Technology Implementation Program
DOD	Department of Defense
DOT	Department of Transportation
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
ISO	International Organization for Standardization
LTAP	Local Technical Assistance Program
LVR	Low Volume Roads (TRB committee)
MSDS	Material Safety Data Sheet
PNS	Pacific Northwest Snowfighters

RITA	Research and Innovative Technology Administration
TRB	Transportation Research Board
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
UTC	University Transportation Centers

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EXECUTIVE SUMMARY

The first Road Dust Management and Future Needs Conference was held in San Antonio, Texas, November 13–14, 2008. The purpose of the conference was to bring together practitioners, scientists and vendors to provide an overview of the state of the practice and to determine the future direction of dust suppression and stabilization. This was accomplished through speakers, panels and open discussions with conference attendees, and a vote on priorities. The four themes explored at the conference were dust suppression, soil stabilization, environmental impacts of dust suppressants used to control dust, and planning and design for the future. Panel discussions and a group vote were used to identify four priorities for future growth in dust control. These were then developed into the following problem statements.

Guidelines and Best Management Practices

Develop a synthesis document on the current status and state of the practice of guidelines and best management practices for soil and soil stabilization.

Performance Measures

Develop an association that will define limits for performance measures, minimum performance standards, and balance these limits with a reporting-based system that allows for complaints to be made by product users and for resolution of these complaints. The limits should provide the end user with enough information for make informed decisions on products.

Specifications and Protocols

Develop a science-based standard for testing and auditing products, including a list of acceptable test methods, specifications for products and projects, and an end user decision making tool, with testing occurring at regional testing facilities.

Education, Clearinghouse, Outreach, and Training

Develop a clearinghouse of information that is owned by the association. Education, training, and outreach can be developed once the clearinghouse is in place.

In addition to developing the four priorities, conference attendees said an association should be assembled to continue the forward progress of the conference. Conference attendees volunteered to be project champions and potential funding sources.

Desired outcomes of this conference were to assemble an association, to make progress on at least one of the four identified priorities, and to hold a follow-up conference in one to two years.

Additional information including the conference white paper, speaker papers and posters can be found in Appendix D. All of the above plus speaker presentations can be found at the conference website:

http://www.wti.montana.edu/TechnologyTransfer/DustControl.aspx.

CHAPTER 1 – INTRODUCTION

The Road Dust Management and Future Needs Conference convened for the first time in the fall of 2008 in San Antonio, Texas, thanks to the hard work of the U.S. Department of Transportation, Federal Highway Administration, Federal Lands Highway, the Western Transportation Institute–Montana State University, Meetings Northwest LLC, and those on the planning committee. The conference was attended by 93 people representing 27 states as shown in Figure 1 and three countries—the United States, Canada and South Africa. The goal of the conference was to bring together practitioners, scientists, and vendors to provide an overview of the state of the practice and to determine the future direction of dust suppression and stabilization. Conference attendees represented federal and state departments of transportation (DOTs), city and county municipalities, Federal Highway Administration (FHWA), Environmental Protection Agency (EPA), Local and Tribal Technical Assistance Programs (L/TTAP), Bureau of Land Management (BLM), U.S. Forest Service (USFS), seven universities, and about 20 private companies.

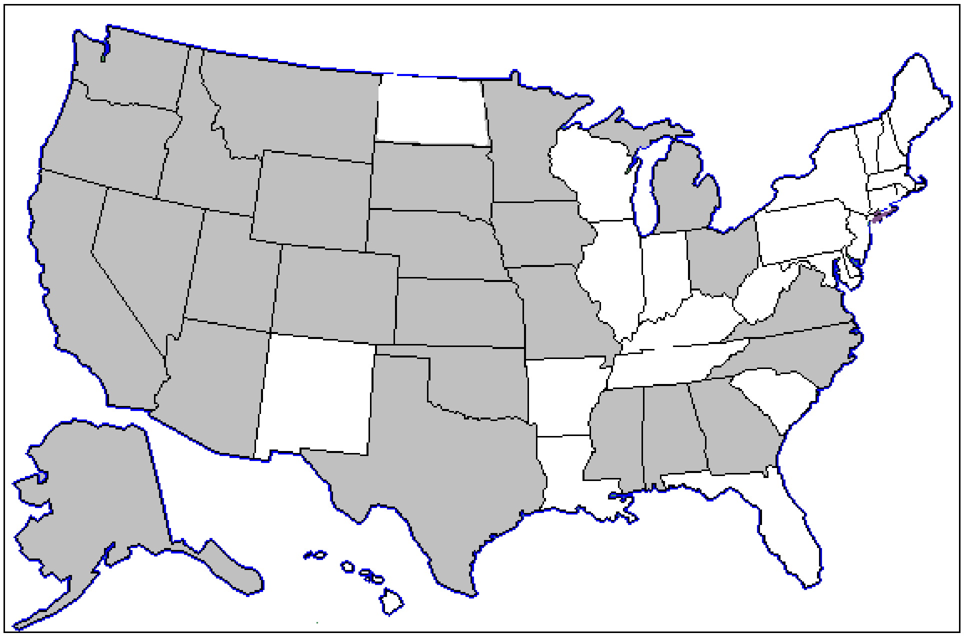


Figure 1 Map. United States locations where the conference attendee states are highlighted in gray.

The conference began with a series of lecture-style talks on dust suppression, soil stabilization, environmental impacts of dust suppressants used to control dust, and planning and design for the future. Following these talks, four panel-led discussions were used to generate ideas for the future directions of the topics discussed in the panels. The ideas generated from each panel-led discussion were presented to the conference audience and the attendees voted on the top four ideas to pursue. Four breakout sessions were used to develop these ideas into tangible problem statements, as shown in Figure 2.

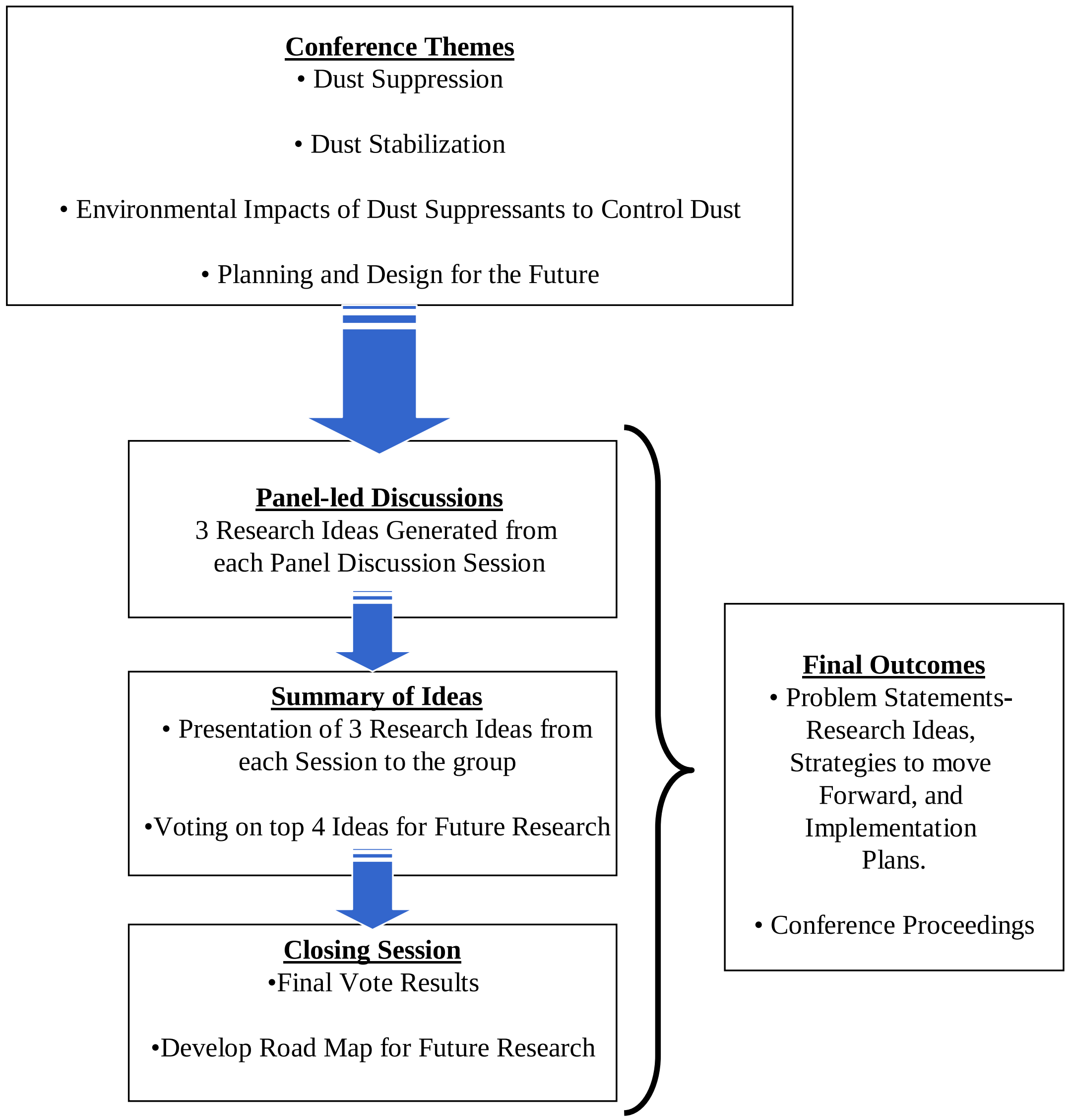


Figure 2. Flowchart. Conference outcome methodology.

The success of the conference was demonstrated by the number of attendees, the diverse fields they represented, enthusiasm for getting the four problems statements funded, and discussion of a follow-up conference in one to two years.

The following Chapter 2 provides background on the topic of dust suppression and stabilization. Chapter 3 provides an overview of what was covered in the keynote and speaker sessions. Chapter 4 presents the ideas generated in each panel-led discussion from the four sessions. Chapter 5 presents the four ideas chosen for development into problem statements, a summary of the problem statements, challenges discussed at the conference, and potential project champions. The conclusions of the conference are then presented in Chapter 6, followed by the References. Appendix A lists the conference attendees, and Appendix B shows the original conference agenda.

CHAPTER 2 – BACKGROUND

"Road dust control and unsealed road stabilization are significant road management issues. Although considerable experimentation on a variety of chemical additives has been carried out in the last 70 years, very little wide-scale implementation has taken place. There are many reasons for this, including the absence of a national authority, a fragmented industry, and a lack of funding for programs among unsealed-road authorities and owners.

This conference was planned to bring practitioners together to discuss road dust and adjacent area management issues, road dust best management practices, knowledge gaps, research needs, barriers to implementation, and identification of future needs. Participants attempted to explain why chemical dust control and unsealed-road stabilization had not progressed to the point that road authorities can implement wider-scale programs with confidence. Remedies were sought to initiate the development of nationwide administrative structures, information resources, and consistent experimental and maintenance protocols that, in a manner similar to those already in place for paved/sealed roads, would facilitate the adoption of standards and practices that will improve performance and reduce both maintenance costs and environmental impacts of unsealed roads. The conference was not intended to be a platform for reporting on another round of experiments, but rather a forum for identifying and overcoming the barriers to wider implementation of the results and recommendations of the past 100 years of research."

The material above originally appeared in the conference white paper titled *Road Dust Management: State of the Practice* by David Jones of the University of California–Davis, David James of the University of Nevada–Las Vegas, and Robert (Bob) Vitale of Midwest Industrial Supply of Canton, Ohio. The complete white paper can be found in Appendix D and at http://www.wti.montana.edu/TechnologyTransfer/DustControl.aspx.

The main themes of the white paper were:

- Unsealed road networks
- Volume of dust generated
- Consequences of road dust
- Dust control using chemicals, compaction aids, and stabilizers
- Environmental considerations
- An overview of dust control research
- Certification of dust control additives
- The way forward

CHAPTER 3 – SPEAKER SESSIONS

This section provides an overview of the speaker session topics and the talking points of the speakers. Speaker presentations, speaker papers, and presented posters can be found at http://www.wti.montana.edu/TechnologyTransfer/DustControl.aspx. Available papers and posters can be found in Appendix D and the conference agenda can be found in Appendix B.

KEYNOTE SPEAKERS

The keynote speakers provided background on dust suppression and stabilization, and offered insight from four perspectives: (1) regional to national scale, (2) research, (3) vendor/construction, and (4) maintenance.

David Jones of the University of California–Davis gave a background talk on the main themes of the white paper that was prepared for the conference as mentioned in section three.

Michael Long of the Oregon DOT and TRB LVR Committee spoke about road dust management from a national and international perspective. He provided a general overview of what is considered dust and why it is a problem, the global scale of the dust problem, and dust issues at the road and project level. He then provided some examples of local and international dust problems.

David James of the University of Nevada–Las Vegas spoke about research needs in the fields of dust suppression and stabilization. Dr. James provided an overview of the current literature, discussed the state of the practice, outlined efforts that have been made to define all the important parameters that need to be measured, and provided ideas on how to move forward.

Ron Wright of the Idaho Transportation Department and Pacific Northwest Snowfighters (PNS) spoke about the development of a chemical selection process that eventually became a qualified product list for PNS in the field of winter maintenance. He provided the specifications they decided upon, lessons learned, and discussed a pathway forward.

Ken Skorseth of South Dakota State University and SDLTAP provided a maintenance perspective and discussed managing the frequency of gravel road blade maintenance, maintaining shape of the road and shoulder, and the need to specify good surface gravel/aggregate. He went on to discuss the general lack of specifications, and of the specifications that exist the problems associated with them, as well as the difference in road performance between surface and base gravel use.

DUST SUPPRESSION

David James of the University of Nevada–Las Vegas moderated this session on research, monitoring and evaluation of road dust suppressants. This session highlighted the current methods, available products, and aggregates used in dust suppression. What works and what does not work, as well as road base preparation were discussed. New technologies and ecological impacts from a research-based perspective were presented.

Chatten Cowherd of the Midwest Research Institute discussed how to quantify dust emissions from unpaved roads and how to measure/control performance monitoring of dust control products. He provided a formula to estimate a national average emission rate in mass per time. Cowherd addressed the importance of field studies in determining performance and also shared techniques using mobile sampling devices.

Tom Sanders of Colorado State University presented results from a study that found maintenance costs for treated roads was 50 percent less than similar costs for untreated roads. Much research is still needed to determine optimal application methods. However, he has found that treating roads with dust suppressants is a win-win situation for those concerned about air quality and maintenance costs.

Dennis Fitz of University of California–Riverside's Center for Engineering Research discussed a mobile method to determine emission rates and evaluate the overall effectiveness of dust suppressants. His work pertained to unpaved roads in public as well as industry settings.

John Bosch of the EPA's Air Program discussed his role in the regulation of fugitive dust. He promoted the formation of a standardized protocol to control dust and presented the myriad motivations of the various types of stakeholders involved in the dust issue. Ultimately, however, due to other pressing environmental concerns, road dust is not a major focus for the EPA. Therefore, Bosch recommended that the association that is to be formed from this conference take the lead if national attention is to be brought to mitigating the road dust problem (see Appendix C - EPA Letter of Support).

SOIL STABILIZATION

Roger Surdahl of the Central Federal Lands Highway Division (CFLHD) moderated this session on road stabilization and maintenance. This session highlighted the current methods, available products, and aggregates used in soil stabilization. What works and what does not work were discussed, as well as road base preparation. New technologies were also presented.

Steve Bytnar of Envirotech provided the perspective of the vendor when dealing with different clients in different climates and explored many of the complexities of deciding how to treat individual road projects. He made a distinction between results from dust suppressants versus road stabilization and emphasized the overriding importance of knowing the goal of each road project. Steve Bytnar was a replacement speaker in the session due to Stan Vitton's delayed arrival.

Heine Junge of South Dakota shared his success story of unpaved road stabilization with the Pennington County Highway Department. He provided many examples of what products and methods work in various road situations and provided insight on how to work with county commissioners and private citizens.

Melvin Main of Midwest Industrial Supply shared information about geo-technology and its use in road stabilization. He provided a case study from the city of Scottsdale, Arizona. Main discussed what they learned about the predictability, strength, and durability of stabilizers from field test installations and evaluations.

Stan Vitton of Michigan Technological University provided a case study on fugitive dust control from mine haul roads in Michigan. Traditional measures for stabilization during cold weather were unsuccessful because the piles are so dynamic and grow by several feet per year. Experimental testing of various stabilizers found that light paper sludge application is a very effective method for controlling cold weather dusting from sublimation. For road applications, Finland compacts paper sludge for use on shoulders and in the pavement structure itself, making geosynthetics and geomembranes obsolete in that country.

ENVIRONMENTAL IMPACTS OF DUST SUPPRESSANTS USED TO CONTROL DUST

Susan Finger of the U.S. Geological Survey moderated and spoke in this session on the environmental impacts of dust suppressants used to control dust. This session covered dust impacts to air quality, human health, vegetation, soil, wildlife, water quality, and dust suppressant chemistry. Susan Finger shared how the USGS's experience with the assessment of environmental contaminants from other fields could aid in the assessment of dust suppression and stabilization chemicals. She presented information on the Columbia Environmental Research Center where lab and field testing can be conducted.

Fred Hall of Environmental Quality Management, Inc., presented information for additional authors Bill Kemner of Environmental Quality Management and Karen Irwin of the EPA Region 9. He provided information on a lab study that looked at a variety of soil types and dust suppressants. He addressed heavy metal concentrations, water leaching studies, the effectiveness of dust suppressants in disturbed and undisturbed environments, a variety of water quality parameters, and aquatic toxicity data.

Rodney Langston of Clark County, Nevada, Air Quality and Environmental Management presented information on what to do if you have PM_{10} issues. His talk covered how and why PM_{10} issues are usually reported. He discussed elements of state implementation plans and control measures and spoke specifically about the Clark County program that involves a working group assigned to develop recommendations and guidelines and conduct research. He presented information on the current unmet needs in this field and different roles of federal, state, and local agencies.

PLANNING AND DESIGN FOR THE FUTURE

Dave Jones of the University of California Pavement Research Center and Council for Scientific and Industrial Research (CSIR) in South Africa was the moderator for the speaker panel on planning and design for the future. This session covered planning projects from conception to completion as well as dust control based on average daily traffic (ADT). Cost analysis of dust control versus soil stabilization was also given.

Pete Bolander provided an overview of USFS perspectives on dust control. The USFS manages 375,000 miles of road (paved and unpaved). The agency has no formal dust abatement management policy but does have a number of guidelines, specifications, toolkits and unpublished studies available. The challenge is to transfer this knowledge to the USFS's 400 district road managers and beyond. A centralized location in the form of a website would drastically improve communication for everyone concerned about road dust issues. In order to improve the state of the practice of dust abatement, everyone from users to manufactures to researchers ought to share and publish failures as well as successes.

Ken Skorseth provided insight into the county engineer's perspective. The state of dust control operations varies widely across the country depending on the agency, substrate, political pressure, product compatibility and other variables. There are many examples of surface treatment failures, the memories of which linger and hinder user and public acceptance of products and projects. However, Skorseth is hopeful that more and more surface treatment successes with documented outstanding performance will drive others to engage in the practice of road dust mitigation.

John Rushing gave the U.S. Army Corps of Engineers' perspective on the Department of Defense (DOD) applications of road dust suppressants, focused on air and ground soldier safety. The DOD has published criteria for road dust management but much of the guidance therein is outdated or environmentally unacceptable. Ongoing military research of products in various scenarios serves to keep guidance and protocols current. Key elements in the process are user training and evaluation to ensure effectiveness and instill confidence in dust suppression products.

Steve Bytnar provided an additive industry perspective. The main barrier to implementation of dust additives is the work it takes to fully understand customers' needs and to agree on expectations. It is necessary to educate customers on the fundamentals of road preparation and compaction, on aggregates, soil types, pH levels and the types of products that can be expected to work in each situation. No standard testing protocols exist so companies are currently forced to devise their own. The industry as a whole will benefit from regionalized performance testing and standardization.

David Jones completed the session with an academic/researcher perspective. The presentation covered the status quo on research on road dust management, an overview of the results of a survey of road industry practitioners' thoughts on road dust management, the need for and use of research protocols, and what constituted appropriate documentation for non traditional road additives. The use of fit-for-purpose certification procedures was also discussed.

CHAPTER 4 – BREAK-OUT SESSIONS TO PRIORITIZE TOPIC IDEAS

The audience had a choice of four concurrent sessions during which they could discuss the most pressing needs. Each session culminated in a vote of the top three priorities within each session topic.

DUST SUPPRESSION

David James of the University of Nevada–Las Vegas moderated this session. He posed a series of questions to panel members and the audience, which are presented below along with a summary of each discussion.

1. What really is the problem?

Dust causes safety problems, in particular, for the military, including loss of visibility and loss of material leading to economic problems. Specifically, (1) tight budgets prevent agencies, users, etc., from testing all products; (2) different approaches to testing result in incomparable data sets; and (3) lack of information available on the impacts of chemical dust suppressants and stabilizers on the environment when applied as recommended.

Customers, private and public, do not know criteria by which to judge the products. A lack of minimum standards and a need for an independent agency to certify the products was also mentioned. In South Africa there is a public testing agency. A vendor added that vendors should provide material information data sheets (MSDS) for customers to use as a reference, and that this should be enough information to evaluate different products against one another.

An audience member commented that the town of Queen Creek, Arizona, was under non-attainment for PM_{10} and that it must implement control measures, but it is not sure what options are available. There is a need for a menu of options for controls. Additionally, a list of what products work, where, and under what parameters (e.g., weather conditions, soil types, specific environments) would be beneficial.

2. Is there a need for testing of dust suppression and stabilization products?

An audience member said that there are a variety of purposes for measurements and protocols, such as temporary versus permanent sealing of roadways. Any developed solution would need to be simple for customers to utilize, for example, an if–then table.

It was also remarked that manufacturers could establish minimum specifications, as has been done in other industries. An audience member remarked that vendors do not have common testing protocols. This means that agencies cannot use a sole source to purchase the product they want to use because it is difficult to compare results/specifications between vendors. A vendor from the audience suggested the need for developing test methods that all interested parties could accept and training people how to use products appropriately. He then gave the example of standard smokestack test methods, and the need to do method verification. Unfortunately, there is no parallel in a non-smokestack environment. The problem is that fugitive dust sources are more variable than smokestacks and that testing in the field is very embryonic. An audience member reiterated the need for test protocols and an independent testing agency, and to approach the issue with wider standards.

3. Where do we start?

Performance criteria should be set by the user. We can look at larger purchasers, such as in the military, as an example, and examine their performance criteria. An audience member suggested that test protocols and methods should be universal to alleviate confusion. One example provided was the EPA, which establishes a workgroup with all stakeholders at the table to develop test methods.

A vendor reminded everyone that there are various categories of dust suppression products that work differently under different conditions. What may work best in some soils will not work as well in other soils. Therefore, test methods should accommodate this variability. An audience member referred back to the if–then table to help with this variability between products.

An audience member reminded everyone of environmental safety issues, and another suggested the need for an index for consumers. There is also a need for guidance for private owners that specifies exposure risk for those doing small applications, such as on driveways. Both public and private roads need to be controlled, but the users are very different. Private haul roads are very important and are major emitters in some areas. Different protocols for different purposes are also needed.

4. How do we accomplish this?

One way would be to institutionalize methods through American Society for Testing and Materials (ASTM) or International Organization for Standardization (ISO) because compliance with either of these organizations has meaning for both private and public consumers.

A vendor suggested we need to decide what problem to address and use screening methods to "bracket" performance. Vendors could then show they have met the minimum criteria with screening methods before going to full-scale performance testing. An audience member then asked who would do performance tests. The vendor responded that contract labs could conduct the testing once they have shown they are able to perform the tests.

An audience member stated that local entities lack resources to do testing. However, there are models for working around this for example, the work done by the Western Regional Air Partnership, an effort administered jointly by the Western Governors' Association and the National Tribal Environmental Council, where review is done by associated responsible state agencies, but this can take a year to get done. An audience member brought up that homeowner protocols might be different from agency protocols.

An audience member said that most DOTs do have qualified products. Some products are more experimental, such as line paint, while others are more mature, like asphalt cement, in testing. Dust control products are likely to be considered experimental at this point, so we must take baby steps.

Below is a summary of the ideas generated from this session to present to the larger conference audience. The ideas in italics were then condensed to three ideas, as seen in the next section.

1. *Development of reliable, repeatable and appropriate-to-use protocols focused on unpaved roads for now, and then look for broader applications later such as vacant lots, construction areas, etc.*

2. *The protocols should measure environmental safety and impacts, occupational safety, and the effectiveness or performance of products against a minimum standard for the purpose of determining an expected lifetime.*
3. *Attributes that should be defined and posted include the service life and manufacturer's warranty, geology, temperature, precipitation, cure time, depth of penetration of the product, solubility of the product for clean-up purposes, MSDS, sufficient information to assess risks, a defined shelf life, corrosivity, application methods, and unit weight.*
4. Performance should be tied to application practices.
5. *A manual of essential practices that is available on the web and contains information about application methods and necessary maintenance linked to performance, and should include case studies or examples of good practice.*

SOIL STABILIZATION

Roger Surdahl of CFLHD moderated the session. The session consisted of a discussion of identifying problems with the current state of road soil stabilization practice. At the end, some ideas were generated on how to start solving those problems.

Roger Surdahl posed the following questions (a summary of the group discussion is provided after each):

1. How many more research studies do we need to do in road stabilization?

It may not be a question of needing more research, per se, but needing guidelines on how to incorporate cost-effective stabilizing materials. Still, there will always be a need for research.

2. What drives the use of the products—is it cost and availability or is it performance?

It depends on the perspective. For some, such as researchers, performance is the key for whether products are used. Another key component in selection of products is the soil type, specifically the amount of clay. For others, such as suppliers or counties, cost is most important. While performance ought to drive use, in reality it comes down to cost.

3. Is there any guidance already available that can be used more widely?

Current manuals may suffice for guidance on maintaining gravel roads but more guidance is needed on applying products. The USFS is creating a guidance document by compiling information on how to choose products for different scenarios. The Cold Regions Research and Engineering Lab published an unsurfaced road condition rating index, which is probably the best example of a guide to gravel road management that is available.

4. What is a reasonable cost per mile for road stabilization?

It is generally agreed that road stabilization is more cost-effective than dust control. Some believe stabilization costs can be recouped within a year, however it may take several years to treat 100 percent of a program. Two cost estimates for stabilization were 1) 10 to 22 cents/square foot, and 2) $3,500/mile/year (compared to an asphalt road, which costs $8,000/mile/year). For sandy bases, a biennial maintenance schedule is needed, whereas for clayey soils, the maintenance schedule becomes less expensive over time. The cost to mobilize equipment can be more than the cost of the product itself. In some places, homeowners must pay for road stabilization or dust control directly. In order to convince decision makers that stabilization is worth the cost, unbiased documentation is needed, such as the paper by Tom Sanders (Sanders and Addo 2000). The question was raised, "What are the costs if unpaved roads are not treated?"

5. What is the single most important problem that needs to be solved in soil stabilization? (Answers are generally listed in order presented; these problems were then voted upon with the resulting top three in italics):
    - *Need to improve the long-term durability/life expectancy of product in terms of ultraviolet degradation, freeze–thaw cycling, etc.*
    - Political influence; need to learn how to convince decision makers that treatment will pay off in the long run.
    - *Need to include dust in long-term pavement management systems; need for more quantifiable and standardized documentation; need for better specifications and best management and construction practices*
    - Environmental and compliance issues; potential violation of Clean Air Act? Other environmental issues such as weed invasions via road corridors, etc.
    - Lack of funding
    - *Need for education for all involved, i.e., customer, politicians, practitioners, etc.*
    - The cost of the product
    - Need for consistent process

While environmental and compliance issues ranked relatively high in the voting, environmental issues were discussed in another session and, therefore, was not included in the final vote results from this group.

6. How are we going to address these top three problems?

There are some examples to follow, such as the Federal Highway Administration's national pooled fund study or perhaps a more regional approach. Ultimately, there is a need to form an organization that can disseminate information via a centralized website, workshops, etc. The key is to keep it simple so that all levels of practitioners may understand how to put the information into practice. However, in order to educate, first you need to have something to teach.

ENVIRONMENTAL IMPACTS OF DUST SUPPRESSANTS USED TO CONTROL DUST

Susan Finger provided an overview talk of what was covered the previous day by the session speakers and information from any relevant conversations she had outside of the session. Panelists were available to address specific topics and provide direction for the session. The audience provided input on a variety of needs and challenges, resulting in the following list of suggestions for the future direction for this topic. The audience then voted on their top three ideas to present to the whole conference audience (in italics). Ideas five through eight listed below were combined into one idea that was then presented to conference audience.

1. Develop an inter-agency working group—a national shell to serve regional groups
2. *Develop a database and/or a management tool*

3. *Develop/standardize test protocols based on EPA environmental and performance protocols and Bureau of Land Management (BLM) mandates*
4. Develop a current list of BMPs
5. *Develop a road safety audit program applied to dust control*
6. *Education/Training*
7. *Guidance document on dust control—Low volume road committee at TRB as a potential champion*
8. *Collect manuals, design and guidance documents to find an appropriate model*
9. Develop a document/template to assess a road's impacts on the adjacent environment

Organizations that most likely have information to help move these ideas forward include: USFS, EPA, BLM, and Federal Highways. The main focus was intended to be on protocols and impacts to water and terrestrial environments, where air quality could fall under the purview of performance of dust suppressants and stabilizers.

PLANNING AND DESIGN FOR THE FUTURE

Dave Jones guided the audience discussion and panelists were available to address specific topics. The audience provided input on a variety of needs and challenges, resulting in a top-ten list of barriers. The audience then voted on their top three barriers (in italics):

1. *Client expectations/knowledge*
2. Client perceptions
3. *Category specifications*
4. New product acceptance
5. Politics/money/future costs
6. Central information location
7. Research/testing protocols
8. Reinventing the wheel
9. Product documentation and information
10. *Education and training*

The top three priorities were then refocused for presentation to the conference audience.

1. Guidelines and specifications (performance based/cost benefit)
2. Education, training and technology transfer
3. Additive category specifications (tied with the following)
3. An "owner" for unsealed road specifications

CHAPTER 5 – COLLECTIVE DISCUSSION

Following the break-out sessions, the attendees met and each break-out session moderator presented his or her group's top three priorities. The conference audience then voted on the top four ideas presented and developed these into problem statements, all of which are presented in this section. This section also discusses potential challenges and project champions.

COLLECTIVE VOTE ON PRIORITIES

Dust suppression

1. Develop reliable, repeatable, and appropriate use of protocols
2. Define what the protocols should measure and specify what attributes that should be defined and posted
3. Develop a manual of essential practices

Soil Stabilization

1. Long-term durability/life expectancy of the product
2. Education for all involved
3. Long-term pavement management system, specifications, and best management and construction practices

Environmental impacts of dust suppressants

1. Develop a database and/or a management tool
2. Develop/standardize test protocols based on EPA environmental and performance protocols and BLM mandates
3. Education, training, guidance document, state of the practice, clearinghouse

Planning and design for the future

1. Guidelines and specifications (performance based/cost benefit)
2. Education, training and technology transfer
3. Additive category specifications (tied with the following)
4. An "owner" for unsealed road specifications

Each audience member was given the opportunity to vote on his or her top four priorities from the list above, some of which were combined due to their similar nature. The following four priorities received the most votes:

1. Guidelines and Best Management Practices
2. Performance Measures
3. Specifications and Protocols
4. Education, Clearinghouse, Outreach, and Training

There was a final concurrent break-out session that focused on the four identified priorities. Moderators facilitated the group in writing brief problem statements for each.

There was also overwhelming support to develop an association. Most conference attendees said that there should be an association even though it was ranked fifth, after the four identified priorities listed above. A steering committee representing various stakeholders will be formed to implement the proposed association and plan the next conference.

PROBLEM STATEMENTS

The following are brief summaries and preliminary problem statements for each of the top four voted priorities.

Guidelines and Best Management Practices

There is a need to develop a synthesis document on guidelines and best management practices for dust control and soil stabilization. Such a document would allow for future comparison between products and to mark progress over time. The document would be submitted to the Transportation Research Board (TRB), the Coordinated Technology Implementation Program (CTIP) or University Transportation Centers for funding.

Performance Measures

"All dust all the time is not acceptable but no dust all the time is unattainable." Finding a necessary balance ought to be the responsibility of the association that will be formed as a result of this conference. The Better Business Bureau model may be the best approach for this complex situation where many different products exist, many of which have no guarantees or even product labels. Develop a reporting-based form that would allow for complaint resolution, and give the end user some information to make informed decisions. Ultimately, the risk of defining performance measures should be shared by the three-legged stool of the government, the end users, and the manufacturers and suppliers.

Specifications and Protocols

The industry needs a science-based standard for testing and auditing products so that MSDSs have meaning and environmental impacts are kept to a minimum. An array of deliverables are needed in order to define industry standards, such as "protocols for protocols," a list of acceptable test methods, specifications for products and for projects, and an end user decision-making tool. To remove bias and to increase accuracy, regional test facilities that represent different climates and soils may be the best option to meet the diversity of needs across the continent.

Education, Clearinghouse, Outreach, and Training

Particulates from fugitive road dust threaten air quality. Products and technology exist to minimize road dust and their use can reduce maintenance costs. Before we can educate, train or reach out to all stakeholders involved, however, we must first assemble the available information. Development of a clearinghouse is the first step in accumulating and disseminating this information. The clearinghouse should be "owned" by the association that will be formed as a result of this conference. Two types of training/outreach formats are needed, one focusing on awareness and promotion (e.g., the "sales pitch" for decision makers) and the other for a more technical audience (e.g., how to build unpaved roads, guidelines, specifications, protocols, best management practices, compendium of studies, etc.).

CHALLENGES

The following is a list of potential short- and long-term challenges that were discussed at the conference.

Short-Term

- Developing an association—who, what, when, and where
- Location of the clearinghouse (EPA volunteered its website)
- Funding to accomplish the top four priorities

Long-Term

- Maintaining continued open dialog and support from practitioners, vendors, and scientists
- Locating funding for the association and conferences

Conference participants were asked to help mediate the short- and long-term challenges listed above by volunteering to join the association, act as project champions, and/or provide funding.

POTENTIAL PROJECT CHAMPIONS

Following the presentation of the problem statement ideas, conference attendees were asked to volunteer if they were interested in helping to move these ideas forward. Provided below, in no particular order, is a list of interested individuals and their affiliations.

John Bosch, Environmental Protection Agency

Steve Albert, Western Transportation Institute–Montana State University

Roger Surdahl, Central Federal Lands Highway Division

Tom Sanders, Colorado State University

Chatten Cowherd, Midwest Research Institute

Ron Wright, Pacific Northwest Snowfighters

Joseph Althouse, The Dow Chemical Company

Gary Kindrick, Maverick Venture Partners

David Jones, University of California–Davis

Bob Vitale, Midwest Industrial Supply, Inc.

Moh Lali, Alberta Transportation

John Fendt, Great Basin Solutions, L.L.C.

John Cary, Envirotex

Tony Accordino, Hill Brothers Chemical Company

Rhino Rohrs, CBR Plus LLC.

Jake Rader, SoilWorks, LLC.

David Barnes, University of Alaska–Fairbanks

Billy Connor, Alaska University Transportation Center

Swayne Walther, EnviRoad

Neville Mercado, Greenmarket Solutions

Matt Duran, Envirotech Services, Inc.

CHAPTER 6 – CONCLUSIONS

CONCLUSIONS

The first Road Dust Management and Future Needs Conference held in San Antonio, Texas, in November 2008 brought together practitioners, scientists and vendors from all levels of public and private agencies. It provided an overview of the state-of-the-practice and set a path for the future direction of dust suppression and soil stabilization. The conference was deemed a success by the hosts and participants alike. Speakers, panels, and audience discussions culminated in a vote on priorities.

The four identified priorities discussed previously in Chapter 5 are listed below.

1. Guidelines and Best Management Practices
2. Performance Measures
3. Specifications and Protocols
4. Education, Clearinghouse, Outreach, and Training

Each priority was developed into a problem statement. Potential funding sources and project champions were suggested at the conference.

A steering committee will be formed to lead and deliver the next phases of the work. Desired outcomes of this conference were to hold a follow-up conference in one to two years and, before that time, to make progress on at least one of the four identified priorities.

REFERENCES

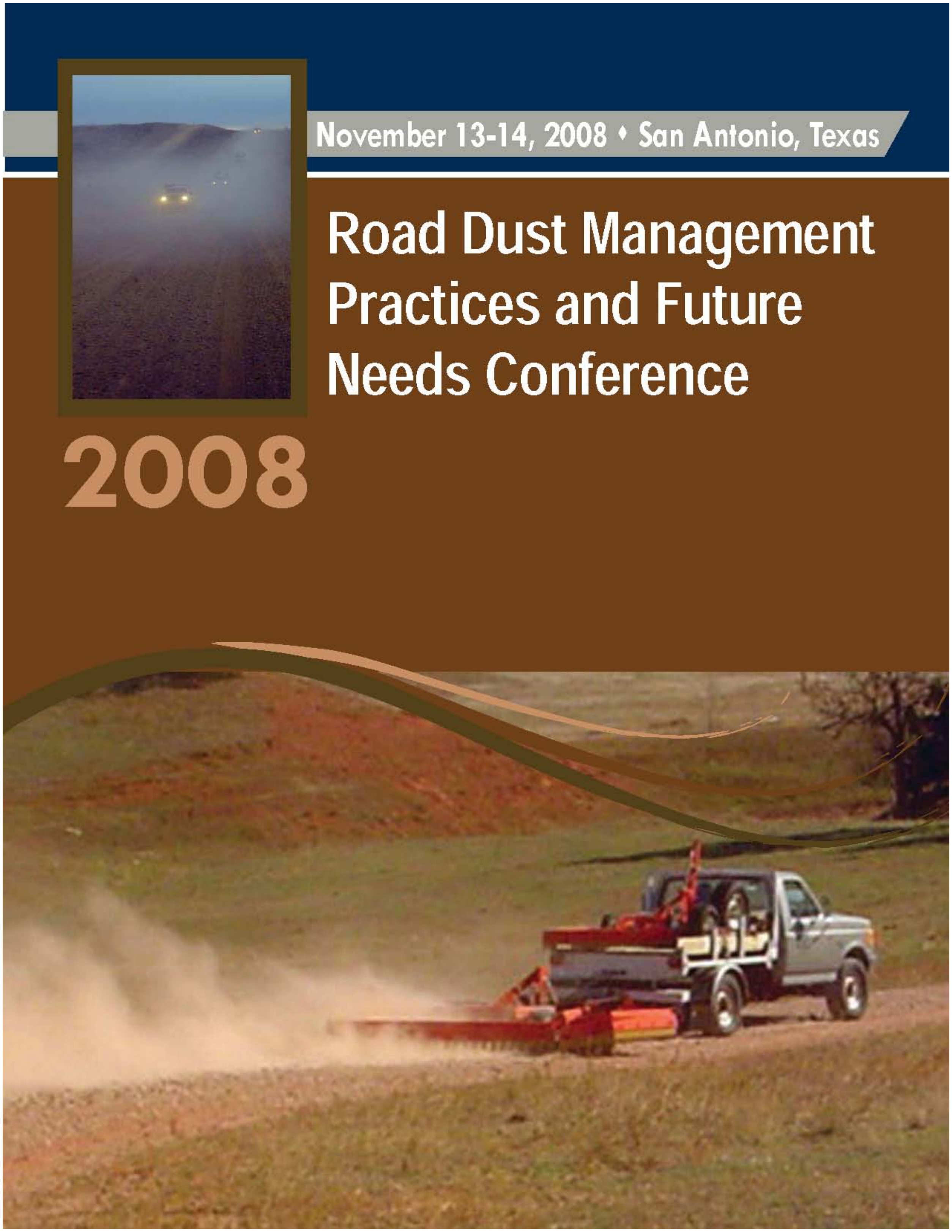
Sanders, T.G. and J.Q. Addo. "Experimental Road Dust Measurement Device." Journal of Transportation Engineering, ASCE. 2000.

APPENDIX A – LIST OF CONFERENCE ATTENDEES

Name		Title	Organization
Tony	Accordino		Hill Brothers Chemical
Steve	Albert	Director	Western Transportation Institute
Joe	Althouse	Tech Service	The Dow Chemical Co.
Joel	Anderson	Waste Section Manager	TCEQ
Jason	Bagley		North American Salt
Bruce	Beanchum	Roads Maintenance Tech	CTUIR Public Works
Luc	Beaulieu	Graduate Student/Master Student	Laval University
Peter	Bolander	Civil Engineer	USDA Forest Service
John	Bosch		US Environmental Protection Agency
Keith	Browning	Public Works Director	Douglas County, Kansas
Steve	Bytnar	Director, Research & Quality	EnviroTech Services, Inc.
John	Cary	Regional Manager	Envirotex
Dennis	Casamatta	Field Engineering Support	Midwest Industrial Supply, Inc.
Beth	Chester	Botanist	USFWS
Lisa	Christianson	Air Quality Specialist	Bureau of Land Management
Brian	Church		Western Transportation Institute
Billy	Connor	Director	Alaska UTC, University of Fairbanks
Chatten	Cowherd, Jr.	Principal Advisor	Midwest Research Institute
Scott	DiBiase	Planning Manager	Pinal County Air Quality
Jeff	Dobson	President	Roadwise, Inc.
Rich	Douglass	Local Government Coordinator	Wyoming Department of Transportation
Matthew	Duran	Vice President of Sales	EnviroTech Services, Inc.
Laura	Fay	Research Scientist	Western Transportation Institute
John E	Fendt	President	Great Basin Solutions, LLC
Susan	Finger	Program Coordinator	US Geological Survey
Dennis	Fitz	Research Engineer	UC Riverside, CE-CERT
Chris	Forti	Street Operations Supervisor	City of El Paso Street Department
Sean	Furniss	National Coordinator Refuge Roads Program	National Wildlife Refuge System
Richard	Garcia	Regional Director	TCEQ
Glen	Ginzel		Intermodal Facility & Maintenance
Gordon	Ginzel		Intermodal Facility & Maintenance
Dale	Green	Production Planner	Western Energy Company
Norman D.	Hadfield	Field Project Manager	Utah LTAP Center
Fred	Hall	Project Manager	Environmental Quality Management, Inc.
William	Heiden	Circuit Rider	Colorado State University
Christopher	Horan	Environmental Engineer	Salt River Pima Maricopa Indian Community
Richard	Hunter	President	Midwest Industrial Supply, Inc.
George	Huntington	Senior Engineer	Wyoming T2/LTAP
Dave	James	Associate Vice Provost for Academic Programs	University of Nevada Las Vegas
Ed	Johnson		Minnesota Department of Transportation
David	Jones	Project Scientist	University of California Pavement Research Center
Marilyn	Jordahl-Larson, PE		Minnesota Department of Transportation
Sylvain	Juneau	Project Manager	Laval University
Hiene	Junge	Highway Superintendant	Pennington County
Dewey	Kennedy	Roadmaster	Gilliam County Road Department
Maureen	Kestler	Civil Engineer	USDA Forest Service
Gary	Kindrick		Maverick Venture Partners
Angela	Kociolek	Research Scientist	Western Transportation Institute
Scott	Koefod	Principal Scientist	Cargill Salt
Jim	Kozik	Road Operations & Maintenance Engineer	US Forest Service

Name		Title	Organization
Moh	Lali	Director, Highway Operations	Alberta Transportation
Rodney	Langston	Principal Planner	Clark County Dept. of Air Quality & Environmental Mgmt.
Glen	Legere	Associate Program Leader Resource Roads	FPInnovations FERIC
Edward	Little	Chief, Ecology Branch	USGS, Columbia Environmental Research Center
Lee-Ann	Lochhead	Sales Manager	Da-Lee Dust Control
Michael	Long	Chair - TRB Low Volume Roads Committee	Oregon Department of Transportation
Travis	Luiting	Sales Representative	Da-Lee Dust Control
Melvin	Main	Director of New Technologies	Midwest Industrial Supply
John	McDonald	Faribault County Engineer	Faribault County
Bekee	Megown	Botonist	USFWS
Bob	Meister	Public Works Director	Minnehaha County
Neville	Mercado	President	Green Market Solutions
Clark	Milne, PE	Northern Region Maintenance Engineer	Alaska Department of Transportation & Public Facilities
Geeta	Nakra	Technical Marketing Manager	SNF Holdings
Sean	O'Brien	Pavement Engineer	DOT/FHWA/EFLHD
Joe	Odhiambo		Agreement South Africa
Pascale	Pierre	Researcher	Laval University
Ted	Plank	Road Supervisor	Boulder County Transportation Department
Philippe	Poulin	Universite Laval	Pavillion Adrien Pouliot Department de genie civil
Craig	Prete	President	Dustbusters, Inc.
Jake	Rader	Sales Rep	Soilworks, LLC
John	Rasmussen	County Engineer	Pottawattamie County
Dan	Ratermann	Outreach Coordinator	Missouri LTAP
David	Rogers	General Manager	Da-Lee Dust Control
Taylor	Rossetti	Program Coordinator	Wyoming Department of Transportation
John	Rushing	Research Physical Scientist	US Army Engineer Research and Development Center
Thomas	Sanders	Associate Professor	Colorado State University
Alan	Sarver	President	Z&S Dust Control Systems
Ramana	Simpson	Management Assistant	Town of Queen Creek, Arizona
Ken	Skorseth	Field Services Manager	SDSU/SDLTAP
Roger	Surdahl	Technology Delivery Engineer	Federal Highway Administration
Roland	Taff	Technical Sales Representative	LignoTech USA
Jaime	Tamez	President	CBR Plus, LLC
Samuel	Tlmaedi Skosana		Agreement South Africa
Russell	Van Leuven	Air Quality Program Manager	Arizona Department of Agriculture
Jerold	Vincent	Liquid Calcium Chloride Business manager	TETRA Technologies, Inc.
Bob	Vitale	CEO/Markets Manager	Midwest Industrial Supply, Inc.
Stan	Vitton, PhD, PE		Civil & Environmental Engineering
Swayne	Walther	Sales & Environmental Specialist	EnviRoad
Michael	Weimar	Commissioner	Gilliam County Road Department
Laressa	Wong	Compliance Assistance Specialist	Texas Commission on Environmental Quality
Ron	Wright	Chemist Supervisor	Idaho Transportation Department
Alan	Yamada	Civil Engineer	USDA Forest Service

APPENDIX B – CONFERENCE AGENDA



WELCOME

Table of Contents

Welcome to San Antonio!

On behalf of the planning committee of the *2008 Road Dust Management Practices and Future Needs Conference*, we would like to welcome you to San Antonio, Texas. As the first conference of its kind, this conference is bringing together experts from industry, research and the environment to present, discuss and prioritize current and future road dust management best practices. We have crafted an agenda which will present the issues, engage you in dialogue and be holistic in examining the realistic solutions for the future. With your help we will reach our goal of drafting a road map to the future for dust management." I would like to recognize and thank the sponsors and partners for their vision for bringing this conference together. We hope you find the conference enjoyable and productive.

Steve Albert, Co-Chair
Western Transportation Institute

Roger Surdahl, Co-Chair
FHWA Central Federal Lands

Special Thanks

Planning Committee - Many individuals have come together to help make this event a success. In addition to those individuals speaking and moderating at the conference, we want to extend a special thank you to our conference planning committee:

Steve Albert, Western Transportation Institute
Brian Allen, FHWA Federal Lands Highway
Amit Armstrong, FHWA Western Federal Lands
Gary Brown, FHWA Eastern Federal Lands
Matt Duran, Envirotech Services, Inc.
Laura Fay, Western Transportation Institute
Susan Finger, USGS, Columbia Environmental Research Center
Sean Furnis, Fish and Wildlife Service
Tony Giancola, National Association of County Engineers
David James, University of Nevada, Las Vegas
David Jones, University of California Pavement Research Center
Rodney Langston, Department of Air Quality & Environmental Management, Clark County, Nevada
Ed Little, US Geological Survey
Mark Nahra, Delaware County
Ken Skorseth, South Dakota State University
Roger Surdhal, FHWA Central Federal Lands
Bob Vitale, Midwest Industrial Supply
Dale Wegner, Coconino County
Dan Williams, Western Transportation Institute
Ron Wright, Idaho Transportation Department
Alan Yamada, USDA Forest Service

Conference Proceedings

Presentations and papers available prior to the conference have been assembled and placed on thumb drives for attendees to pickup at the close of the conference. Every attempt will be made to collect additional presentations onsite for loading on the subject drives. However, it is likely that some presentations will not be available. As such, presentations, papers, podcasts and proceedings information from the conference will also be made available on the Western Transportation Institute's website at http://www.wti.montana.edu/TechnologyTransfer/Conferences.aspx. It is anticipated that information will be available via the website beginning December 1, 2008.

Vendors

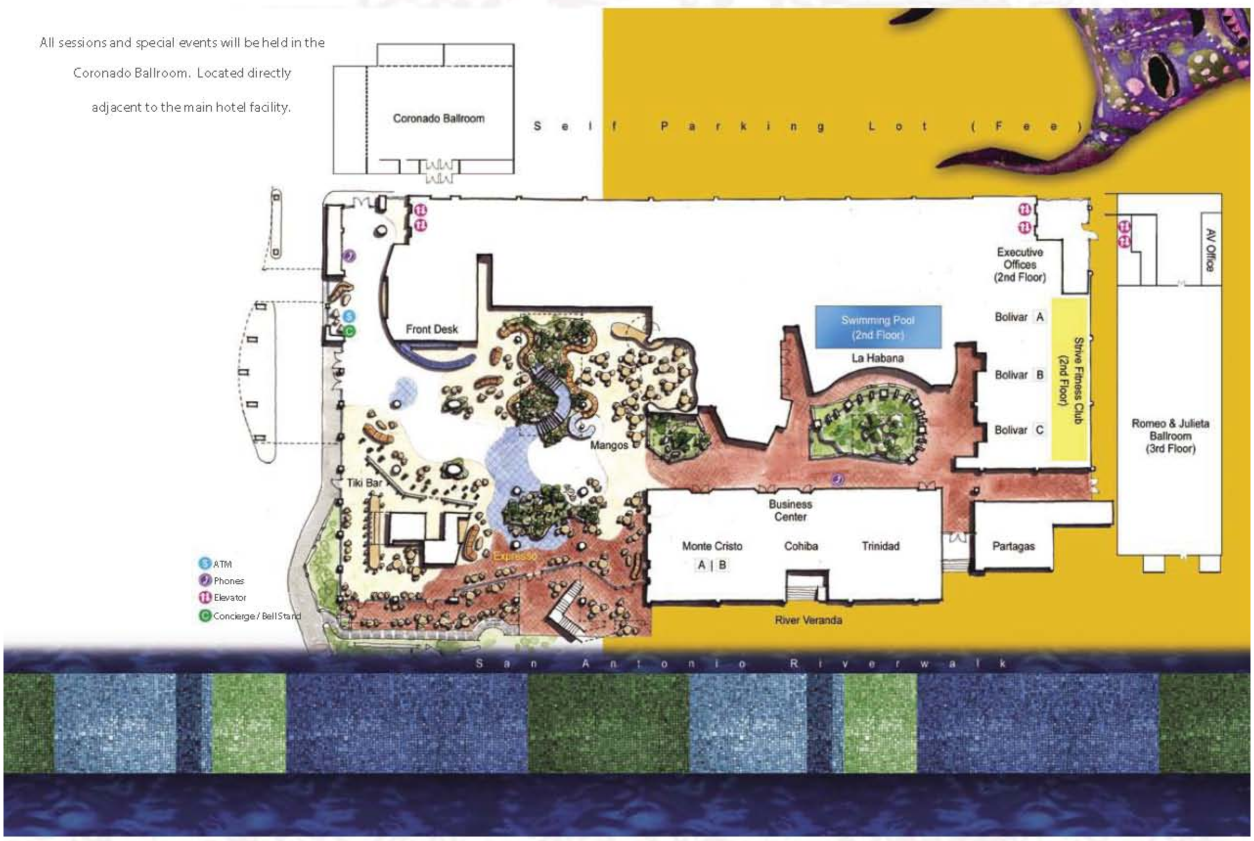
The following vendors will have displays setup in Section E of the Coronado Ballroom beginning at 8:00 am, Thursday, November 13th and continuing through 3:30 pm Friday, Novemer 14th.

- CBR Plus, LLC
- EnviRoad
- Midwest Industrial Supply, Inc.
- North American Salt, Inc.
- Soilworks, LLC

A vendor reception and poster session will be held from 4:30 - 6:00 pm on Thursday, November 13th in Section E of the Coronado Ballroom. Hors d'oeuvres will be served and a cash bar will be open for attendees and guests to enjoy. This will be a wonderful opportunity to see the new products that are available and network with peers. There will be plenty of time to enjoy dinner on your own at one of the many fine Riverwalk restaurants following the reception.

Site Map

All sessions and special events will be held in the Coronado Ballroom. Located directly adjacent to the main hotel facility.



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Schedule at a Glance

Thursday, November 13, 1008

7:00 am	Registration/Continental Breakfast/Vendor Area Opens	
8:00 am	Opening Session	
9:30 am	BREAK	
10:00 am	Session A: Dust Suppression	
12:00 pm	LUNCH, sponsored by North American Salt	
1:00 pm	Session B: Dust Stabilization	
2:30 pm	BREAK	
2:45 pm	Concurrent Sessions (C)	
	Session C1: Environmental Impacts of Dust Suppressants to Control Dust	Session C2: Planning and Design for the Future
4:15 pm	Sessions Adjourn	
4:30 - 6:00 pm	Poster Session and Vendor Reception	

Friday, November 14, 2008

7:00 am	Registration/Continental Breakfast/Vendor Area Opens			
8:30 am	Concurrent Sessions - Summary of Future Needs and Roadmap			
	Session D1: Environmental Impacts of Dust Suppressants to Control Dust (guided discussion)	Session D2: Dust Suppression (guided discussion)	Session D3: Dust Stabilization - Benefits from Soil Stabilization (guided discussion)	Session D4: Planning and Design for the Future (guided discussion)
10:00 am	BREAK			
10:30 am	Summary of Ideas from Morning Session			
12:00 pm	LUNCH			
1:30 pm	Vote Results and Outline of the Road Map to the Future			
3:30 pm	End of Conference			

Sponsors

This event is sponsored in part by the Bureau of Indian Affairs, EnviroTech Services, Inc., FHWA - Federal Lands Highway, National Park Service, North American Salt, United States Fish and Wildife Service, United States Forest Service, and the Western Transportation Institute - Montana State University. Special thanks to the United States Geological Survey, National Association of County Engineers, University of Nevada at Las Vegas, University of California at Davis, Department of Environmental Quality & Environmental Management in Clark County, Nevada, Local Technical Assistance Program, San Diego State University, Idaho Transportation Department, and Midwest Industrial Supply, Inc. for their input and assistance in planning this event.

U.S. Department of Transportation
Federal Highway Administration

Montana State University
Western Transportation Institute

North American Salt Company
A Compass Minerals Company

EnviroTech Services, Inc.

CTIP

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Conference Background

There are millions of miles of unsealed roads around the world which are managed by a wide assortment of national, state, and local authorities as well as private entities. Unacceptable levels of dust, poor riding quality, and impassability in wet weather are experienced on much of this global unsealed road network. Although it is acknowledged that these roads are fundamental to the economies of almost every country in the world, many of the management practices followed leave much to be desired, with programs for dust control, chemical stabilization, low-cost upgrading, etc., largely overlooked.

Chemical dust control on unsealed roads has been researched for decades and there are numerous published papers documenting the establishment and monitoring of experiments. However, much of this has been agency-specific and there are no comprehensive guidelines or specifications available to help practitioners with establishing longer-term dust control programs, identifying which type of additive would be most appropriate for a specific application, undertaking life-cycle analyses, quantifying negative environmental impacts and positive social benefits, designing appropriate treatments, applying the additive, and maintaining the treated road.

Increasing concerns with regard to deteriorating air quality, the sustainability of repeatedly replacing gravel on unsealed roads, and the increasing cost of asphalt binders used for sealing roads have placed renewed interest on road dust management. Attendees of this conference will be provided a brief current status of global road dust management together with some points for consideration that may lead to wider implementation of dust control programs in unsealed road management initiatives. Discussions on the extent of unsealed road networks, the volume of dust generated, the consequences of dust, categorization of road additives, environmental considerations, and dust control research will also be held.

The ultimate goal for this event is to generate a roadmap for achieving wider, effective and environmentally sustainable, and cost-effective implementation of dust control Best Management Practices on unsealed roads and adjacent areas.

How will this goal be achieved? A series of invited keynote speaker presentations will provide attendees with critical background information on past, continuing and new dust management efforts. Supplemented with paper and poster presentations, participant workshops and roundtable discussions, attendees will learn about:

(1) Environmental Impacts of Dust Suppressants - including air quality, human health, and impacts to vegetation, soil and wildlife, water quality, as well as impacts from products and suppressant chemistry.
(2) Topical Dust Suppression - including Best Management Practices for topical applications of dust-control additives such as current methods, available products, application and construction procedures, and implementation of experimental findings.
(3) Soil Stabilization - including Best Management Practices for mix-in applications of dust-control additives and surface stabilizers such as current methods, available products, applications, construction and engineering procedures, and implementation of experimental findings.
(4) Planning and Design for the Future - including implementation of dust-control programs as unsealed-road management strategies, design procedures, additive certification, performance evaluation techniques considering current/future average daily traffic, cost/benefit analysis, and models for unsealed road management systems.

Portions of the above taken from *Road Dust Management: State of the Practice* by David Jones, University of California Pavement Research Center, David James, University of Nevada, and Robert Vitale, Midwest Industrial Supply. This document will be presented at the Conference.

Agenda

THURSDAY, NOVEMBER 13TH

All events are held in the Coronado Ballroom at the El Tropicano Riverwalk in San Antonio. It is a separate building directly behind the hotel adjacent to the self parking lot.

7:00 am
REGISTRATION, *Coronado E*

The Registration Desk will open at 7:00 am. Attendees should pickup their registration packets prior to attending the continental breakfast.

7:00 am
CONTINENTAL BREAKFAST, *Coronado E*
This event sponsored by EnviroTech Services, Inc.

7:00 am
VENDOR AREA OPENS, *Coronado E*

8:30 am
OPENING SESSION, *Coronado E*

Welcome/Overview

- Steve Albert, Western Transportation Institute
- David Jones, University of California Pavement Research Center

Keynotes

- Michael Long, Chair, TRB LVR Committee, Oregon Department of Transportation
- David James, University of Nevada, Las Vegas
- Ron Wright, Idaho Transportation Department
- Ken Skorseth, South Dakota State University

Keynote speakers will provide insight from four perspectives: (1) national, (2) research, (3) vendor/construction, and (4) maintenance.

9:30 am
BREAK, *Coronado E*

10:00 am
SESSION A: DUST SUPPRESSION, *Coronado E*
Moderator: David James, University of Las Vegas, Nevada

Chatten Cowherd, Midwest Research Institute
Road Dust Control Performance Monitoring

Tom Sanders, Colorado State University
Road Dust Suppressants Research Results

Dennis Fitz, University of California Riverside
Evaluation of Dust Control Suppressants on Unpaved Roads Using Mobile Sampling

This session will highlight the current methods, available products, and aggregates used in Dust Suppression. What works and what does not work as well as road base preparation will be discussed. New technologies and ecological impacts from a research based perspective will also be presented.

12:00 pm
LUNCH, *Coronado E*
This lunch sponsored by North American Salt.

1:00 pm
SESSION B: DUST STABILIZATION, *Coronado E*
Moderator: Roger Surdahl, Central Federal Lands Highway Division

Stan Vitton, Department of Civil and Environmental Engineering, Michigan Technological University
The Use of Paper Sludge for Dust Stabilization on Mine Haul Roads and Tailing Impoundments

Hiene Junge, South Dakota Pennington County Highway Department
Magnesium Chloride Stabilization and Spot Dust Control

Melvin Main, Midwest Industrial Supply
The Predictable Nature of Materials Stabilized with Polymer Agents

This session will highlight the current methods, available products, and aggregates used in Soil Stabilization. What works and what does not work as well as road base preparation will be discussed. New technologies will also be presented.

2:30 pm
BREAK, *Coronado E*

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Agenda

2:45 pm
CONCURRENT SESSIONS

Session C1: Environmental Impacts of Dust Suppressants to Control Dust, ***Coronado A/B***
Moderator: Susan Finger, Columbia Environmental Research Center

Fred Hall, US Environmental Protection Agency
Investigation of Water Runoff and Leaching Impacts from Dust Suppressants

Rodney Langston, Department of Air Quality & Environmental Management, Clark County Nevada
What to do if You Have PM 10 Issues

Susan Finger, Columbia Environmental Research Center
Determining Ecological Effects of Dust Suppressant Chemicals on Terrestrial and Aquatic Resources

This session will cover air quality, human health and impacts to vegetation, soil and wildlife, water quality and impacts from products as well as suppressant chemistry.

Session C2: Planning and Design for the Future, ***Coronado C/D***
Moderator: Dave Jones, University of California Pavement Research Center

Pete Bolander, US Department of Agriculture, Forest Service
US Forest Service Perspective on Planning and Design for the Future

Ken Skorseth, South Dakota State University
County Engineers' Perspective on Planning and Design for the Future

John Rushing, US Army Engineer Research and Development Center
US Army Corps of Engineers' Perspective on Planning and Design for the Future

Steve Bytnar, EnviroTech Services
Additive Industry Perspective on Planning and Design for the Future

Dave Jones, University of California Pavement Research Center
Research/Academia Perspective on Planning and Design for the Future

This session will cover planning projects from conception to completion as well as dust control based on ADT. Cost analysis of dust control versus dust stabilization will also be given.

4:15 pm
Sessions conclude for the day.

4:30 - 6:00 pm
Poster Session and Vendor Reception, ***Coronado E***

Welcome to the *Poster Session and Vendor Reception*! Enjoy some hors d'oeuvres while visiting with poster session authors and vendors. A wonderful opportunity to see the new products that are available and network with peers.

POSTER PRESENTATIONS:

Chatten Cowherd, Midwest Research Institute
Mobile Monitoring of Unpaved Road Dust Emissions

P. Poulin et al, Civil Engineering Department, Universite Laval, Quebec
Field Study Evaluation of Granular Materials Treated with Dust Suppressants - Behavior Evolution under Traffic and Climate

Stan Vitton, Department of Civil and Environmental Engineering, Michigan Technological University
Cold Weather Dusting: Its Generation, Testing and Control

L. Beaulieu et al, Civil Engineering Department, Universite Laval, Quebec
Field Test Program of Stabilization on a Principle Forest Road

Eddie Johnson et al, Minnesota Department of Transportation
Investigation of Dust Control Practices in Minnesota

George Huntington et al, Wyoming Technology Transfer Center
Dust Suppression by Incorporating Reclaimed Asphalt Pavement (RAP) into Gravel Road Surfacing

Tom Sanders et al, Colorado State University
Mobile Dust Measuring Devices - Dustometer System

Dennis Fitz, University of California Riverside
Mobile Dust Measuring Devices - SCAMPER System

Vic Etyemezian, Desert Research Institute
Measurement of Road Dust Emissions: The TRAKER and PI-SWERL Tools

Agenda

FRIDAY, NOVEMBER 14TH

7:30 am
REGISTRATION/CONTINENTAL BREAKFAST/VENDOR AREA OPENS, *Coronado E*

8:30 am
CONCURRENT SESSIONS

Session D1: Environmental Impacts of Dust Suppressants to Control Dust (guided discussion), *Coronado A*
Moderator: Susan Finger, Columbia Environmental Research Center

Panelists
- Bob Vitale, Midwest Industrial Supply
- Ron Wright, Idaho Transportation Department

This session is a follow-up to Thursday and will feature a panel of experts and audience participation.

Session D2: Dust Suppression (guided discussion), *Coronado B*
Moderator: David James, University of Nevada, Las Vegas

Panelists
- John Bosch, US Environmental Protection Agency
- TBD

This session is a follow-up to Thursday and will feature a panel of experts and audience participation.

Session D3: Dust Stabilization - Benefits from Soil Stabilization (guided discussion), *Coronado C*
Moderator: Roger Surdahl, Central Federal Lands Highway Division

Panelists
- Melvin Main, Midwest Industrial Supply
- TBD

This session is a follow-up to Thursday and will feature a panel of experts and audience participation.

Session D4: Planning and Design for the Future (guided discussion), *Coronado D*
Moderator: Dave Jones, University of California Pavement Research Center

Panelists
- Pete Bolander, US Department of Agriculture, Forest Service
- Ken Skorseth, South Dakota State University
- John Rushing, US Army Engineer Research and Development Center
- Steve Bytnar, EnviroTech Services

This session is a follow-up to Thursday and will feature a panel of experts and audience participation.

10:00 am
BREAK, *Coronado E*

10:30 am
SUMMARY OF IDEAS FROM MORNING SESSION, *Coronado E*
Moderator: Steve Albert, Western Transportation Institute

12:00 am
LUNCH, *Coronado E*

1:30 pm
VOTE RESULTS AND OUTLINE OF THE ROAD MAP TO THE FUTURE, *Coronado E*
Moderator: Steve Albert, Western Transportation Institute

3:30 pm
Conference adjourns.

Speaker Bios

BEAULIEU, LUC
Universite Laval, Quebec

Luc Beaulieu obtained his Bachelor of Science degree from Université Laval (Québec) in June 2008. He is now a graduate student at the Department of Civil Engineering at Université Laval under the supervision of the researcher Pascale Pierre. His master subject deals with the mineralogy and grading influence on granular aggregate stabilized or treated with dust suppressant.

BOLANDER, PETE
USDA Forest Service

Pete Bolander is a civil engineer with 27 years of experience with the USDA Forest Service in providing technical assistance on road surfacing and geotechnical engineering for the design, construction and maintenance of Forest Service roads in the Pacific Northwest. He has written a USDA-FS publication entitled "Dust Palliative Selection and Application Guide", presented three papers at the TRB Low Volume Roads Conference concerning dust abatement, and was a panel member of EPA's "Potential Environmental Impacts of Dust Suppressants: Avoiding Another Times Beach" in 2002.

BOSCH, JOHN
US Enviromental Protection Agency

Since 1971 Mr. Bosch has worked in the national air programs within the U.S. Environmental Protection Agency located in Research Triangle Park in North Carolina. Prior to joining EPA, he obtained his M.S. degree in Chemical Engineering from the University of Washington in Seattle and worked as an environmental consultant in Vancouver, British Columbia. Mr. Bosch developed and implemented both EPA's AP-42 emission factor program and the engineering protocols for estimating emissions which are still in use by Federal, State, and local environmental agencies throughout the country. For the past fourteen years, he has focused on advancing new concepts and technologies related to quantifying air emissions for purposes of both research and compliance measurements. He has been EPA's liaison with the Department of Defense and the USARMY on research programs relating to the air issues challenging military installations, of which fugitive fine-particulate emissions are an important part. One of his main recent interests is to further agency and national acceptance of new, more accurate, more inexpensive, and more streamlined ways to estimate fugitive dust emissions from paved and unpaved roads.

BYTNAR, STEVE
Envirotech Services, Inc.

Steve Bytnar is the Director of Research and Quality for Envirotech Services, Inc. He has been involved in the development of products for dust control and soil stabilization since 1998. Through the work at Envirotech the research team has spent countless hours testing and evaluating different road bases from throughout North America. The data gathered in analyzing the varying road bases has become an invaluable tool in developing new products and application techniques for dust control and road base stabilization.

The focus of Mr. Bytnar and his team at Envirotech is to develop new high performance products with keen attention to the environmental impacts of such products. Mr. Bytnar and his group at Envirotech have multiple patents (issued and pending) in the arenas of dust control, soil stabilization, erosion control and highway de-icing.

COWHERD, CHATTEN, PHD
Midwest Research Institute

Dr Cowherd is internationally known for his work on the characterization and control of open source particulate matter (PM) emissions, including fugitive dust. He specializes in field and laboratory studies of the kinetics and mechanisms of particle entrainment from stabilized and unstabilized surfaces. He has performed extensive field studies of dust plume generation and dispersion using fixed and mobile monitors, with a recent focus on airborne particle capture by vegetation and other types of groundcover.

Dr. Cowherd pioneered the isokinetic exposure profiling technique, which became the EPA-preferred method for quantifying particulate emissions from line or moving point sources such as roadway traffic. In addition, he has been instrumental in the recent development of mobile monitoring strategies for mapping road dust emission potential and the effectiveness of dust control measures.

Dr. Cowherd received his Ph.D. in Chemical Engineering from the Johns Hopkins University. He has coauthored more than 100 technical publications and papers during his career of more than 30 years. He is a Fellow Member of the Air and Waste Management Association and has served on the AWMA national board of directors. He maintains certification as a Qualified Environmental Professional by the Institute of Professional Environmental Practice (No. 11940135).

Speaker Bios

FINGER, SUSAN
Columbia Enviromental Research Center

Susan is an aquatic toxicologist with the Biological Resources Division of the US Geological Survey. She has over 25 years of experience assessing the effects of contaminants on aquatic resources. In her position as Program Coordinator for the Columbia Environmental Research Center, she provides guidance in the identification and implementation of new research areas for the Center and its field stations. She has led research studies assessing the effects of irrigation drain water on endangered fish species in the western United States, in studies evaluating the effects of oil spills on freshwater ecosystems, and in a multi-year study to determine the effects of contaminants on striped bass survival in tributaries of Chesapeake Bay. During the past 15 years, she has also been involved in investigations to determine the ecological effects of fire-fighting chemicals on the terrestrial and aquatic environment. She currently serves as the USGS Science Advisor for the Department of Interior's Natural Resource Damage Assessment and Restoration Program and plays an active role in the design and review of scientific studies to evaluate biological injury and ecological recovery at over 30 historically contaminated sites nationwide. She will be actively involved in the recently initiated US Geological Survey's study for assessing potential responses of terrestrial and aquatic organisms to dust suppressant chemical application in critical habitats including those managed by the US Fish and Wildlife Service National Wildlife Refuge Systems.

FITZ, DENNIS
University of California Riverside

Mr. Fitz has a Masters Degrees in both Chemistry and Applied Sciences from the University of California, Riverside. He is currently the manager of the Atmospheric Processes Group and Deputy Director at the College of Engineering-Center for Environmental Research and Technology (CE-CERT) at that institution. Mr. Fitz has more than 30 years of experience in managing air quality measurement studies. The Atmospheric Processes group conducts research to determine the fate of air pollutants after they are emitted into the atmosphere using measurements and modeling. The current research includes determining the reactivity of VOC to form ozone and particulate matter in smog chambers and evaluating and developing measurement methods to better characterize products formed in photochemical air pollution. The group also conducts studies to determine emission rates from fugitive sources into the atmosphere.

Mr. Fitz's research focuses on developing and applying methods to accurately measure trace pollutants in the atmosphere. He is currently the Principal Investigator on projects to evaluate ammonia emission rates from dairies, measure PM emission rates from vehicles on paved roads using on-board sensing instruments and evaluate methods to minimize particulate organic carbon collection artifacts. Mr. Fitz has also conducted studies to evaluate the exposure to pollutants when riding in school buses and how to minimize that exposure. He has over 30 publications in peer-reviewed journals.

HALL, FRED
US Enviromental Protection Agency

Fred Hall is a Senior Project Manager and Engineer for Environmental Quality Management, Inc. headquartered in Cincinnati, Ohio with eleven other offices, including Las Vegas. His major areas of experience are in projects dealing with control technology evaluation, fugitive dust measurement and control, evaluation of control strategies, and environmental control costs. He received his undergraduate degree in Chemical Engineering from the University of Kentucky and a Masters in Business Administration from Xavier University. He is a registered Professional Engineer in several states.

HUNTINGTON, GEORGE
Wyoming Technology Transfer Center

Mr. Huntington has a Bachelor's Degree in Earth Science from Dartmouth College and Bachelor's and Master's degrees in Civil Engineering from the University of Wyoming. He spent eight years with the Wyoming Department of Transportation, including five years as a materials research engineer in Cheyenne and three years as a project engineer in Sundance and Rawlins. In 2003 he went to work with the Wyoming T^2/LTAP Center where he has taught workshops on erosion and sediment control, soils, work zone traffic control, pavement design, and other topics. He has also worked extensively on the Center's asset management project. He has served on NLTAPA's Executive Committee for the past two and a half years where he co-chairs the Products and Services workgroup.

JAMES, DAVID, PHD
University of Las Vegas, Nevada

David James is currently Associate Vice Provost for Academic Programs and Associate Professor of Civil Engineering at the University of Nevada Las Vegas. He is a licensed Civil Engineer in the state of Nevada. Dave earned a B.A. in Chemistry from the University of Nevada, Las Vegas, and MS and Ph.D. degrees in Environmental Engineering Science from the California Institute of Technology. Dave has worked on dust emissions and controls since the mid-1990's, and has evaluated the long-term weathering performance of dust suppressants on vacant lands, the effects of water on dust-emission potential of desert soils, and measured dust emissions from paved roads in support of the Clark County Department of Air Quality and Environmental Management's efforts to develop and maintain a State Implementation Plan for particulate matter.

Speaker Bios

JOHNSON, EDDIE
Minnesota Department of Transportation

Eddie Johnson is a research project engineer with the Minnesota Department of Transportation. He holds a Masters in Civil Engineering from the University of Minnesota. He is specifically interested in aggregate roads, asphalt mixtures, and recycled materials and has authored or co-authored several publications and reports including: *Investigation of Winter Pavement Tenting; Investigation of Superpave Fine Aggregate Angularity Criterion for Asphalt Concrete; Flexibly Slurry-Microsurfacing System for Overlay Preparation: Construction and Seasonal Monitoring at Minnesota Road Research Project;* and *Special Practices for Design and Construction of Subgrades in Poor, Wet and/or Saturated Soil Conditions.*

JONES, DAVID, PHD
University of California Pavement Research Center

Dr. David Jones is a Project Scientist at the University of California Pavement Research Center (UC Davis and UC Berkeley), on assignment from the Council for Scientific and Industrial Research in South Africa. He manages the UCPRC Accelerated Pavement Testing facility and related research, as well as all research related to sustainability in the design, construction, and maintenance of transportation infrastructure. He maintains close involvement in unsealed road research in South Africa and other countries.

JUNGE, HIENE
South Dakota Pennington County Highway Department

Hiene started his career in road and bridge construction in 1968. He has been employed as a highway superintendent for 25 years. He is currently the Highway Superintendent of Pennington County, Rapid City, SD.

Pennington County covers 2,783 square miles and has a population of approximately 92,776. He is responsible for 1,800 lane miles of road, 138 bridges and supervises 50 employees.

Hiene is a past president of the National Association of County Engineers (NACE) 2006-2007 and has been a member of NACE since 1988.

He was President of the South Dakota Association of Highway Superintendents in 1990-1991, is chairman of their certification committee and is a member of the South Dakota Transportation Hall of Honor committee.

He has three children and just last month celebrated his 44th year of marriage to his wife LaVonne.

LANGSTON, RODNEY
Department of Air Quality & Environmental Management, Clark County, Nevada

Mr. Langston holds the position of Principal Planner with the Clark County (Nevada) Department of Air Quality and Environmental Management. Mr. Langston's work experience includes State Implementation Plan development, fugitive dust control measure development, air pollution control regulation development, and emission factor development over a sixteen-year period with air regulatory agencies in California and Nevada. He is an active participant in the Best Available Control Measures Working Group, the STAPPA/ALAPCO Criteria Pollutants Committee, and the Western Regional Air Partnership Dust Emissions Joint Forum. Mr. Langston holds a B.S. Degree in Biology with Environmental Studies Concentration and a Master of City and Regional Planning degree.

LONG, MICHAEL
TRB LVR Committee
Oregon Department of Transportation

For the past three years, Mr. Long has been the Project Delivery Manager for the Oregon Department of Transportation, Region 2, which includes 13,000 square miles of western Oregon. Mr. Long manages a program that includes project development and community affairs, engineering design, and construction, with a staff of 200 employees and a program budget of over $300 Million. His primary responsibilities are to keep over 150 projects on time and under budget, and to coordinate issues with locally elected officials and the public.

Prior to this assignment, he spent six years as the manager of the Oregon D.O.T. statewide Geo-Environmental Section in Technical Serves. His section was responsible for technical design standards, and regulatory agency coordination. During the previous ten years, he served as the geotechnical services manager, with the U.S. Forest Service, for six National Forests in Oregon. Prior to that, he worked six years as a project geologist with both the Oregon D.O.T. and the U.S. Forest Service.

Mr. Long holds undergraduate degrees in Geography and Geology from the University of Oregon and the State University of New York, Cortland, respectively. He was appointed by the Governor of Oregon to two three-year terms on the Oregon State Board of Geologist Examiners, and is a registered professional geologist and a certified engineering geologist in Oregon and Washington. He has published over a dozen professional papers, co-authored the National Slope Stability Design Guide for the U.S. Forest Service, and was featured in three Oregon Public Television programs on the environment.

Mr. Long currently serves on the National Academies, Transportation Research Board, as Chair of the Committee on Low-Volume Roads, and was Chair for the Ninth International Conference on Low-Volume Roads held in Austin, Texas in June 2007. Mr. Long is a Vietnam veteran and is married with four children (two of which are still at home). He enjoys boating and holds a Black Belt in Tae Kwon Do.

Speaker Bios

MAIN, MELVIN
Midwest Industrial Supply

Melvin Main has an undergraduate and graduate education in physics. He has spent over thirty years designing, developing and manufacturing complex electro-mechanical systems for both military and commercial applications.

Germane to this meeting is Mel's ten years of experience with the stiffness and modulus-based evaluation of geotechnical materials. He has initiated the use of such evaluation and corresponding QA/QC methods in support of the application of stabilized materials by numerous state and local DOTs.

POULIN, PHILIPPE
Universite Lavel, Quebec

Philippe Poulin obtained his Bachelor of Science degree from Université Laval (Québec) in August 2008. He is now a graduate student at the Department of Civil Engineering at Université Laval under the supervision of the researcher Pascale Pierre. His master subject deals with the performance of unpaved roads stabilized or treated with dust suppressants in a northern context

RUSHING, JOHN
US Army Engineer Research and Development Center

John has been employed by the Airfields and Pavements branch of the Geotechnical and Structures Laboratory at the U.S. Army Engineer Research and Development Center in Vicksburg, MS since 2003.

He received a B.S. in Polymer Science from The University of Southern Mississippi in 2003. John is currently finishing a M.S. in Civil Engineering from Mississippi State University.

His research areas include dust mitigation, asphalt pavement materials, pavement evaluation, soil stabilization, and contingency airfield preparation

SANDERS, TOM
Colorado State University

Not available at time of printing.

SKORSETH, KEN
South Dakota State University

Ken Skorseth has studied unpaved roads across the US and as far away as New Zealand. He has lectured on the subjects of Gravel Road Maintenance and Low Volume Road Maintenance to audiences of engineers, managers, elected officials and maintenance workers over the past 15 years. Ken first developed a Gravel Road Maintenance Course in 1989 and has lectured on that subject in many states since that time. He also served as the lead author of the FHWA *Gravel Roads* Manual and has presented the course to over 3000 participants. Ken has assisted in developing several other courses related to low volume road maintenance.

Ken has served on the Executive Board of the South Dakota Association of County Highway Superintendents (SDACHS), as the Region Eight representative on the Executive Committee of the National Local Transportation Assistance Program Association (NLTAPA), and is currently serving as the NLTAPA liaison to the National Association of County Engineers. He has also served on several SDDOT Research Review panels, the SDACHS Certification Committee, and as Coordinator of the annual Region County Road Conference.

Ken has spent nineteen years as the Field Services Manager at the South Dakota Local Transportation Assistance Program at South Dakota State University in Brookings, SD and is currently the Program Manager. He has twelve years experience in the highway and heavy construction industry and eight years as a County Highway Superintendent in Deuel County, SD. Ken is a graduate of Associated Schools of Miami, FL and Minnesota West Technical College, Canby, MN.

SURDAHL, ROGER
Central Federal Lands Highway Division

Roger Surdahl has worked since 1987 for the Federal Highway Administration (FHWA) in Baton Rouge, Louisiana; McLean, Virginia; Baltimore, Maryland; Washington, DC; and is now in Lakewood, Colorado with the FHWA's Central Federal Lands Highway Division Office.

He holds a Civil Engineering Master's Degree from Montana State University, and is a Registered Professional Civil Engineer in Colorado. Roger has been a construction inspector, material sampler and tester, construction supervisor, material engineer, and most recently, a Technology Deployment Engineer.

The Technology Program managed by Mr. Surdahl focuses on deploying solutions for transportation problems encountered on low volume roads. For results of his deployment studies visit www.cflhd.gov/techDevelopment. While Roger has a broad range of knowledge in many areas, his key interests are promoting geophysical imaging methods, preventing alkali-silica reactivity in concrete, stabilizing and controlling dust on unsurfaced roads.

Speaker Bios

VITALE, BOB
Midwest Industrial Supply

Bob Vitale founded Midwest Industrial Supply, Inc in 1975 and has spent the past 33 years providing the company its leadership and vision for providing the market with dust control and stabilization solutions that assist in the achievement of air quality and water quality goals.

In addition to his responsibilities of managing business basics Bob is responsible for the company's product development activities and has been responsible for the introduction of more than 35 innovative products. The company's emphasis has been environmental efficacy and reliable, predictable performance. In this role, he has had the company's products participate in and support programs including the US EPA Environmental Technology Verification Program, Canada Environmental Technology Verification Program, CalCert California Environmental Technology Certification Program, and Pennsylvania DEQ Dirt and Gravel Roads Program. He has included the new products in testing performed for US EPA by Midwest Research Institute, Desert Research Institute, San Diego State University, RTI International and for the US military by US Army Engineer Research and Development Center.

VITTON, STAN, PHD, PE
Department of Civil and Environmental Engineering, Michigan Technological University

Dr. Vitton has been at Michigan Tech for 14 years. Prior to Michigan Tech he was an Assistant Professor at the University of Alabama. He spent eight years with the Shell Oil Company in their mining company. He was the Engineering Manager for Shell's R&F Coal Mine located in Cadiz, OH for approximately four years. His first four years at Shell were spent on the development of surface coal mines located in the Powder River Basin. Dr. Vitton's PhD is in Civil Engineering (Geotechnical Engineering) from the University of Michigan, his MSE is in Mining Engineering (rock mechanics) and his BSE is in Geological Engineering both from Michigan Techchnological University.

WRIGHT, RON
Idaho Transportation Department

Ron Wright has over 30 years experience in laboratory operations. He has worked as a Bench Chemist, Quality Control Coordinator, Chief Chemist, Laboratory Manager, and Chemist Consultant for both independent and governmental laboratories. Ron graduated with a Bachelor of Sciences Degree in Chemistry from the University of Idaho in 1978. He is a participating member of the American Chemical Society, Steel Structures Painting Council, and the National Association of Corrosion Engineers. Ron is a founding member of the Pacific Northwest Snowfighters, which has developed chemical specifications for snow and ice control products. Ron has participated on several research pool fund projects either as a member of the Steering Committee or the Technical Advisory Committee. He has experience in the fields of analytical, environmental, and materials chemistry. Ron has worked for the Idaho Transportation Department since 1989 in the Materials and Research Laboratory. He currently manages the operations of the Chemistry Laboratory, Materials Section, within the Division of Highways for the State of Idaho.

APPENDIX C – EPA LETTER OF SUPPORT

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

December 31, 2008

Mr. Steve Albert , Director
Western Transportation Institute
P.O. Box 174250
Bozeman, Montana 59717-4250

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

Dear Mr. Albert:

I wish to commend you for your leading and sponsoring the Workshop, "2008 Road Dust Management Practices and Future Needs Conference" recently held in San Antonio, TX. As I discussed with you and others at the time, the Workshop created an essential national focus for networking between regulators, the transportation industry, and vendors of dust suppression/soil stabilization technologies. Another very positive result was the formation of a strategic plan with committed partners and a beginning list of specific projects on which to build. Guidelines, performance measures, specifications & protocols, and outreach are all essential parts of the national solution to dust issues.

I attended and spoke at the Workshop as the EPA person responsible for developing and improving emission factors and associated methodologies for the estimation of fugitive particulate emissions from roadways, construction, and similar activities. In this capacity, I foresee that PM10 and PM2.5 particulate emissions from public and private roadways and construction sites will become increasingly important components of air permits and State pollution control strategies. Moreover, President-Elect Obama has placed high priorities on construction and roadways in his infrastructure program. By their very nature, these will produce environmental problems through the generation of vast quantities of dust. It is thus very fitting that the regulating agencies, regulated entities, and the private manufacturers of control techniques join forces as quickly as possible to find common and workable solutions to these growing national issues.

Projects either being undertaken or planned by Department of Defense and associated military services strongly suggest the strategic need for a national Center of Excellence in the area of fugitive particulate emissions. A nationally known firm has indicated to me their interest in pursuing such a program and would welcome, I am sure, partners and joint ventures in such an endeavor.

I am planning to retire from the Environmental Protection Agency in early January and am now discussing succession of my responsibilities with Agency management. I plan to continue to be active in this field, however, after my retirement and can be reached at the following numbers: [redacted] Please feel free to call me anytime if I can be of help.

Sincerely yours,

John C. Bosch Jr.
Senior Engineer
Office of Air Quality Planning and Standards

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APPENDIX D – CONFERENCES PAPERS AND POSTERS

Available papers and posters are included here. PowerPoint presentations can be found online at http://www.wti.montana.edu/TechnologyTransfer/DustControl.aspx.

WELCOME/OVERVIEW

David Jones, University of California Pavement Research Center

Road Dust Management: A State of the Practice

KEYNOTE

Michael Long, Chair, TRB LVR Committee, Oregon Department of Transportation

Road Dust Management Practices: A National and International Perspective

SESSION A: DUST SUPPRESSION

Chatten Cowherd, Midwest Research Institute

Road Dust Control Performance Monitoring

Tom Sanders, Colorado State University

Road Dust Suppressants Research Results

Dennis Fitz, University of California Riverside

Evaluation of Dust Control Suppressants on Unpaved Roads Using Mobile Sampling

SESSION B: SOIL STABILIZATION

Melvin Main, Midwest Industrial Supply

The Predictable Nature of Materials Stabilized with Polymer Agents

SESSION C1: ENVIRONMENTAL IMPACTS OF DUST SUPPRESSANTS TO CONTROL DUST

Fred Hall, US Environmental Protection Agency

Investigation of Water Runoff and Leaching Impacts from Dust Suppressants

SESSION C2: PLANNING AND DESIGN FOR THE FUTURE

John Rushing, US Army Engineer Research and Development Center

US Army Corps of Engineers' Perspective on Planning and Design for the Future

P. Poulin et al, Civil Engineering Department, Universite Laval, Quebec

Field Study Evaluation of Granular Materials Treated with Dust Suppressants - Behavior Evolution under Traffic and Climate

Stan Vitton, Department of Civil and Environmental Engineering, Michigan Technological University

Control of Fugitive Dust Emissions in Surface Mining Operations

L. Beaulieu et al, Civil Engineering Department, Universite Laval, Quebec

Field Test Program of Stabilization on a Principle Forest Road

Eddie Johnson et al, Minnesota Department of Transportation

Investigation of Dust Control Practices in Minnesota

George Huntington et al, Wyoming Technology Transfer Center

Dust Suppression by Incorporating Reclaimed Asphalt Pavement (RAP) into Gravel Road Surfacing

Vic Etyemezian, Desert Research Institute

Measurement of Road Dust Emissions: The TRAKER and PI-SWERL Tools

ROAD DUST MANAGEMENT: STATE OF THE PRACTICE

D. Jones[1], D. James[2], R. Vitale[3]

[1] University of California Pavement Research Center, UC Davis, Davis, CA
[2] University of Nevada, Las Vegas, NV
[3] Midwest Industrial Supply, Canton, OH

This paper provides a background for the 1st Road Dust Management Conference, to be held on November 13 and 14, 2008, in San Antonio, Texas. It will be presented in the opening session to provide a platform for the following presentations, thereby eliminating the need for presenters to provide basic background information at the beginning of each presentation.

1. INTRODUCTION

There are millions of miles of unsealed roads around the world, which are managed by the national road authorities, state or provincial road agencies, local authorities, the forestry and mining industries, agriculture, national park authorities, and tourism, railroad, and utility companies. There are also numerous unproclaimed roads that no authority takes responsibility for, but which serve a need such as access to informal communities in developing countries. Unacceptable levels of dust, poor riding quality, and impassability in wet weather are experienced on much of this global unsealed road network, and although it is acknowledged that these roads are fundamental to the economies of almost every country in the world, many of the management practices followed leave much to be desired, with programs for dust control, chemical stabilization, low-cost upgrading, etc, largely overlooked. There are no comprehensive guidelines for implementing dust control programs.

Chemical dust control on unsealed roads has been researched for decades and there are numerous published papers documenting the establishment and monitoring of experiments. However, much of this has been agency-specific and mostly focused on assessing performance of one additive under a particular set of conditions. There are no specific comprehensive guidelines or specifications available to help practitioners with establishing longer-term dust control programs, identifying which type of additive would be most appropriate for a specific application, undertaking life-cycle analyses, quantifying negative environmental impacts and positive social benefits, designing appropriate treatments, applying the additive, and maintaining the treated road. Similar documentation for sealed roads has long been available and is continuously updated. Additionally, there is no national industry group serving the interests of additive manufacturers and suppliers, similar to the National Asphalt Paving Association (NAPA) and the American Concrete Paving Association (ACPA). There is no "owner" for documentation, procedures and test methods relating to chemical dust control, similar to the American Association of State Highway Officials (AASHTO), nor is there a sustained source of national funding for research to prepare this documentation and develop procedures and test methods.

Increasing concerns with regard to deteriorating air quality, the sustainability of repeatedly replacing gravel on unsealed roads, and the increasing costs of asphalt binders used for sealing roads have placed renewed interest on road dust management. Although upgrading the road to a sealed (asphalt surface treatment, asphalt concrete, or portland cement concrete) standard is always preferable and usually the most economic option in terms of life-cycle costs, the rapidly increasing costs associated with this practice results in less distance being upgraded each year. The application of various additives can provide satisfactory dust control on most road surfaces until such time as sufficient funds become available for a more permanent surfacing. Provided that appropriate construction and maintenance practices are followed, and the additives are rejuvenated at regular intervals, chemically treated surfaces are often structurally adequate to function as a base or subbase in a staged construction of a sealed road.

This paper provides a current status of global road dust management together with some points for consideration that may lead to wider implementation of dust control programs in unsealed road management initiatives. The paper includes discussion on the extent of unsealed road networks, the volume of dust generated, the consequences of dust, categorization of road additives, environmental considerations, and dust control research.

2. UNSEALED ROAD NETWORKS

There is no accurate estimate of the size of the global unsealed road network. Table 1 provides some estimates of the extent of unsealed road networks in the United States[1] (1st World, 9,6 million km^2), South Africa[2] (2nd World, 1,2 million km^2), and Tanzania[3] (3rd World, 0.9 million km^2), indicating the magnitude of global unsealed road management issues.

Table 1: Estimates of unsealed road networks (in kilometers)

Owner	United States	South Africa	Tanzania
Land area (km^2)	9,600,000	1,200,000	880,000
Sealed road network (km)	3,700,000	300,000	5,000
Unsealed road network (km)	2,700,000	600,000	85,000
State/county	850,000	150,000	81,000
Municipal	Unknown	200,000	5,000
Forestry	620,000	100,000	Unknown
Bureau of land management	130,000	-	-
Nature conservation/tourism	17,000	5,000	Unknown
Agriculture	Unknown	50,000	Unknown
Mine	Unknown	5,000	Unknown
Other*	Unknown	100,000	Unknown
* Includes service roads for railroad, powerlines, military, border patrol, other commercial activities, etc			

3. VOLUME OF DUST GENERATED

Documented studies in the United States indicate that as much as 50 percent of PM_{10} emissions and 19 percent of $PM_{2.5}$ emissions are attributed to road dust (Figure 1)[3]. Road dust is the single biggest source of PM_{10} emissions and approximately 65 percent of road dust emissions are attributed to unsealed roads. These percentages increase in developing countries that have higher proportions of unsealed roads, and are of particular concern in urban areas with predominantly unsealed infrastructure.

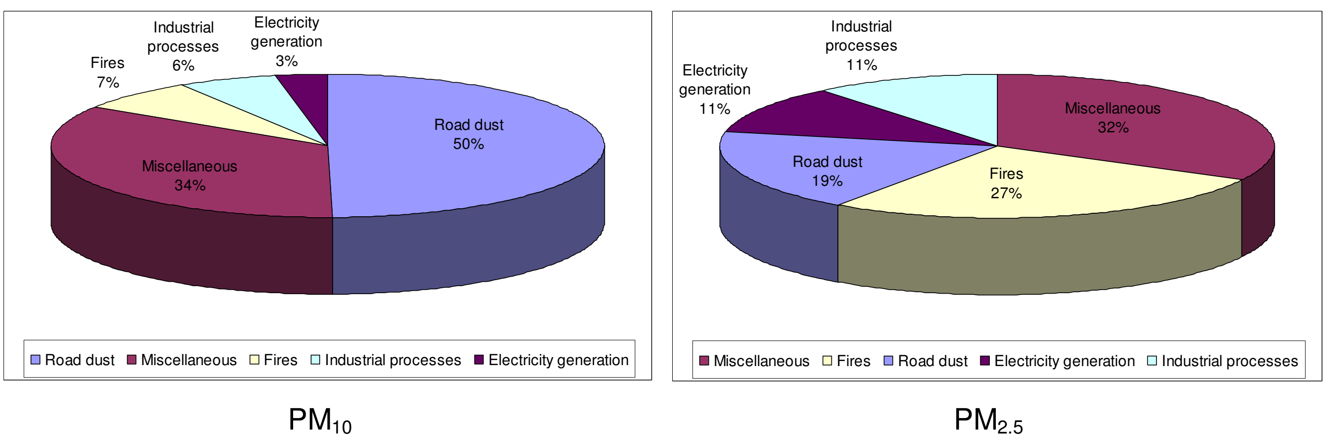

Figure 1: US PM_{10} and $PM^{2.5}$ emissions in 2002 by principal source category[3]

4. CONSEQUENCES OF ROAD DUST

Road dust is often considered only as a nuisance or minor safety hazard by many practitioners. However, using models developed by the United States Environmental Protection Agency[5] and calibrated in various countries[6], it can be shown that millions of tons of dust are generated on unsealed road networks every year. Although much of this dust falls back onto the road to be regenerated by the next vehicle, studies have shown that at least a third of it is permanently lost in the form of deposits away from the road (Figure 2), with losses increasing under crosswind conditions.

Figure 2: Fines lost from unsealed roads

Apart from the obvious consequences of reduced quality of life and increased safety hazard for road users, pedestrians, and workers, the loss of fines (which perform an integral material-binding function) from the road surface results firstly in accelerated gravel loss, thereby increasing the frequency at which the gravel has to be replaced, and secondly in more rapid deterioration of the riding quality of the road, thereby requiring more frequent grader maintenance[6]. This has significant economic and environmental implications in terms of regular regravelling programs. Other serious, but often overlooked consequences, include reduced agricultural and forestry yields. These are attributed to retarded plant growth, increased insect activity, crop blemishing, and reduced palatability of pasture and associated reduced yields in terms of dairy production. There are even published reports on accelerated tooth wear of animals grazing in pasture adjacent to unsealed roads[7]. Environmental consequences in terms of air and water pollution and associated health hazards, primarily those linked to respiratory diseases, are also significant, especially in developing countries where a large proportion of urban road infrastructure is often unsealed. Vehicle operating costs increase significantly in dusty conditions, with numerous publications compiled comparing the cost of operating vehicles in dusty and dust-free environments.

5. DUST CONTROL

Dust control can be achieved either by better selection of base and wearing course materials, mechanical stabilisation using two or more different materials to achieve a better particle size distribution and to increase or reduce the plasticity, or by applying a chemical dust palliative. Only chemical treatments are addressed in this paper.

5.1 Chemical Dust Control Categories

Numerous additives are available for dust palliation, improved compaction, and stabilization of unsealed roads. Most of these bind the fine particles together without any significant chemical reaction occurring in the soil, although certain additives will only perform once a chemical reaction has occurred. A number of additives are material and/or climate-dependent and costs vary significantly. It is therefore important that the bonding nature, limitations and life-cycle costs of these additives be investigated and their performance understood before widespread use is considered.

Most unsealed road additives are proprietary formulations, and information regarding their composition is often not readily available. This knowledge gap can limit the extent of applications if no clear information is available with regard to potential human and environmental impacts and in instances where competitive tendering is required. In order to facilitate research, technology transfer, palliative certification, classification of palliative types for different uses, climates and base material types, selection of appropriate additive type and application rate for particular conditions, and transparent and competitive bidding/tendering procedures, additives need to be categorized based primarily on their function and chemistry. A suggested categorization is provided in Table 2[6]. Similar categorizations are used by the US Forest Service[9] and the Environmental Protection Agency. A brief introduction to each category is provided below. Details on the stabilization mechanism and research on laboratory and field testing of each of these categories are discussed elsewhere in the literature.

Most road authorities cannot specify proprietary product names in tender documents. In order to facilitate implementation under these conditions, authorities could consider using category names in tender documentation if a design or experience dictates a specific type of application. Alternatively a performance specification (e.g. dust level reduction) can be used and the contractor can apply an additive of his own choosing, provided that it meets human and environmental safety requirements.

Table 2: Suggested road additive categories

Category	Sub-categories	Examples
Dust palliatives	Water and wetting agents	-
	Hygroscopic salts	Calcium, magnesium or sodium chloride
	Natural polymers	Lignosulfonate, molasses, tannin extracts
	Synthetic polymer emulsions	Acrylates, acrylics, vinyl acetates
	Synthetic oils	Mineral oils, synthetic iso-alkaines
	Petroleum resins	Blend of natural polymer and petroleum products
	Bitumen, asphalt and tar	-
	Other	Industrial wastes
Compaction aids and stabilizers	Synthetic polymer emulsions	Acrylates, acrylics, vinyl acetates
	Synthetic oils	Mineral oils, synthetic iso-alkaines
	Sulfonated oils	-
	Enzymes and biological agents	-
	Bitumen, asphalt and tar	-

5.1.1 Dust Palliatives

Dust palliatives can be applied either as a topical application to a prepared road surface, as a mix-in treatment to an existing road, or mixed into the material during construction or regravelling. Mix-in treatments typically provide significantly improved performance compared to topical applications. Standard engineering considerations such as adequate compaction, road shape and drainage should not be overlooked in the application process. If topical applications are used, it should be remembered that applying additives to roads in poor condition will result in some dust reduction, but will not correct ride-related issues. Depending on the degree of compaction on the surface of the road, topical applications are best applied as a series of light applications over a period of time, rather than in a single application, to ensure adequate penetration of the additive.

- **Water and Wetting Agents:** Water is probably the most commonly used dust suppressant, especially on mines and on industrial sites where it is an effective means of disposing of contaminated water. Surfactants are occasionally added to reduce the surface tension and allow more rapid distribution of the water through the soil. However, in many instances evaporation results in regular applications being necessary to maintain the required level of dust control. This can have a detrimental effect on road performance, including erosion and segregation of fines, which leads to ravelling of the surface material.

- **Hygroscopic Salts:** These additives, which include calcium chloride, sodium chloride and magnesium chloride, absorb moisture from the atmosphere and bind the material particles together, thus preventing them becoming entrained by air associated with moving vehicles.
- **Natural Polymers:** Natural polymers are by-products from a sulfite process commonly used in the pulp and paper industries, from tannin extraction, sugar refining and other plant processing industries. Their composition is variable and depends on the vegetable matter and chemicals used during processing. When used as dust palliatives, they physically bind the particles of the road together, thus preventing them becoming entrained by vehicles. These additives are usually soluble in water.
- **Synthetic Polymer Emulsions:** Synthetic polymer emulsions, or more correctly, polymer dispersions, are suspensions of synthetic polymers in which the monomers are polymerised in a dominantly aqueous medium. Particles are typically 100 nm in size and comprise many individual polymer chains. Numerous formulations have been developed for various soil "conditioning" applications, many of which are potentially suitable for dust control, gravel preservation and strength improvement on unsealed roads. A number of products are currently available, which "glue" the soil particles together to prevent entrainment by vehicles. Strength gains may be achieved, depending on product formulation and application rate and method.
- **Synthetic Oils:** Synthetic oils include base fluids, mineral oils, and unique formulations of synthetic iso-alkaines. They are insoluble in water and are applied to the road surface in undiluted form. Once applied, they agglomerate particles preventing them becoming entrained by air associated with moving vehicles. Synthetic iso-alkaines also provide a chemical bond between aggregates further preventing entrainment and reducing the effects of surface water.
- **Petroleum-Resins:** Petroleum resins are usually a blend of natural polymers and petroleum based additives. They have a similar binding action to natural polymers, but are more resistant to leaching by water.
- **Bitumen, Asphalt and Tar:** Bituminous additives are offered by most petrochemical and asphalt suppliers as part of their product line. Products range in price and durability from simple spray-on applications that will last approximately four weeks before requiring rejuvenation, to thicker applications that can be blinded with sand, which perform similarly to sand seals and which can last up to three years before requiring rejuvenation. Tar-based additives are derived from coal tar or synthetic fuel distillates to which solvents are added to improve penetration. They are used in a similar way to bitumen additives, however, tars, in

general, are known carcinogens and hence their use could have serious health and environmental implications. Their source, composition and potential carcinogenicity should be established prior to considering their use on roads.

- **Other chemicals:** Various chemicals, which cannot be categorised in the list provided above, are introduced to the road industry from time to time. These are usually waste products that are "sticky" and which the suppliers believe will act as effective dust palliatives. Their dust control properties are often "discovered" accidentally during spills or dumping in evaporation ponds and it is these experiences that form the basis for marketing them as road additives. Waste motor and bunker oils, both of which have been used in the past for dust suppression on unsealed roads, are included in this category. Numerous studies have shown significant negative impacts on groundwater and surrounding vegetation, and therefore they should not be used on roads under any circumstances. The Times Beach, Missouri clean up in the 1970's and 1980's, which cost hundreds of millions of dollars to remediate and required demolition and relocation of the entire town, resulted from spraying of dioxin-contaminated oil as a dust control agent on the towns unsealed roads and vacant lots.

5.1.2 Compaction Aids and Stabilizers

Compaction aids and stabilizers are typically applied as a mix-in treatment. Little benefit will be gained by applying these additives as a topical application.

- **Synthetic Polymer Emulsions:** See above
- **Synthetic Oils:** See above
- **Sulfonated Oils:** These additives contain mostly mineral oils, which have been modified with sulfuric acid to form sulfonic acids. Research has shown that the stabilization process is relatively complex and material-dependent. The two properties that potentially make sulfonated oils useful in soil compaction and stabilization are their ability to displace and replace exchange cations in clay and to waterproof clay minerals by displacing the adsorbed water and preventing re-adsorption. Suppliers claim that the additives improve the soaked strength of high plasticity soils and thus their wet-weather passability.
- **Enzymes and Biological Agents:** These additives vary widely depending on their formulation and intended use. In roadway applications, enzymes are mostly used as surfactants to lower the interfacial tension between the surfactant-dosed water and soil particles, thereby increasing capillary penetration into the soil. It is also claimed that some products contain microbes that extract mineral traces from the soil to produce exocellular

polysaccharides, which can act as natural "glues" to bind adjacent soil particles. This could improve the soaked strength of the soil and hence wet-weather passability.

- **Cementitious and Bituminous Stabilizers:** Cementitious (cement and lime), bitumen and tar products have been widely researched. Specifications and guidelines on their use in road material stabilization have been extensively published and are readily available. They are generally unsuitable for unsealed road treatments, but are widely used in improving marginal materials when unsealed roads are upgraded to a sealed standard.

6. ENVIRONMENTAL CONSIDERATIONS

There are significant environmental benefits associated with road dust control, including reduced particulate matter and the preservation of scare natural resources. However, care must be taken to ensure that the use of road additives will not have any significant negative environmental impacts. Potential environmental impacts include plant and animal toxicity, contamination of water resources, and corrosion of infrastructure and vehicles.

No internationally recognized laboratory or field procedures have been specifically developed for assessing the environmental impacts associated with the use of road additives[10]. However, a number of initiatives, mostly voluntary, have been established with a view to assessing potential impacts associated with road dust control (e.g. The Environmental Protection Agency's Environmental Technology Verification program), while a number of state EPA's require some form of product assessment before they can be applied. However, the laboratory procedures are based on those developed for other applications, such as assessing leachates from landfills and although in some instances these are practically appropriate, the lack of a single standard complicates the comparison of additives for a given application. The tests often provide a very worst-case scenario that is often not remotely realistic in road applications, resulting in potentially beneficial additives being excluded from use. A number of field trials have been carried out in the United States and elsewhere to assess runoff characteristics, but the findings are typically dependent on a multitude of factors and hence interpretation of the data and extrapolation of the findings to other regions is difficult. There is also no process for deciding whether the benefits of road dust control outweigh the potential negative impacts associated with an application. The problem is exacerbated for those additives that require periodic rejuvenation resulting in residual product build-up over time.

7. DUST CONTROL RESEARCH

The first reported chemical dust control experiments (i.e. those other than water spraying, which probably dates back to Roman times) occurred in the early 1900's, when chlorides[11] (calcium, magnesium, and sodium) and then lignosulfonates[12] were applied to road surfaces to reduce dust emissions from passing vehicles. No significant new dust control products appear to have been introduced in the period between the 1930s and 1960s, but in the 1970's and 1980's, numerous chemical additives were introduced to the road industry. These included natural and synthetic polymer emulsions, oils and resins, sulfonated oils, enzymes, and various petroleum-based products. Proprietary products, primarily based on these technologies continue to be introduced.

Over the years, varying levels of research have been conducted on the array of dust control and stabilization additives listed above, by additive developers, road owners, and independent researchers. Since the 1920's, thousands of laboratory studies and full-scale field experiments have been undertaken, and numerous publications prepared on the findings. However, implementation in the form of improved road management practices is almost non-existent world-wide, with no clear indication of why road authorities do not consider chemical improvement a standard practice, despite research continually proving the operational, economic and environmental benefits. For example, the conference proceedings of the 1932 Highway Research Board meeting[13] included a paper on the effectiveness of calcium chloride as an unsealed road additive. A literature review of subsequent Highway Research Board and then Transportation Research Board (TRB) publications up to and including the proceedings of the 2006 TRB Low-Volume Roads Conference[14] reveals that calcium chloride experiments continued to be established and monitored, and that papers on their performance continue to be published at regular intervals. However, road authorities appear no closer to wide-scale implementation of calcium chloride (or any other additive) than they did in 1932. This appears to be attributed in part to the establishment of experiments to assess performance under a particular given set of circumstances, as opposed to establishing them to identify boundary conditions of performance and develop guideline documentation and specifications. Despite this observation, valuable data on issues such as comparing performance of topical applications with mix-in treatments[15], stabilization mechanisms[16], and potential environmental impacts[17] have also be collected and documented in many of these studies, which if appropriately analyzed, would contribute significantly to the preparation of appropriate documentation.

Conversely, other strategies for low-volume road construction and management such as soil stabilization with cement, lime, and asphalt emulsions, bituminous surface treatments (sand and chip seals), and full-depth recycling (foamed asphalt, asphalt emulsion, and cement and lime), which were all developed long after basic chemical dust control, are widely implemented. Quality design guides and specifications for these strategies have been prepared at state and national levels in many countries; little or no new experimentation is being conducted, and design engineers consider them in their choice of alternatives as a matter or course. The number of TRB publications on topics such as low-volume road cement stabilization and chip seal design were considerable at the time of the research studies, but have since dwindled to papers on specific project implementation or the development of new test methods and design tools.

7.1 Certification of Additives

A number of initiatives have been taken in various countries in an attempt to overcome this lack of implementation. One such initiative is that of fit-for-purpose certification[8], which entails reviewing the research conducted on a specific additive and the documentation developed from it to determine whether sufficient information is available for an engineer or manager to make an informed decision on its use as a potential alternative in a road design or for maintenance. Certification systems are also used to ensure that additives comply with certain minimum standards, particularly those related to potential environmental impacts. A series of laboratory control tests are usually carried out as part of the review process. The procedure is based on a relative performance evaluation methodology, which:

- Provides potential users as well as manufacturers and suppliers with a measure of the performance of the submitted additive relative to the performance of a range of additives, as well as to the standard specifications of conventional additives.
- Identifies strengths and limitations of the submitted additive, thereby better defining suitable applications
- Facilitates judgement regarding the engineering and economical advantages of using the submitted additive instead of more conventional products

The process typically involves the following:

1. Establishing a technical assessment team
2. Assessing the manufacturers quality management system
3. Assessing environmental compatibility and validity of the material safety data sheet

4. Reviewing research procedures followed and background research that has been conducted
5. Reviewing guideline documentation
6. Control testing
7. Issuing a fit-for-purpose certificate
8. Post-certificate monitoring

Fit-for-purpose certification is ***not*** intended to serve as a formal acceptance or rejection of an additive based on an absolute performance evaluation. It also does ***not*** serve as a guarantee of performance, ***nor*** does it obviate the need to carry out an engineering investigation, including material testing, for every project where the use of the additive is considered.

8. THE WAY FORWARD

There is no clear way forward to ensure that road dust management initiatives will be implemented on a wider scale than current practice. A number of suggestions are offered for consideration. These are mostly institutional reforms and include:

- An "owner" of unsealed road guidelines, specifications, test methods, and management principles needs to be identified and encouraged to take an active role in ensuring that funding dedicated to unsealed roads is used optimally and sustainably. Gravel retention, good riding quality, and safe driving conditions, all of which are enhanced through appropriate dust management programs are key issues to be considered.
- The manufacturers and suppliers of dust palliatives and non-traditional stabilizers should establish an industry body similar to NAPA, ACPA, and other such institutions. This organization could initiate "ownership" as described above, educate road authorities and road owners, introduce procedures for regulating the industry, hold workshops, training course, and seminars, etc.
- A dedicated environmental protocol detailing procedures to be followed for assessing potential environmental impacts of road additives needs to be developed and approved by relevant agencies. This should include appropriate test methods, as well as a procedure for comparing potential benefits against potential impacts. A standard, auditable format for presenting the results will provide road authorities and owners with an appropriate means for deciding on the use of an additive.
- A dedicated research protocol establishing a minimum requirement for research on an additive before it is no longer considered as experimental should be introduced to the

industry and could serve as a basis for fit-for-purpose assessment. This protocol should include procedures for additive description and categorization, literature reviews, laboratory screening, detailed laboratory studies of performance and environmental impacts, full scale field experiments, data analysis and guideline documentation.

- Guidelines and specifications covering road dust management procedures should be prepared in a format that is acceptable and adoptable by county engineers, the US Forest Service, the Bureau of Land Management, the mining industry, etc.
- A module on unsealed road management practices should be written and offered to colleges and universities offering transportation engineering courses.

9. CONCLUSIONS

Road dust control and unsealed road stabilization are significant road management issues. Although considerable experimentation on a variety of chemical additives has been carried out in the last 70 years, very little wide-scale implementation has taken place. There are many reasons for this, including the absence of a national authority, a fragmented industry, and a lack of funding for programs amongst unsealed road authorities and owners.

This conference is aimed at bringing practitioners together to discuss road dust and adjacent area management issues, road dust best management practices, knowledge gaps, research needs, barriers to implementation, and identification of future needs. Participants will attempt to explain why chemical dust control and unsealed road stabilization has not progressed to the point that road authorities can implement wider-scale programs with confidence. Remedies will be sought to initiate the development of nationwide administrative structures, information resources, and consistent experimental and maintenance protocols that, in a manner similar to those already in place for paved/sealed roads, will facilitate the adoption of standards and practices that will improve performance, and reduce both maintenance costs and environmental impacts of unsealed roads. The conference is not intended to be a platform for reporting on another round of experiments, but rather a forum for identifying and overcoming the barriers to wider implementation of the results and recommendations of the past 100 years of research.

A “white paper” documenting the discussion and the recommendations for a way forward will be published after the conference.

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Road Dust Management Practices
A National and International Perspective

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ABSTRACT

Dust control management is no doubt one of the elusive challenges that have not been resolved in any comprehensive manner. Scale and resources are always operative factors in an agency's will, or ability, to adopt reliable systematic measures. On the matter of scale, global geography, geology and weather conditions have, and always will be, the un-controllable factors. However, at the project or road system level, unsealed road surfaces often stand on their own as the prime generator of dust particles. In some circumstances they may be conveyances of dust by wind, water, and transport from other adjacent activities such as mining, construction, demolition, farming and aviation. In order to comprehensively manage these activities, the components of health and safety, environmental impacts, product selection and reliability, application techniques, cost-benefit analysis, and asset management must in some way all be considered. In a disconnected framework, several states, individual counties, and the international community is facing the challenge, each placing more-or-less emphasis on one or more of the components and solutions. This paper will discuss a sampling of just some of the attempts of those agencies.

INTRODUCTION

"Dust" a general term relating to particles smaller than 10 micrometers (PM10) that are susceptible to airborne transport. Cosmic dust, coal dust, domestic dust, even *"pixie dust"* (1) has all had a part in our collective cultures. Metaphoric religious references to dust are still part of most eulogies today. Our concern however is Road Dust and the management of it. On a global scale, road dust is a small generator of the overall world-wide dust volume. Remote sensing now gives us a clear understanding of the magnitude and scale of global dust transport (Figure 1). Mega dust storms from the Sahara desert can be traced to deposits in Florida that have had an effect on the severity of thunderstorms and hurricanes in that area (2, 3).

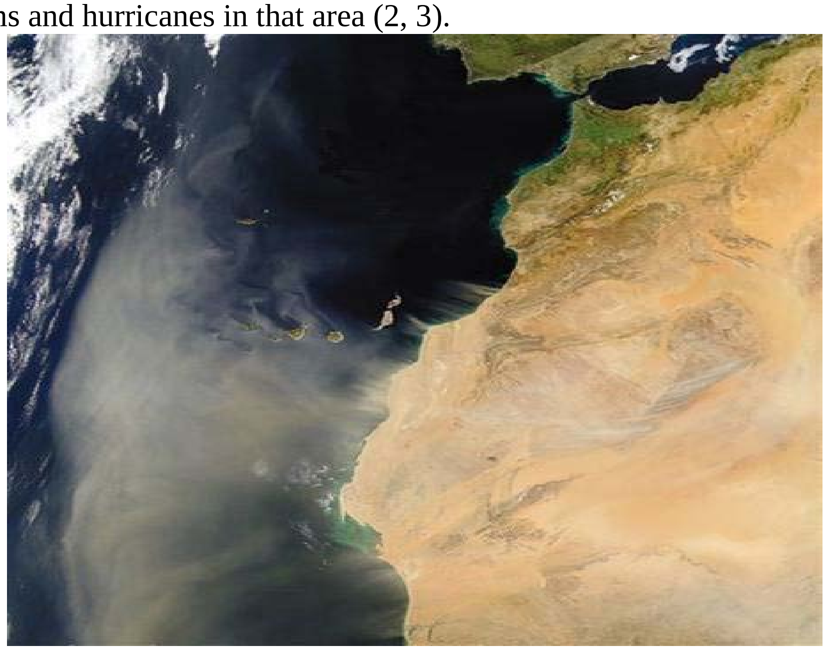

Figure 1. Dust storm blowing off the Saharan west coast of Africa toward the Canary Islands and Florida (NASA photo library)

NASA scientists have also concluded that global climate change produced a temperature differential between the tropical Atlantic and Pacific oceans that were the cause of the great dust bowl in the American Midwest between 1931 and 1939 (Figure 2). The temperature differentials produced large scale weather patterns that inhibited the amount of moisture from the Gulf of Mexico, and subsequently the amount of rain that reached the Great Plains (4).

Figure 2. Texas Dust Bowl era storm (NASA photo library)

U.S. STATE AND COUNTY PROGRAMS

One of the earliest accounts in U.S. “Road Dust Management” history comes from Massachusetts (5):

> *1909 July 25 New York Times, New York, New York*
> *Lenox, MA – "Mrs. William Pollock has caught the fancy for dustless roads from the experiments carried on by the Lenox and Stockbridge authorities, and at her own expense has oiled a mile of highway on Holmes Road, fronting her Holmesdale property, setting an example for the rest of the rich property owners. The experiments carried on by the Lenox village association in sprinkling highways with calcide has proved a failure in Lenox and has been abandoned. This new movement for dustless roads is largely due to the increased number of automobile tourists and the wearing of the surface of the highways by the travel and suction caused by the heavy motors.*

Virginia

According to Mr. William Bushman, former unpaved roads manager for the Virginia D.O.T. for over 17 years, VDOT manages over 18,000 miles of unpaved public roads (6). Based on the South African philosophy of “minimizing aggregate loss” and recommendations by Dr. David Jones, they implemented a comprehensive road management program which includes deep mixing of soil stabilizers. *"If one takes that approach and crafts the maintenance activities appropriately, then dust is not an issue."* This philosophy was validated through their research in Loudoun County, Virginia (7).

Others agree with this. *"And the more dust that leaves your road surface, the less road surface that remains. As dust departs, aggregates and other fines loosen, leading to surface woes and costly replacement with new gravel* (8).

Missouri

The work done by Freeman and Bowders (9,10), shows some promising results to prevent silt-sized particles from migrating up from the subgrade into the surfacing rock by placing a geotextile layer between the base course and the surfacing course (Figures 3, 4, 5).

Figure 3. Geotextile layer installed prior to surfacing.
(Photo courtesy of John Bowders)

Figure 4. Surface layer placement
(Photo Courtesy of John Bowders)

Figure 5. Minimized dust generation from vehicle (Photo courtesy of John Bowders)

Their studies showed that a geotextile layer was successful in maintaining lower silt content in the surfacing layer which resulted in a 50 to 75% reduction in emissions. They went on to conclude that *"In essence, the geotextile could provide low maintenance, long term dust control for the gravel road."*

Kansas

But the unpaved roads that generate dust exist primarily because the rural jurisdictions in which they occur never could afford to pave them in the first place. These road departments may be unable to generate the funds needed to control dust." (11).

Funding maintenance activities has been a long standing challenge for most rural road managers. Since 1989, most counties in Kansas have developed a "cost share" with home owners for dust treatment in front of rural residences in which the county provides the service for a fee. The statement that *"Counties in Kansas are not required to control dust on county roads. No county in Kansas has a free dust control program."* is the underlying fact in the cost-share programs. The rates of cost-share can range from one-third to almost full cost. For example; Magnesium Chloride treatment in Pottawatomie County in 1999 cost the residence only 30 cents per linear foot. The rates in Miami County in 2007 however had risen to $5 per linear foot for asphalt oil and $1.50 per foot for Magnesium Chloride while Coffey County only charged 90 cents per foot in 2007 (12,13,14).

Oregon

Similarly in Oregon, counties promote and regulate the application of dust suppressants by rural residents, however the entire cost and contracting is born by the resident. As an example, Coos county established a county dust abatement policy in 2002 (15) that says:

> *AND IT FURTHER APPEARING to the BOARD that it would not be fiscally possible or desirable to make free dust control to all County residents, but recognizes the importance of dust control, and as such is prepared to allow persons to treat sections of County Roads with a product to control dust, at their own cost, subject to the policies stated herein below.*

INTERNATIONAL ISSUES

Niger

An interesting study that was conducted in Nigeria illustrates the ingenuity of road managers in developing countries to adapt local materials for road maintenance uses (16). The oil palm tree is a common variety that grows extensively in West Africa. Palm Oil is extracted from the fruit of the tree and is used to make a wide variety of commercial products including soap, candles, and margarine. The residual by-product from the extraction process is the shells from the seed kernels of the fruit.

A number of passenger vehicles were used to obtain baseline dust generation samples from untreated sections of the unpaved Minna to Saukankahuta road and were run at speeds ranging from 30 to 80 kph to collect samples. A volume of palm oil seed kernels were then placed on five controlled sections of the unpaved road in 5 meter sections to a depth of 30mm, and the vehicles run within the same speed range for five days. Samples were collected hourly for the duration of the test. Results showed that after five days, the palm kernel shells were effective in reducing the volume of dust generation by 75%; however, no long-term tests have been conducted to determine the durability or longevity of the material.

Cameroon

Regardless of the geography or resources of a country, public outrage is a common theme wherever dust control is not implemented as part of routine maintenance, or a construction project plan. An example of uncontrolled fugitive dust during construction that caused a major disturbance in the local population occurred during construction of the Mutengene-Muea road in Cameroon, West Africa. (17) *"Anthony Akari, an inhabitant of Bomaka said: 'We are suffering a lot from the dust caused by the road construction. The workers go about their job without watering the road. Dust gets into our houses…right into our wardrobes. It has given us chronic cough. For that matter the locals said they mobilized at one moment and blocked the road to compel the road builders to start watering the road."*

Another example from Cameroon of an angry public outcry occurred: "*Graded a few years ago, the stretch of road after Long Street toward Bishop Rogan College is another dust blower. The locals in a bid to slow down speeding vehicles that churn up the dust have arranged stones on the road. Thus, motorists are forced to slow down and dodge around them."*

South Africa

As was mentioned, the South African approach to "minimizing aggregate loss" on public roads is a comprehensive approach to road design and maintenance including deep mixing of soil stabilizers, and the standardized evaluation of non-standard products for selection purposes (18, 19, 20,). In the mining industry, however, just keeping up with fugitive dust emissions during mining activities is a full time activity. In order to reduce vehicle accidents, (amounting to 74% of surface mining accidents with dust as a significant cause), and to mitigate worker health and safety issues, a comprehensive strategy has been developed to set criteria for water-based applications, and an economic evaluation method for cost effectiveness for selection and use of chemical dust palliatives to rejuvenate wearing surfaces to original specifications (21).

Selection Guides and Environmental Issues

Much work has been completed regarding selection guides, best application techniques, maintenance practices, and performance and laboratory testing, by international researchers, U.S. Federal Agencies, the Transportation Research Board, and State Local Technology Assistance Program Centers. These works are well known and well established in the literature. Health and safety of the public and those involved in construction, application and maintenance, and risks to long-term environmental damage of dust palliative and soil stabilization products have been in debate for over 35 years, since the 1973 Time Beach, Missouri disaster where waste oil, contaminated with dioxin, was used as a dust suppressant in a residential neighborhood which resulted in decades of litigation and a superfund cleanup site that cost over $80 million (22). Both of these issues continue to create ad hoc guidance as evidence and new products emerge.

Summary

Dust suppression and soil stabilization has matured to a point in time where they are a major component of short and long-term road design and maintenance programs. In the words of Mr. Melvin Main of Midwest Industrial Supply, Canton, Ohio, and echoed by many in all sides of the industry,

> *"…what's needed is a comprehensive approach to road improvement (design along with preservation of fines and surface smoothness) …Environmental performance…it would seem to me that a standardized set of criterion should be promoted by TRB and developed by ASTM that all users and suppliers could look to as a comparative gauge of environmental performance." (23)*

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Road Dust Control Performance Monitoring

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Abstract

Traffic-generated dust emissions from unpaved roads constitute a major national source of PM_{10} emissions. Unpaved road dust emissions can be reduced by a variety of means including the application of petroleum-derived and other chemical binders to the road surface. The performance of chemical stabilizers depends on the structure of the road base and the surface material including the degree of surface compaction. Control performance also depends on the traffic conditions, including vehicle weight and speed and the average daily traffic count. The accepted surrogate for road dustiness is the silt content of loose surface material, which is defined as the fraction of the material passing a 200-mesh screen upon dry sieving. Typically, chemical stabilizers or other forms of dust control need to be reapplied periodically to maintain the desired average emission control efficiency.

This paper describes a field testing program that was conducted to determine the long-term control effectiveness of common types of chemical stabilizers applied to unpaved roads. This program was conducted as part of EPA's Environmental Technology Verification Program. The test road segments were located on a driver training course at Ft. Leonard Wood in southeast Missouri and on a public unpaved road in Maricopa County, Arizona. The application of each dust suppressant followed the recommendations of the manufacturer.

A mobile monitoring system on a test vehicle was used to determine average control efficiencies over treated road segments. Prior to performance testing of road dust suppressants, the mobile monitoring system was validated against the traditional EPA reference method to assure statistical comparability. Dust suppressant performance testing measured seasonal variations in control effectiveness, noting whether the dust controls had been reapplied during the period between testing. Uncontrolled road segments were used to establish the comparison baseline for road dust control performance. The paper presents information on road dust control performance for the five chemical stabilizers tested.

Background

Characterizing the dust control effectiveness of palliatives requires measuring the source emission strength of both the treated unpaved road surface as well as the untreated road (i.e., experimental control). However, several features inherent to open dust sources (as opposed to more traditional stack sources) complicate the situation:

1. Unlike stack emission sources with "end of the pipe" controls, it is not feasible to measure the uncontrolled emissions and the controlled emissions simultaneously on the same road. If simultaneous testing is performed, two road segments of the same characteristics are required.
2. Next, all unpaved road dust suppression is time-dependent, decaying from roughly complete control at the time of application to essentially no control after some period of time (ranging from hours in the case of watering to months for chemical dust suppressant and years for paving). Thus, no single set of measurements can characterize the long-term, average control performance.
3. The extended period of time necessary because of item 2 further complicates the situation. The treated road surfaces are exposed for a long period of time to the environmental conditions (ranging from precipitation to water erosion from roadside areas) that may affect performance of the palliatives.

Historically, road dust control performance data have been gathered using a technique known as roadside plume "exposure profiling." Roadside plume profiling relies on simultaneous multipoint measurements of particulate concentration and wind speed over the vertical extent of the dust plume to determine the mass of particulate matter that is emitted by a "unit" of vehicle activity on the roadway. Profiling produces an emission factor in terms of pounds per vehicle-mile-traveled (lb/vmt). The emission factor indicates that "*x*"pounds of airborne particulate are generated by a vehicle traveling a distance of 1 mile over the road.

Although profiling produces the most reliable emissions rate information, the method suffers from some disadvantages. First of all, profiling measurements are labor-intensive, and the inherent decay in unpaved road dust suppressants requires that the measurements be undertaken several times after application. Next, profiling places severe physical constraints on acceptable test sites. For example, roads suitable for exposure profiling must (1) be located in areas with open wind fetch; (2) be oriented perpendicular to the prevailing wind direction; (3) have no more than a gentle curve; and (4) have no significant upwind particulate matter (PM) sources in the immediate vicinity. Thus, in terms of defining control performance, the profiling approach provides very accurate data but at relatively high cost and at the exclusion of many potential test locations.

However, because quantifying dust control performance does not require absolute emission rates, there are other simpler on-board test procedures with significant labor savings that provide information on **relative** rather than **absolute** emission rates. These procedures are also suitable for determining road dust control efficiencies by testing controlled and uncontrolled roadway segments and determining emission reductions attributable to the dust control.

This paper describes an on-board mobile sampling method for evaluating road dust control performance, as developed by Midwest Research Institute (MRI) with funding from the US Army Construction Engineering Research Laboratory (CERL). The on-board method was subsequently used to evaluate five chemical dust suppressants for unpaved roads, under EPA's Environmental Technology Verification Program at test sites in Missouri and Arizona.

Conceptual Design and Development

In designing the new test method, initial conversations with CERL confirmed that the mobile sampler should have the following attributes:

1. **The device should collect samples in the three particle size ranges of regulatory interest: PM-10, PM-2.5, and PM-30.** As used in this context, "PM-*x*" refers to particulate matter no greater than *x* microns in aerodynamic diameter.
2. **The device should be based on a well-characterized sampler.** Such a sampler, MRI's "hybrid sampler," is described below.
3. **The focus must be on particulate matter that is airborne and capable of being transported away from roadway.** Other samplers developed to mount directly behind a wheel and only slightly (approximately 1 ft) above the road surface [1,2] are directed toward the quantification of total roadway material depletion and nearby deposition. By contrast, the mobile sampling system is positioned farther behind the vehicle and well above the road surface to place it in the vehicle wake dust plume.
4. **The method should be as reproducible as possible.** To the extent practical, sampler operation should avoid or "even out" potential systematic biases and minimize measurement variability
5. **The device should not require extensive amounts of equipment, be relatively easy to operate and require no more than approximately 1 hr per test.** Exposure profiling tests of highly controlled unpaved surfaces typically require 2 to 4 hr of sampling duration.

MRI's "hybrid sampler" constituted the focal point for the mobile sampling system. The hybrid sampler was first developed in 2000, originally for use in an EPA-sponsored test of emissions from mud/dirt tracked out onto public streets from construction sites[3]. The device incorporates a commercially available PM-2.5 sampler into a high-volume air sampler to simultaneously collect and aerodynamically separate collected airborne dust into PM-10, PM-2.5, and total particulate (TP) size fractions.

Figure 1 shows a schematic representation of the device in which a URG-2000-30EH cyclone is coupled with the high-volume cyclone preseparator. The high-volume cyclone preseparator exhibits a D_{50} cutpoint of approximately 10 micrometers in aerodynamic diameter (μmA) at a flow rate of 40 actual cubic feet per minute (acfm)[4], and thus collects a PM-10 sample on an 8-in by 10-in glass fiber filter. The URG device exhibits a D_{50} cutpoint of 2.5 μmA at a flow rate of 16.7 liters per minute (lpm) and thus captures PM-2.5 on a 47-mm filter. By positioning the URG intake below the outlet tube of the high-volume cyclone, the URG unit was protected from large particles entering the cyclone that might otherwise overwhelm the URG unit. In this arrangement, the URG unit samples a small portion (approximately 1 to 2 %) of the cyclone effluent. As part of the 2000 EPA study, the hybrid sampler underwent field and laboratory evaluations to determine reproducibility of the device in a "near-source" (i.e., high concentration) service environment and to confirm the URG's cutpoint when sampling the effluent of the high-volume cyclone.

In addition to the PM-10 and PM-2.5 samples, the high-volume cyclone body collects coarse particulate matter (> PM-10). To determine the weight of material that collects on the interior of the cyclone, the cyclone is washed with distilled water. The entire wash solution is passed through a Büchner-type funnel holding a tared glass fiber filter under suction. This ensures the collection of all suspended material on the filter.

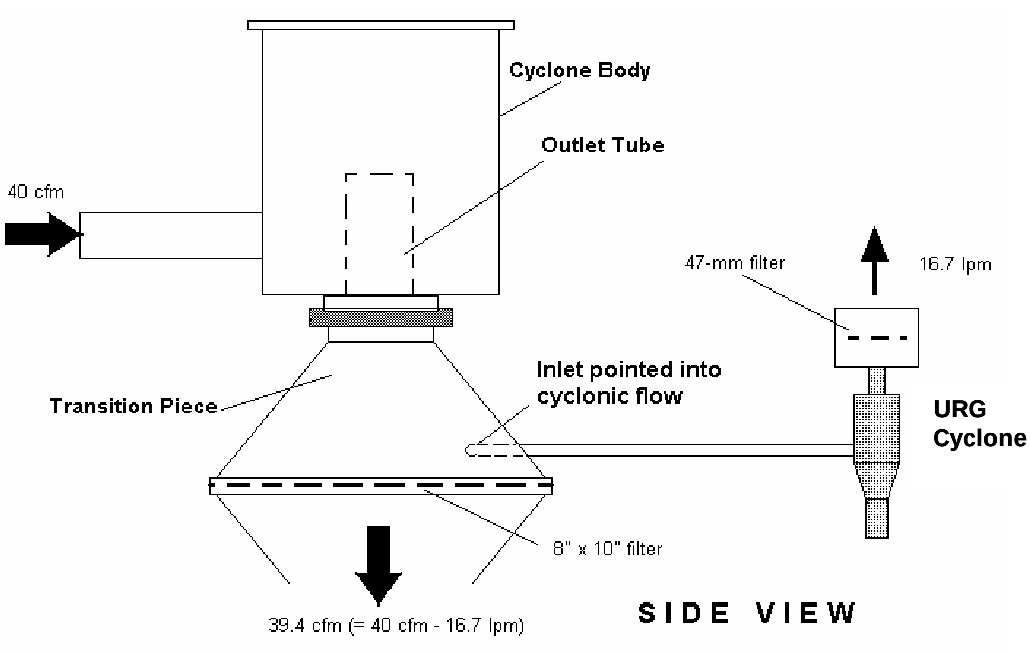

Figure 1. Hybrid PM-10/PM-2.5 Sampler

Adaptation of the hybrid sampler to mobile use required several logistical issues be addressed, including

- Physical placement and support of the sampler
- Operating procedures

The physical placement of the sampler relative to the vehicle is one of the most important differences between the mobile sampling system and devices used in the past. The focus is on PM that is truly airborne and thus capable of contributing to PM fence line concentrations.

Figures 2 and 3 show views of the sampling and support systems, respectively, used during preliminary tests of the mobile sampler. As a practical matter, the sampler needed to be attached (a) as far back as practical from the truck and (b) high enough above the road surface to collect truly airborne material but (c) close enough to the surface to collect adequate sample mass. The physical dimensions of the aluminum box tube, cyclone preseparator, and the mounting carriage combined to limit placement of the cyclone inlet no more than 2.5 m behind the truck's endgate, and between 0.7 to 1.3 m above the road surface. A sampling intake height of 1 m was selected because, based on MRI's past exposure profiling experience, 1 m is representative of the peak PM-10 exposure (i.e., wind speed multiplied by particulate concentration) immediately downwind of an unpaved road. As such, the suspended dust at that height is airborne and capable of being transported downwind.

A set of operating procedures needed to be established to avoid confounding influences from wind. These included the following:

- The truck travel speed should be well above ambient wind speeds so that plume flow dynamics at the sampling point are dominated by the vehicle wake rather than ambient winds.
- A nozzle should be used to match the sampling intake velocity to the truck travel speed.
- A test should consist of multiple trips in both directions along the test road to "average out" the effect of ambient wind direction.

Furthermore, to keep results as reproducible as possible, the desire to use the same truck, tires, and driver during all sampling runs at a location became apparent.

The next set of operating parameters involved the specific details about the truck and how it should be driven in order to collect the desired sample mass in each particle size fraction. The parameters of interest included travel speed, travel distance, and length of the treated road segment.

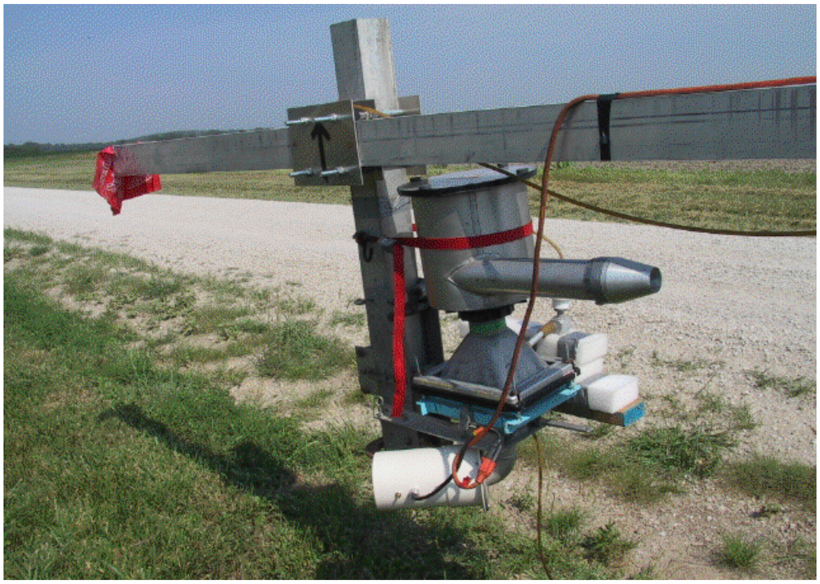

Figure 2. Sampling System used in Preliminary Tests

Figure 3. Support System used in Preliminary Tests

Preliminary tests were conducted on rural roads in Cass County, Missouri. Based on practical experience gained through the preliminary tests, a final design and set of operating procedures were selected for use at Ft. Leonard Wood.

Those procedures are given below:

1. Load the 8-in by 10-in filter cartridge and 47-mm filter holder.
2. Start the vacuum pump and allow it run for at least 1 min.
3. Set the flow at 16.7 lpm through the URG using a rotameter.
4. Start the high-volume sampler and check the back plate pressure.
5. Adjust the autotransformer ("variac") to set the flow through the high-volume sampler to nominally 40 cfm.
6. Turn off the high-volume sampler.
7. Position the truck to start the test.
8. As the truck passes the start of the 500-ft test section, activate the high-volume sampler using the autotransformer (check the red light to ensure that generator circuit breaker has not tripped).
9. As the truck passes the end of the 500-ft test section, deactivate the sampler using the autotransformer.
10. Slow the truck gently and reposition for another trip over the test section (in opposite direction).
11. Repeat Steps 8 through 10 until 6 to 24 passes (depending upon the level of control) have been completed.
12. Stop the truck and briefly reactivate the high-volume sampler to read the back plate pressure.
13. Shut off the high-volume sampler and the vacuum pump.
14. Recover filter cartridge and holder.

Figure 4 shows a schematic of the mobile sampler. Figure 5 presents a photograph of the sampler as deployed at Fort Leonard Wood.

Field Test Comparison with Exposure Profiling

Once the prototype had been evaluated, the mobile sampler underwent a multi-month field-testing program at Fort Leonard Wood, located in Pulaski County, Missouri. Six test sections along the "Driver's Course" (DC) in training area (TA) 236 were treated with six different chemical dust palliatives October 2001.

On three of the six test sections, both exposure profiling and mobile sampling tests were conducted. Results from contemporaneous measurements at these locations were used to determine the relationship between results from the two different methods. Details on the test program, including a thorough discussion of exposure profiling and mobile sampling procedures as well as results, are provided elsewhere[5].

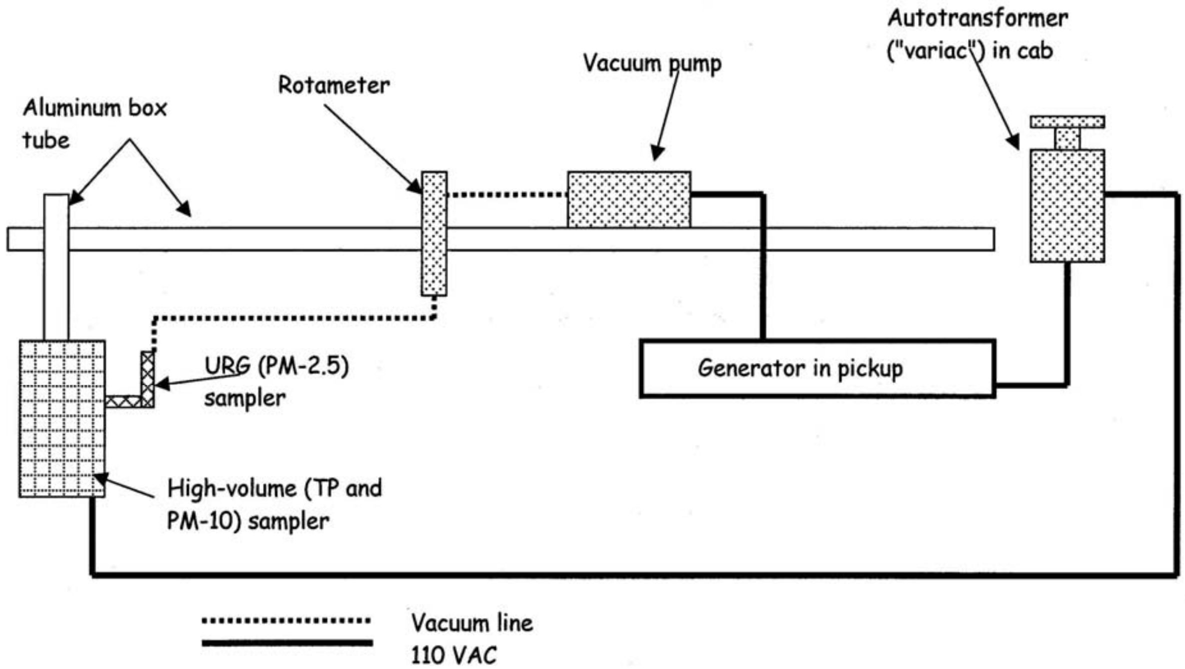

Figure 4. Schematic diagram of mobile sampler components

Figure 5. Mobile Sampler in Use at Fort Leonard Wood

Figure 6 plots the average of the replicate exposure profiling emission factor test results against the average of the two associated mobile sampler results.

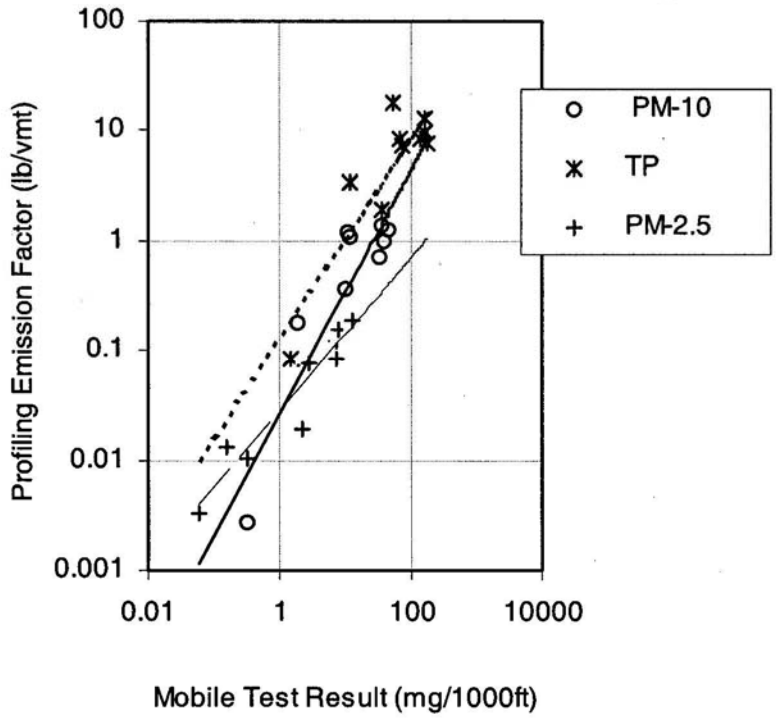

Figure 6. Exposure Profiling Results vs. Mobile Sampler Result

Also shown in the figure are the least-squares (log-log) lines of best fit for the three size ranges. Summary information on those lines is given in Table 1 below:

Table 1. Comparison of Mobile Sampling and Profiling Test Results

Size range	Line of best fit [a]	R^2
PM-10	$y = 0.0268\ x^{1.10}$	0.810
TP	$y = 0.129\ x^{0.910}$	0.794
PM-2.5	$y = 0.0282\ x^{0.697}$	0.905

[a] "y" represents the emission factor in lb/vmt, "x" denotes the mobile sampler test result in mg/1000 ft.

All three relationships are significant at well beyond the 1% level. There is a roughly linear relationship between the mobile and the exposure profiling results for PM-10 and TP. The relationship for the PM-2.5 is slightly sublinear.

Table 2 presents summary information obtained from the three-month test at Ft. Leonard Wood. Note that, for the third test period (99-100 days after application), the average control efficiency was found to be higher than at the second period (50-51 days after application). This unexpected behavior is believed to be due to the fact that cold wintertime controlled emission levels were compared against uncontrolled emission obtained during a much warmer period. To better reflect the control efficiency at any given time, the decision was made to base control efficiency values on uncontrolled emissions measured during each test period.

Table 2. Average Control Efficiency Values for Method Comparison

		Average Control Efficiency (%) Reported		
Test Period	Days After Treatment	Total Particulate	PM-10	PM-2.5
1	22-23	68	73	80
2	50-51	58	70	66
3	99-100	76	71	94

The field test comparison showed that

- The mobile dust sampler, operating over a fixed distance of 500 ft, may be used to develop relative control effectiveness information for TP, PM-10, and PM-2.5.
- Mobile sampler results for all three particle size ranges are highly correlated with results derived from exposure profiling measurements. There is approximately a linear relationship between the two methods.
- Control effectiveness values based on mobile sampling are highly correlated with control efficiency values developed with exposure profiling test data. The correlation is significant at the 1% level.
- The mobile test method should be revised to include measurements of uncontrolled emissions during each test period. Control efficiency values should be based on the uncontrolled emission levels measured during individual field campaigns.

Field Evaluations of Road Dust Suppressants

Based on the success from the field comparison[6], the mobile sampler was subsequently used in a field study of dust suppressant performance on unpaved roads at Fort Leonard Wood (FLW), Missouri, and on a public unpaved road in Maricopa County (MC), Arizona. These field investigations were conducted as part of EPA’s Environmental Technology Verification (ETV) program and the Air Pollution Control

Technology Verification Center (APCTVC). Research Triangle Institute (RTI) served as EPA's verification partner in this effort and MRI was RTI's testing subcontractor.

The field test program was designed by MRI and RTI to evaluate the performance of five dust suppressant products manufactured or distributed by three firms. The goal of each test was to measure the performance of the products illustrated in Table 3, relative to uncontrolled sections of road over an approximate 1-year period. Table 3 also gives the Internet addresses for each of the test reports. The reports were kept separate to discourage cross comparisons without studying the details of road surface treatment procedures for each dust suppressant.

Table 3. EPA/ETV-Sponsored Field Tests of Road Dust Suppressants Using the MRI On-Board Monitor[7]

Dust Suppressant	Test Location*/Date	EPA/ETV Verification Test Report
EK-35, Midwest Industrial Supply, Inc.	FLW Oct 2002 FLW May 2003 FLW Oct 2003 MC May 2003 MC Aug 2003	http://www.epa.gov/etv/pubs/600r05128.pdf
EnviroKleen, Midwest Industrial Supply, Inc.	FLW Oct 2002 FLW May 2003 FLW Oct 2003 MC May 2003 MC Aug 2003	http://www.epa.gov/etv/pubs/600r05134.pdf
DustGard, North American Salt Co.	FLW Oct 2002 FLW May 2003 FLW Oct 2003	http://www.epa.gov/etv/pubs/600r05127.pdf
PetroTac, SynTech Products Corp.	FLW Oct 2002 FLW May 2003 FLW Oct 2003	http://www.epa.gov/etv/pubs/600r05135.pdf
TechSuppress, SynTech Products Corp.	FLW Oct 2002 FLW May 2003 FLW Oct 2003	http://www.epa.gov/etv/pubs/600r05129.pdf

* FLW—Fort Leonard Wood, MO
* MC—Maricopa County, AZ

The schedule of activities during the EPA/ETV test program is shown in Table 2.

Table 2. Schedule of Activities during EPA/ETV Test Program

Date	Location	Activity
Early 2001	Multiple	Stakeholder meetings
Fall 2001	FLW	Preliminary tests to develop a cost-effective technique to measure the relative performance of seven dust suppressant products

March 2002	Multiple	Site survey and vendor meetings
Oct 2002—July 2003	Kansas City/RTP, NC	Test/QA Plans
June 2002	FLW MC	Initial treatments of selected unpaved road segments with dust suppressants
2002-2003	FLW	Quarterly tests of performance efficiency—five dust suppressants from three vendors
2003	MC	Quarterly tests of performance efficiency—two dust suppressants from one vendor
Winter 2004	Kansas City/RTP, NC	Test analysis
2005/2006	Kansas City/RTP, NC	Verification reports

Test sections at both the Fort Leonard Wood and the Arizona locations were initially treated with dust suppressants during June 2002. Tests were planned at quarterly intervals for a period of one year after application. In keeping with the findings from the three-month method comparison study at Fort Leonard Wood, uncontrolled tests were conducted during each field campaign. Furthermore, all control efficiency values were to be based on five replicate measurements made on both the treated and uncontrolled surfaces.

Conclusions

A new on-board mobile monitoring method was developed for reliable testing of the performance of dust suppressants for unpaved roads. The new method was shown to correlate with the traditional standard test method known as roadside plume "exposure profiling." The mobile monitoring method characterizes a full segment of treated road segments, as opposed to depending on the selection of representative points of the road for application of the traditional method, and at a fraction of the cost of implementing the traditional method. The new method was verified and accepted as a standard test method for EPA's ETV program for evaluating commercially available dust control technologies.

The on-board mobile monitoring method was used to test the performance of five chemical dust suppressants for unpaved roads. The products were tested on base roads within the Ft. Leonard Wood in southeast Missouri, and on a public road in Maricopa County, Arizona, near Phoenix. The test reports are available on the Internet. Because of some differences in application methods and frequencies, no overall comparison report for the five products was prepared under the ETV program.

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ROAD DUST SUPPRESSSANTS RESEARCH RESULTS

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Abstract Road dust suppression has two significant benefits: 1) decreasing a major source of air pollution, 2) prolonging the life of a dirt road. It is well known that a large portion of the particulates in the air are related to dirt roads. And it is known that the use of chemical dust suppressants or even just regular watering increases the time between road maintenance and aggregate replacement. In fact, this research has shown that the use of dust suppressants will decrease aggregate loss between 2-3 times of treated dirt roads versus untreated dirt roads.

The purpose of this paper is to discuss the research results from Colorado State University of the effects of the use of chemical dust suppressants on dirt road life and fugitive dust emissions. The dust suppressants tested were lignonsulfanate, magnesium chloride, calcium chloride and calcium chloride special. During the initial stages of the research it was determined that the use of the conventional bucket surveys would not be sufficient and could not generate enough quantitative data for the research to find the most effective dust suppressant. As a result, the Colorado State University Dustometer and a field test protocol were developed to generate a large amount of data to determine which dust suppressant is most effective for the given conditions. The road test sections were one mile, the vehicle, driver and vehicle speeds remained unchanged throughout the research. In another test, the Dustometer was used to quantitatively assess the impact of the vehicle velocity on dust emissions. And as part of the research the tons of aggregate loss per vehicle per mile per year was quantified as well. While the untreated road lost 2.59 tons/mi/ADT/yr, the road treated with lignonsulfanate lost 1.01, $CaCl_2$, 1.49 and $MgCl_2$, 1.04. In terms of dust generation, the lignonsulfanate was the most effective for about three months but deteriorated rapidly. In the economic analysis for the given cost of aggregate and the existing ambient conditions, $MgCl_2$ was the best choice when the ADT was greater than 120. The relationship between dust generation and vehicle velocity was also established. Increasing the vehicle speed from 30 mph to 50 mph almost doubled the amount of dust production and although it appears to be linear, visual observations in the field indicate it is more probably nonlinear and quite possibly exponential. What is not known which future research could answer is the effect of vehicle weight and tire dimensions on dust production and the relationship between dust production and aggregate loss. More fundamentally there are no data that the suggested application rates and field procedures recommended by the suppressants distributors are optimal.

Although the Dustometer was developed specifically for this research replacing and improving upon bucket surveys and other measurement techniques, it may, in fact, be better suited and more applicable as a management tool to generate data on site prior to road dust management decisions.

INTRODUCTION

There are over 2.6 million miles of roads and streets in the United States which carry low traffic volumes and over one million miles of these roads are unpaved road (FHWA, 1992). The loss of fines, a primary source of fugitive particulate emission in the air and the cause of deterioration of unpaved roads often lead to high maintenance costs especially in the form of aggregate replacement cost. In terms of air pollution alone, the problem of unpaved road dust can not be overlooked due to health issues and governmental regulations to meet atmospheric air quality standards. In terms of dirt road life, high maintenance cost, increased road user cost, public awareness of road dust problems, and the loss of fines from the road surface, among other things, have raised concerns about the quality of unpaved roads. These have led to increased interest in reevaluating current dust control management practices.

The objective of dust control is to stabilize the road surfaces by causing the finer soil particles to be firmly bounded to the coarser aggregates. Not only is road life prolonged, but less particulate air pollution results. Currently, dust palliation is achieved by the reduction of vehicular speed, spraying of water on the road surface and the use of dust suppressing chemicals. Although dust control studies have been ongoing for several decades now with numerous attempts to measure and quantify dust from unpaved roads, there is lack of any uniform, standard, repeatable/reproducible and quantitative method or technique for measuring road dust.

The purpose of this paper is to discuss the research results from Colorado State University on the effects of the use of chemical dust suppressants on dirt road life and fugitive dust emissions and the “Colorado State University Dustometer” a mobile dust collector developed specifically for this research (Sanders and Addo, 2000). Four chemical dust suppressants, Lignosulfanate, Calcium Chloride, Magnesium Chloride and Calcium Chloride

Special. were tested and their effectiveness is compared to an untreated road. After initial tests, Calcium Chloride Special was not tested in the second year.

EXPRIMENTAL DESIGN

The tests were performed on four unpaved section of CR12/29 near the city of Loveland in Larimer County, Colorado (Figure 1). Each test section was 1.25 miles long and 33 feet wide. The choice of this site was due to the fact that the road had never been treated with a dust suppressant except for water and the relative closeness to Colorado State University. Figure 1 shows the research site and the treatment of each section.

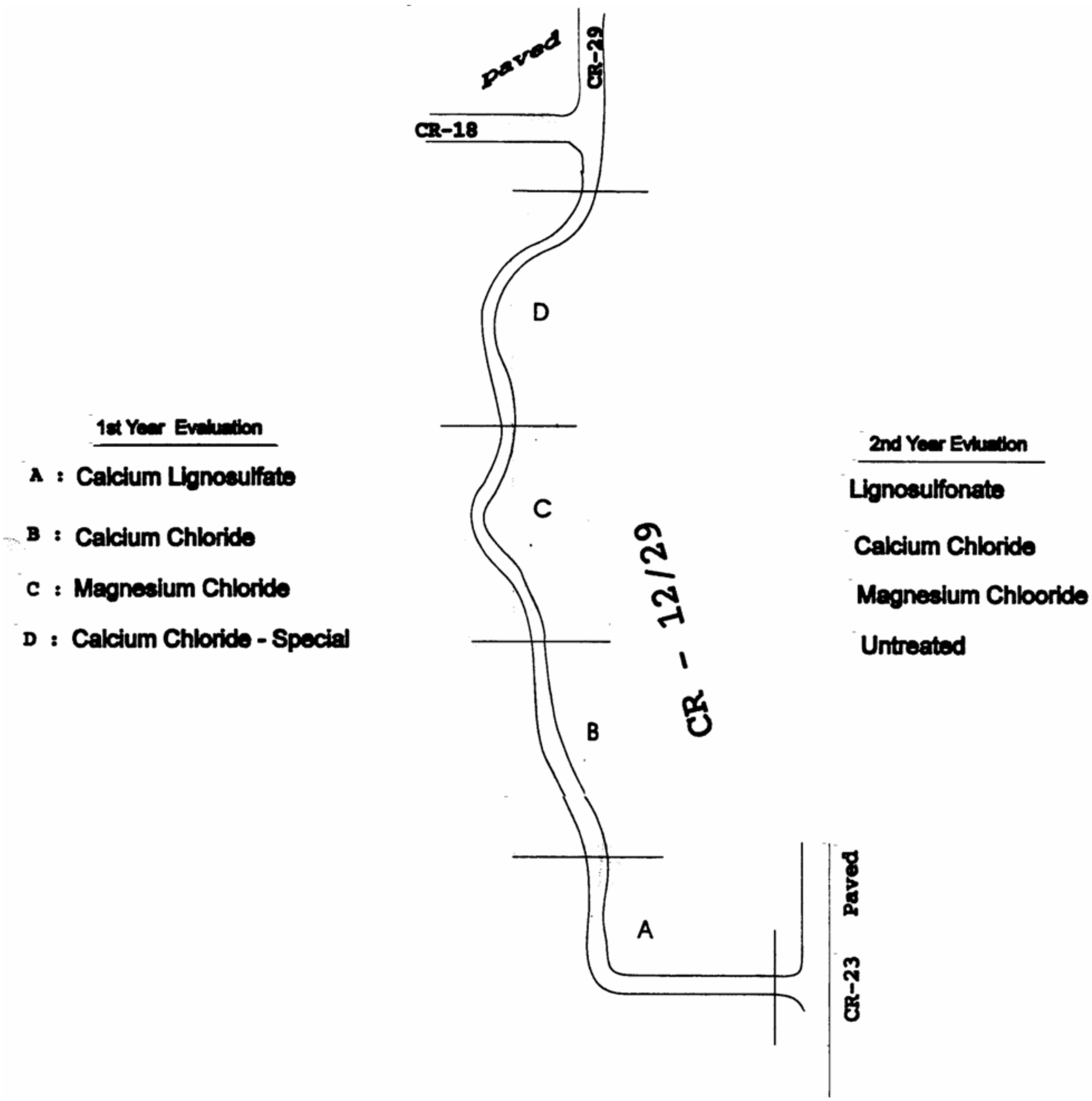

Figure 1 Location of Test Sections and treatment.

To perform the testing, a ¾ ton truck (Figure 2) provided by the Larimer Country Road & Bridge Department was used. The vehicle was operated by the same driver at a constant speed of 45 mph during the hottest and driest time of the day when most dust would be generated. The dust measurement was carried out over 1 mile of the 1.25 mile test section. The 0.25 miles of each test section was used as the start and stop distances of the test vehicle. The vehicle was brought up to the desire speed of 45 mph before turning on the Dustometer (Addo, 1995). After the first year's tests, 6 inches of new aggregate was placed on the road test sections by the county. This allowed a second year's test on a virgin, untreated road.

Three tests per section of each treatment were conducted on the same day about the same time of day once-a-week for an entire summer. Averages were calculated and are presented in the paper. At the beginning and end of the summer tests of the second year, the cross section road elevations of the test roads were measured to estimate the loss of aggregate. Vehicle counters were located at the beginning and end of each test section so that the aggregate loss per mile per vehicle could be determined.

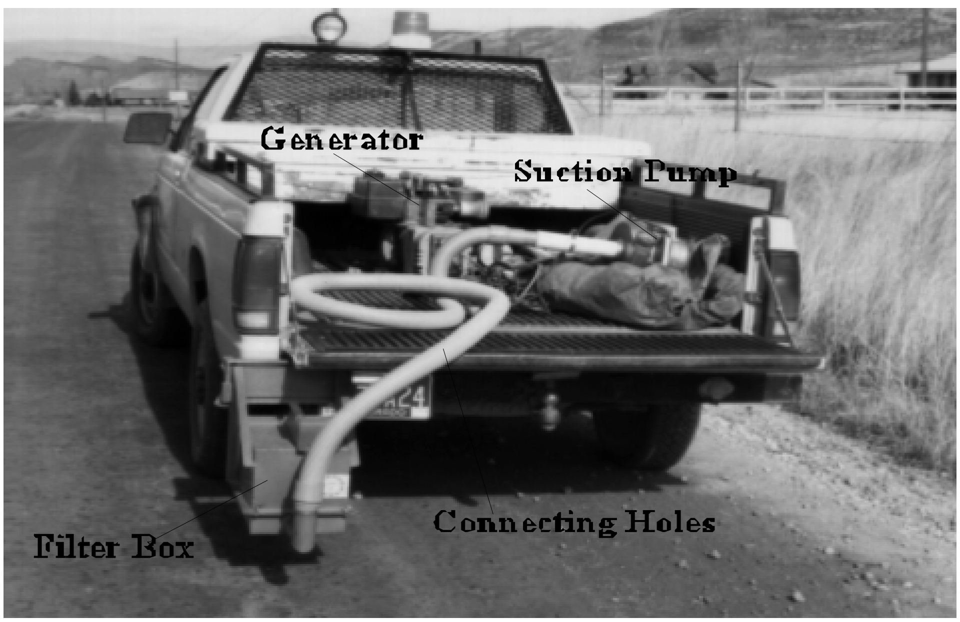

Figure 2. The ¾ ton truck used in all the tests.

RESULTS

Before the tests of the dust suppressants were initiated, the precision of the Dustometer as an experimental road dust measurement device was evaluated. Nine replicate sample measurement were taken on the 1-mile, untreated test section. Table 1 shows the data and its distribution. A mean of 2.74 g was obtained with a standard deviation of 0.21, a variance of 0.04 and a coefficient of variation of 7 % at a speed of 45 mph. It is obvious from the data that the Dustometer is precise especially when it is considered that it is a field measurement devise and not a lab instrument. During the initial testing of the Colorado State University Dustometer, it became quite obvious that the speed of the vehicle was related to dust production. The faster the vehicle traveled, the more dust is generated. In order to quantify this observation, three dust test measurements were taken for each of the four different speeds. Figure 3 presents the average amount of dust generated at speeds of 20, 30, 40, and 50 mph. on the 1-mile, untreated test section. The fit of the data appeared linear.

Sample #	**Weight of Dust (g)**
1	2.85
2	2.60
3	2.83
4	2.86
5	2.87
6	2.47
7	2.62
8	2.48
9	3.09

Mean = 2.74 g   Standard Deviation = 0.21 g   Variance = 0.04 g

Table 1. Typical Dust Measurement Data
Speed: 45 mi/hr
Length of Run: 1.0 mile
Test Section: Untreated

Because the dust measurement involves the suction of dust as it is generated, the mass of the dust collected is related to how long the suction pump is allowed to run. In order to remove this variable, the amounts of the dust collected for a 3 minute run for each speed were plotted versus speed (Figure 4). The results indicate linearity. To verify this linear relationship of the dust collected vs speed for the collection device additional, runs were made at 25, 35, and 45 mph (Figure 5).

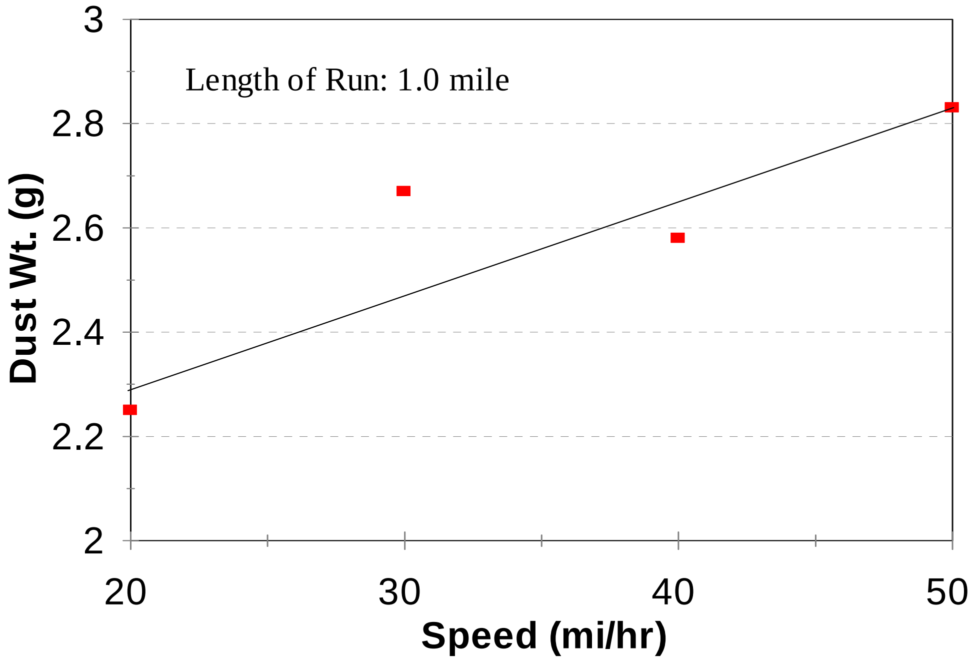

Figure 3. Dust production vs speed for the 1-mile test section.

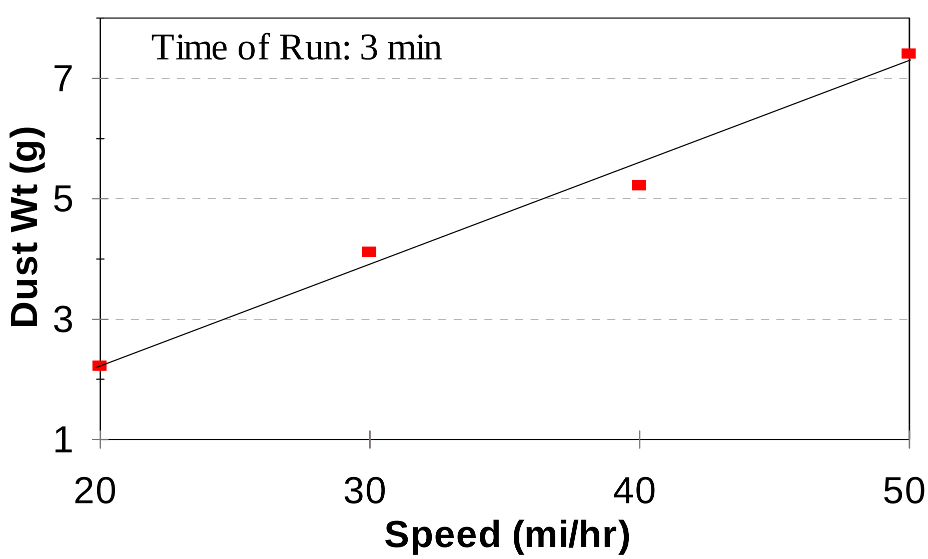

Figure 4. Dust production vs speed for a three minute time period.

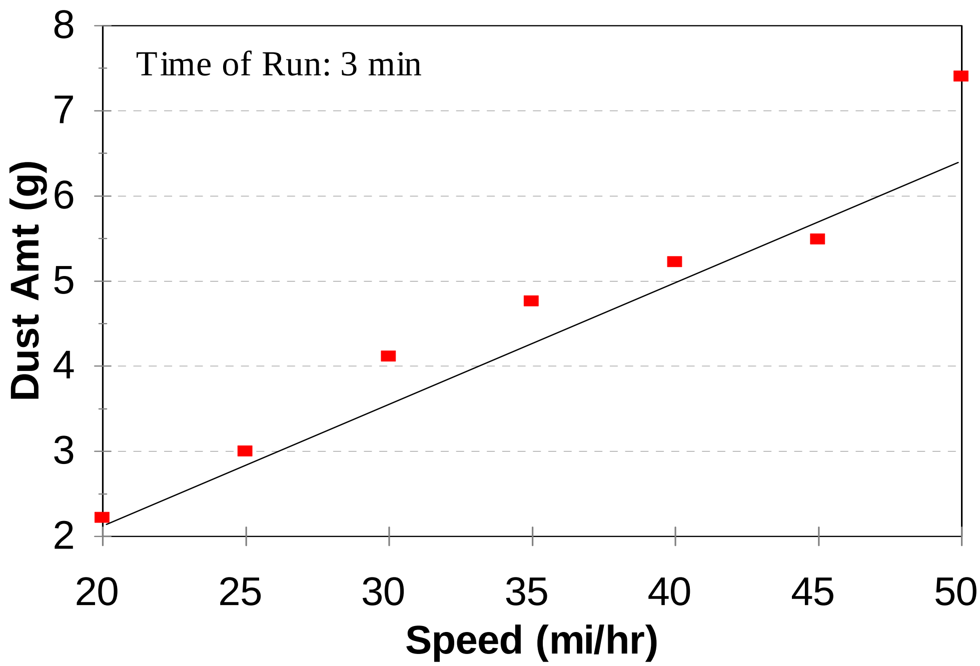

Figure 5. Dust production vs speed for a three minute time period for all data.

Dust Measurements.

The results of the fugitive dust emissions from each of the four tests sections are shown in Figure 6. Each data point in Figure 6 is an average of three test runs made by driving the truck in the wheel path of the same driving lane and in the same direction. It is apparent that all three dust suppressants were effective in reducing the amount of dust generation in comparison to the amount of dust generated from the untreated section.

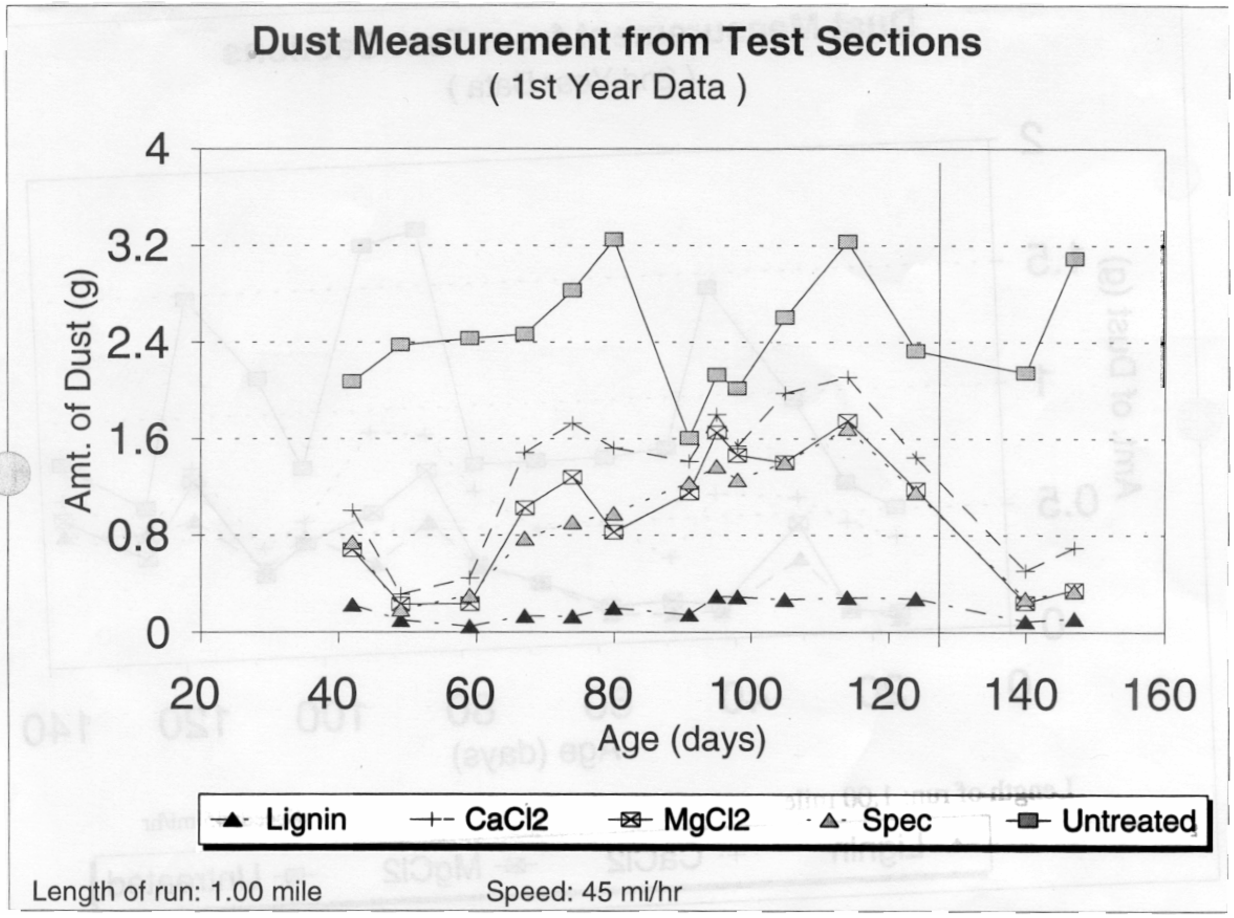

Figure 6. The dust generated at the four test sections during the first year(Addo and Sanders,1995).

It should be noted that as the test sections aged the amount of dust emissions increased but dust emissions would decrease for a short time after a rain storm. The test section treated with the lignin dust suppressant had the least dust emissions in the majority of all tests during the two years of tests. However, toward the end of the tests, the lignin dust suppressant appeared to break down and the test road deteriorated rapidly with a large increase of pot holes.

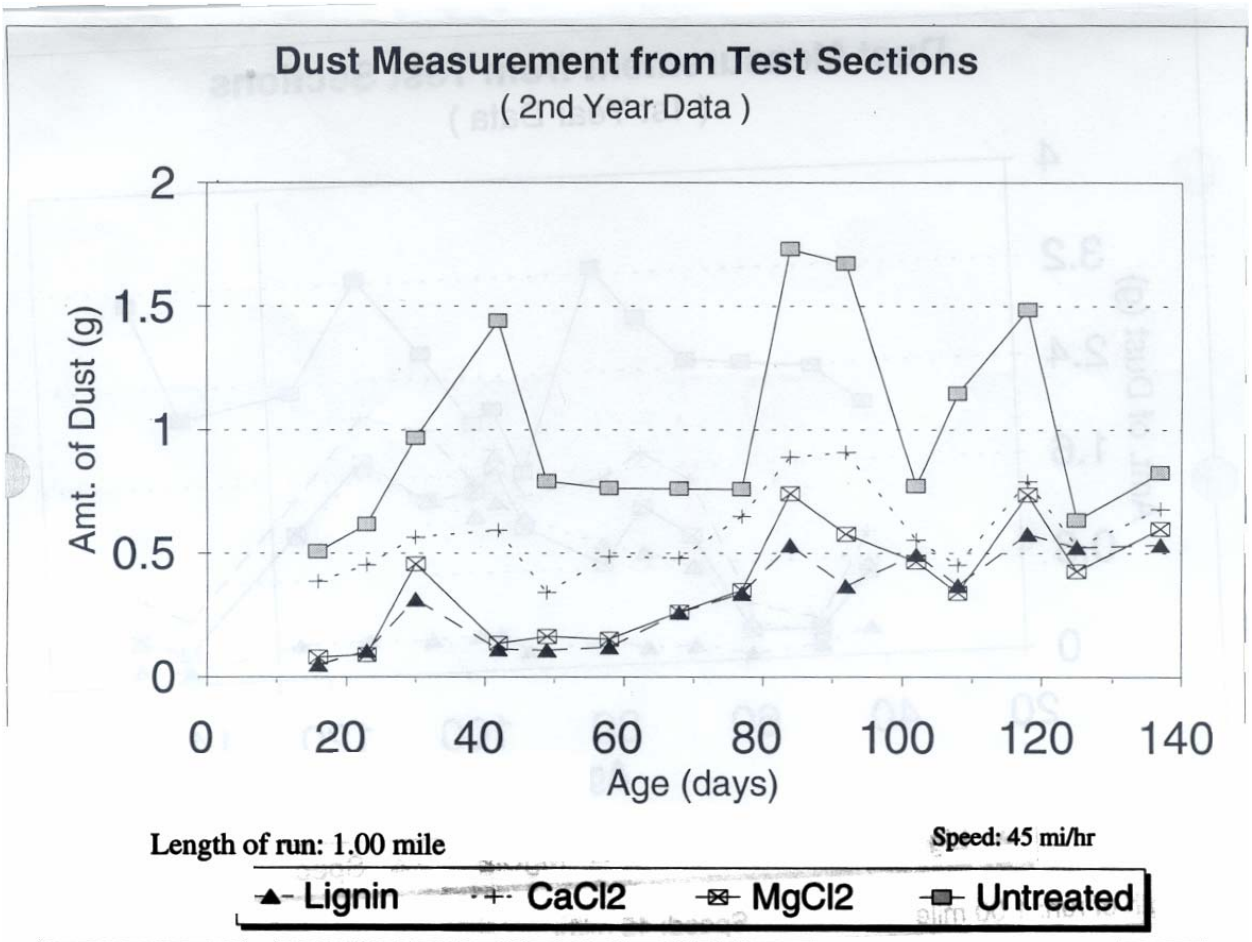

Figure 6. The dust generated from the four test sections during the second year.

Aggregate Loss Measurement

At the conclusion of the research the first year, it was decided to try to estimate the amount of aggregate loss by taking multiple measurements of the pavement elevations before and after the tests. The road surface elevations were measured at three cross sections of each test section. Measurements were made every three feet across the road. Quantitative differences were able to be determined primarily because of the capability of the Larimer County equipment operators to rebuild the road test sections from the displaced aggregate. The aggregate loss was estimated from the elevation differences of the road surfaces before and after the tests (Figure 7).

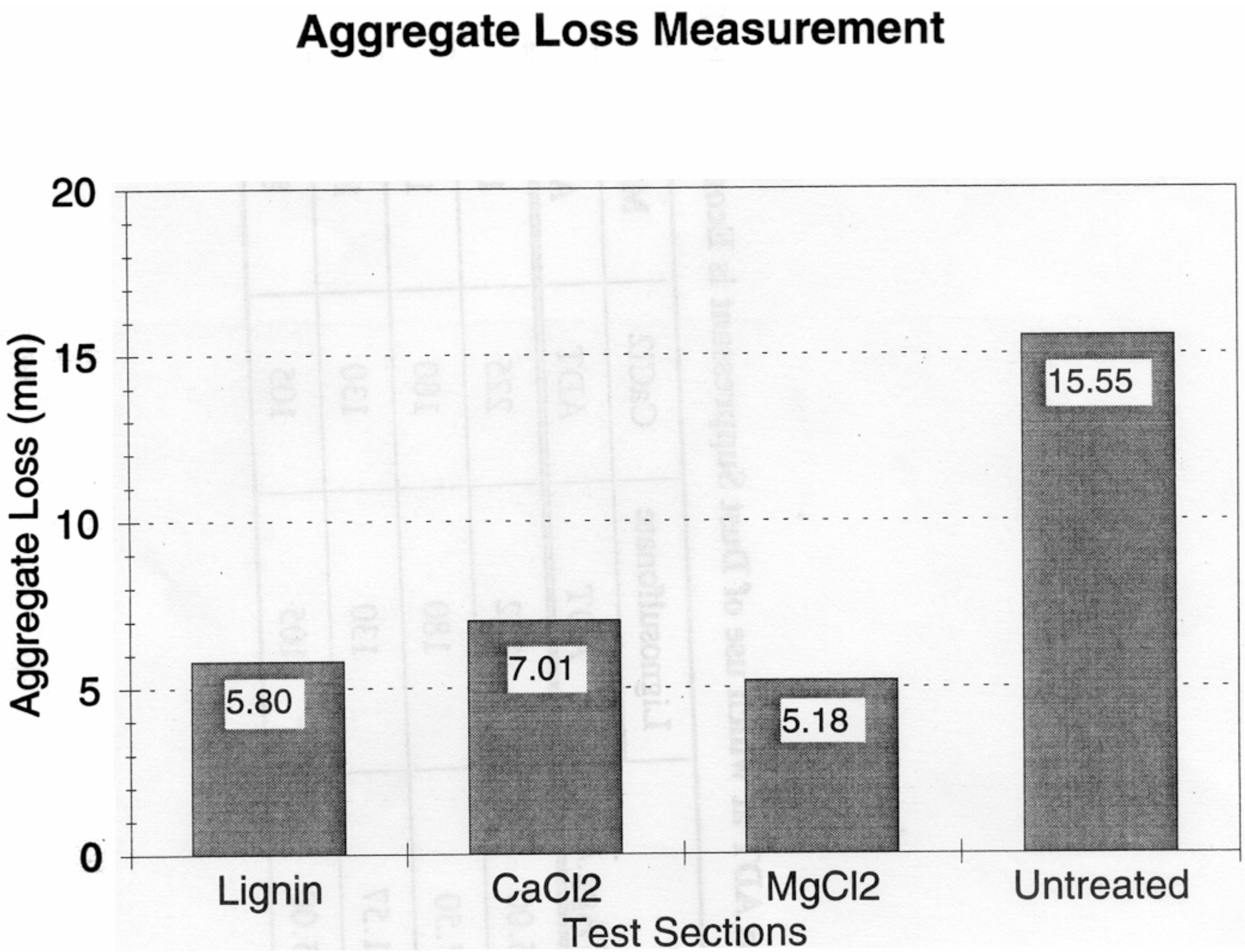

Figure 7. The estimated aggregate loss of each test sections in mm from the second year data.

Figure 7 shows the measured aggregate loss from each of the test sections over the 4.5 month period in which the study was done. The aggregate loss from the treated test sections were measured as 0.23 inches (5.80 mm) for the Lignosulfonate, 0.28 inches (7.00 mm) for $CaCl_2$, and 0.2 inches (5.18 mm) for $MgCl_2$**.** The untreated section had an aggregate loss of 0.6 inches (15.55 mm). Table 2 summarizes the aggregate loss per mile per year per vehicle from the loss data measured and using the ADT traffic measurements. Again it should be noted that all the dust suppressants were effective when compared to the aggregate loss of 2.6 tons/yr/mile/vehicle from the untreated section. The test section treated with Lignosulfonate lost 1 ton/yr/mile/vehicle, the $MgCl_2$ treated section lost 1 ton/yr/mile/vehicle as well and the $CaCl_2$ treated section lost 1.5 tons/yr/mile/vehicle.

Test Section (1)	ADT (2)	Measured aggregate loss per mi for 4.5 months (ft) (3)	Estimated aggregate loss/mi/yr (ft) (4)	Estimated aggregate loss /mi/yr (tons) (5)	Estimated aggregate loss per mi/yr/veh (tons) (6)
Lignosulfonate	515	0.019	0.050	520	1.0
$CaCl_2$	431	0.023	0.061	629	1.5
$MgCl_2$	448	0.017	0.045	465	1.0
Untreated	538	0.051	0.135	1.395	2.6

Table 2. Estimated total annual aggregate loss /mile/vehicle.

Using an aggregate cost of $11.57 ton for replacing the lost aggregate, the cost/mile/yr as a function of ADT is plotted in Figure 8. The plot indicates that if the ADT is less than 120, it is cost effective to not treat the dirt roads with a dust suppressant And if the ADT is over 120 it is more cost effective to use any of the three dust suppressants and it appears that $MgCl_2$ was the most cost effective.

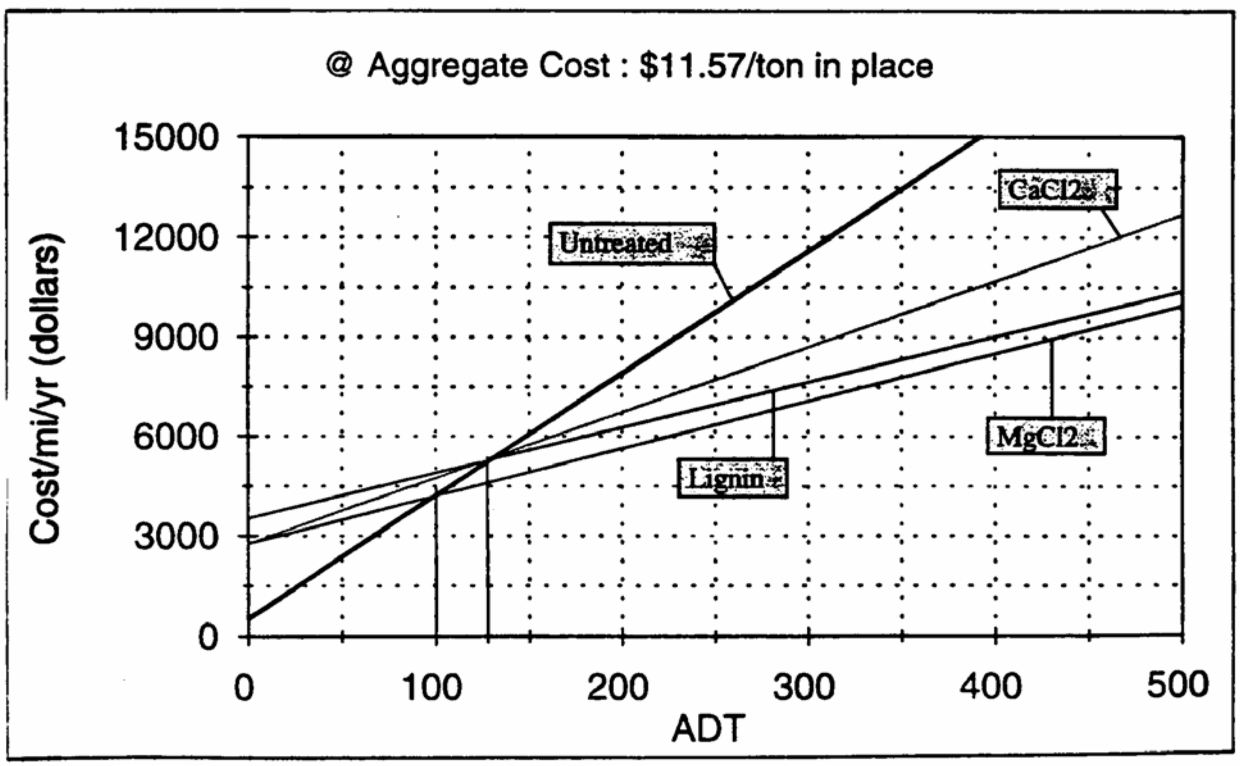

Figure 8. The cost/mile/year for each treatment vs. ADT assuming an aggregate cost of $11.57 (Sanders et al., 2000).

Water Quality impact of the dust Suppressants

Figure 9 list the quality of the runoff during a rainfall event July 7, 1994. Unfortunately there was very little runoff quality data from other storms during two years of research due to the fact that very little measurable runoff occurred.

Date of Rain 07/22/94 Rainfall amt. Av. = 0.42in (10.75 mm)		Test Sections		
	Lignin	$CaCl_2$	$MgCl_2$	Untreated
pH	6.05	6.28	6.98	7.20
E.C. µmhos	1,428.75	8,517.50	7,655.00	485.75
TDS	975.26	5,706.73	5,128.85	325.45
Ca	239.30	1,538.50	90.73	52.75
Mg	58.00	96.53	926.25	18.55
Cl	267.18	2,725.75	3,728.48	83.58
Na	16.55	33.70	20.83	5.78
K	9.70	6.18	6.45	0.63
B	0.40	0.26	4.45	0.11
P	0.25	0.33	4.38	0.10
Al	0.83	0.25	0.90	0.15
Fe	9.73	0.26	0.28	0.07
Mn mg/l	3.09	0.88	0.10	0.03
Cu	0.06	0.01	0.19	0.01
Zn	0.10	0.15	0.01	0.12
Ni	0.09	0.02	0.11	0.02
Mo	0.02	0.02	0.06	0.02
Cd	<0.01	<0.01	<0.01	<0.01
Cr	0.04	0.09	0.07	0.01
Ba	0.26	0.70	0.23	0.05
Pb	<0.05	<0.05	0.11	<0.05
So2	129.10	486.93	455.80	44.45
Hardness as CaCO3	589.92	4,248.44	4,086.19	209.17

Figure 9. Runoff water quality from the different test sections.

Although the concentration of some of the variables appeared to be very high, TDS for example, the amount of mass going back into the environment was extremely small because there was very little runoff from the storms.

CONCLUSIONS

The Colorado State University Dustometer is precise, portable and inexpensive. It also is capable to generate copious amounts of dust emission data.

There was a substantial reduction of dust emissions using any of the tested dust suppressants.

It appears that the dust production measured by the Colorado State University Dustometer was linearly related to vehicle speed.

The lignon based dust suppressant was the best under high temperatures and low humidity (but degraded after several months).

There was a 41-61 percent reduction of aggregate loss using the dust suppressants.

There was also a 30-46 percent reduction in total annual maintenance costs of treated vs untreated roads.

For an ADT over 120 any of the dust suppressants tested was cost effective.

The aggregate loss in tons/mile/year/ADT was, 2.59 untreated, 1.01 Lignon, 1.49 $CaCl_2$, and 1.04 $MgCl_2$.

Water quality impacts were significant but total mass going into the environment was small.

RECOMMENDATIONS

Study the effects of vehicle weight, number and size of wheels on fugitive dust emission.

Determine the relationship of Dustometer dust measurements and total dust production.

Determine optimal application procedures for the dust suppressants to minimize costs.

Determine the relationship between dust production and aggregate loss.

Determine the portion of the dust emissions of the 10 microns (PM_{10}) or less that might cause respiratory problems.

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Addo, J. Q. and Sanders, T.G. *Effectiveness and Environmental Impact of Road Dust Suppressants*. Mountain Plains Consortium MPC Report No. 92-28A, March 1995.

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Sanders, T.G., Addo, J.Q., Ariniello, A., and Heiden, W.F. *Relative Effectiveness of Road Dust Suppressants*. ASCE Journal of Transportation Engineering, Vol. 123, No.5, Sept/Oct. 1997.

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Evaluation of Dust Control Suppressants on Unpaved Roads Using Mobile Sampling

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ABSTRACT

PM_{10} emission rates were measured on treated and untreated unpaved roads using fast-response optical PM_{10} sensors mounted in the front and behind the vehicle in the well-mixed wake. A special inlet probe was used to allow isokinetic sampling under all speed conditions. The emission factors were calculated by multiplying the concentration difference between front and back of the test vehicle by the frontal area. The test system has been designated as SCAMPER (System of Continuous Aerosol Monitoring of Particulate Emissions from Roadways).

Measurements of PM_{10} emission rates were made on two different unpaved state highways in Arizona. Each route consisted of unpaved road with sections of several miles length treated with either Envirotac II Acrylic copolymer or CRS II Emulsified liquid. The SCAMPER tow vehicle was a 1995 Chevrolet Suburban and the average speeds ranged from 20 to 30 mph. The average emission rate of the treated section was approximately five times lower than the untreated gravel for the Envirotech II and sixty times lower for the CRS II treatment. Based on the replicate circuits, the precision of the measurement was approximately 20%.

The SCAMPER was also used to determine PM_{10} emissions from a treated unpaved mine haul road using a Ford Expedition (2.5 tons) and loaded and unloaded haul vehicles (50 and 150 tons, respectively). The average emission rate was 0.5 g/VKT for the Expedition, 4.2 g/VKM for the unloaded haul vehicle, and 7.0 g/VKM for the loaded haul vehicle. Assuming 12% silt content, the AP-42 equation for unpaved roads predicted a PM_{10} emission rate of 1480 g/VKM for the unloaded haul vehicle and 2450 g/VKM for the loaded haul vehicle. The treatment therefore lowered the PM_{10} emission rate by approximately a factor of 300. While the AP-42 equation grossly over-predicted the PM_{10} emission rate (since the unpaved haul road was treated), the equation correctly predicted the relative differences of the emission rates based on vehicle weight.

SCAMPER has been shown to be an effective approach in determining the effectiveness of dust suppressants on unpaved roads and would be useful in assessing the long-term benefit of these products in planning for cost-effective product application.

BACKGROUND

The PM emission rate from unpaved roads is generally determined by sampling both upwind and downwind of the road to characterize the concentrations of PM in the plume. To do this a vertical array of PM samplers downwind of the road are located at various elevations up to the plume height. A single sampler is used upwind of the road to determine the background concentration. Collocated with these samplers are instruments to measure wind speed and direction. The flux of PM from the road is then determined by subtracting the background concentrations from the concentrations at each height and multiplying the result by the perpendicular component of the wind speed at that height. These values are then integrated from ground level to the highest sampler to calculate the emission rate.

This technique was used to measure PM emission rates from unpaved roads under a variety of conditions. By regressing these values against the variables in the tests, the emission rates were found to be related to the silt content of the surface material and the weight of the vehicle. This expression is contained in the EPA document AP-42 for predicting emission rates of suspension of material from unpaved industrial roads the following empirical equation:

$$E = k(s/12)^{0.9} (W/3)^{0.45})*281.9 \text{ g/VKT} \quad (2)$$

where:

E = PM emission factor in the units shown
k = A constant dependent on the aerodynamic size range of PM (0.23 for $PM_{2.5}$; 1.5 for PM_{10})
s = surface material silt content
W = mean vehicle weight in tons
VKT = vehicle kilometer traveled

While this expression is generally useful for estimating emission inventories, it does not take into account any surface treatment. Directly measuring emission rates using the upwind-downwind approach is labor and equipment intensive and provides data for only one array at a time. To facilitate PM emission measurements from roads, we have developed a method based on measuring the PM_{10} concentrations in front of and behind the vehicle using real-time sensors. We called this system the SCAMPER: System of Continuous Aerosol Monitoring of Particulate Emissions from Roadways. We developed this alternative technique using a vehicle equipped real-time PM sensors to measure concentrations in front of a vehicle and in its rear wake (Fitz and Bufalino, 2002; Fitz et al. 2005a,b). In this approach the PM_{10} concentrations are measured directly on moving vehicles in order to improve the measurement sensitivity for estimating the emission factors for vehicle on paved roads. Optical sensors are used to measure PM_{10} concentrations with a time resolution of approximately two seconds. Sensors were mounted in the front and behind the vehicle in the well-mixed wake. A special inlet probe was designed to allow isokinetic sampling under all speed conditions. The emission factors are based on the concentration difference between front and back of the test vehicle and the frontal area.

This SCAMPER technique is useful for quickly surveying large areas and for investigating hot spots on roadways caused by greater than normal deposition of PM_{10} forming debris. While the AP-42 equation for unpaved roads that has silt content as an independent variable, the SCAMPER approach directly measures emissions and does not depend on independent variables. The approach is therefore as valid for unpaved roads as for paved roads.

This SCAMPER has six major components:

1) **Front Sampling Inlet:** An inlet for the real-time PM sensor was used that allowed sampling isokinetically over the range of vehicle speeds. This involves a bypass flow system that is adjusted to vehicle speed with a PC using GPS speed data.

2) **PM_{10} Sensors:** DustTrak optical PM sensors with PM_{10} inlets being used.

3) **PM_{10} Filter Sampler**: Custom made sampler with a Graseby-Andersen model 246B PM_{10} inlet to calibrate the DustTRak data to a mass basis.

4) **Sampling Trailer:** From our studies to determine concentrations in the vehicle wake the sampling position behind the vehicle was optimized. This position required using a trailer to mount the sampling inlet. The trailer was designed to disturb the vehicle wake as little as possible. In addition, the trailer holds the bypass flow system.

5) **Position Determination:** A Garmin GPS Map76 global positioning system using WAAS technology was used to determine vehicle location and speed.

6) **Data Collection:** A PC was used to collect data from GPS and PM_{10} measuring devices. Data was stored as two-second averages. The PC also was used to automatically adjust the front sample inlet bypass flow to maintain isokinetic particle sampling using a 10-second running average of vehicle speed based on the GPS.

Figure 1 is a photograph of the SCAMPER. The tow vehicle is a 1995 Chevrolet Suburban with a custom trailer with an extended hitch. The approximate frontal area was 3.66 m^2.

Figure 1. Photograph of the SAMPER

UNPAVED TEST ROADS

Unpaved Public Roads

Field measurements of PM_{10} emission rates were made on two different Arizona state highways, routes SR88 and SR288. The SCAMPER test vehicle was operated at speeds consistent with safe operation and that observed of other vehicles.

The segment of state route 88 between mile point 220.1 and mile point 227.5 was treated with Envirotac II Acrylic copolymer at a rate of 1 gallon per 36 square feet. To the west the road was paved and to the east it was unpaved gravel. The section between miles 226.5 and 227.5 was first treated in late 2003 and the section between miles 220.1 and 226.5 was treated in May 2005. The SCAMPER testing was conducted from Tortilla Flats eastbound on paved road to mile 220.1 where the road transitioned from paved to treated gravel. The treated section ended at mile 227.5 and the SCAMPER vehicle continued eastward on untreated gravel until it turned around and headed westbound back to Tortilla Flats. Four circuits were completed on October 10, 2005.

In 2004 the segment of SR 188 between mile points 274.7 and 280.5 was treated by milling 6in of the base material that was treated with a 1:1 ratio of SS1 followed by an application of CRS II Emulsified liquid at a rate of 0.5 gallon per square yard and then 28 pounds per square yard of 3/8 in chips. The road was untreated gravel on both sides of the treated section. The SCAMPER test route consisted of a circuit starting on the south approximately 1/4mile from the treated section, covering the treated section at the southern end and continuing north on the gravel for another quarter mile.

Unpaved Mine Haul Road

The mine haul road was approximately 5 miles long and was composed of treated native material. The speeds were regulated by permit. The tow vehicle was a 2006 Ford Expedition with a custom trailer with an extended hitch. For evaluating the PM_{10} emissions from the haul road we used both the SCAMPER as described above and we also used a haul vehicle outfitted with the SCAMPER equipment. Figure 2 shows the SCAMPER outfitted to the haul vehicle.

The SCAMPER in the normal mode was used for measuring PM_{10} emissions during all of the first day of sampling and all but one roundtrip on the second day of. A frontal area of 3.66m^2 was used for the Ford Expedition and the estimated weight is 2.5 tons. After completing four round trips on the second day of sampling, the SCAMPER equipment was installed on the haul vehicle for all subsequent testing. The frontal area of the haul vehicle was estimated to be 10.6 m^2 based on the overall height and width. The weight of the haul truck was 50 tons empty (northwest direction) and 150 tons fully loaded (southeast direction).

Figure 2. The SCAMPER trailer attached to a haul vehicle

RESULTS

Unpaved Public Roads

Figure 3 is a map showing the location of state routes 88 with the emission rates are represented as circles with the shading becoming darker as the emission rates become larger. Progressing from left to right the emissions increase as the SCAMPER transverses paved, treated unpaved, and untreated unpaved. Figure 4 shows the time series of PM_{10} emission rates calculated as a running ten-second average for periods when the running average speed was greater than 10 mph. The units are in mg/m. The data from treated and untreated unpaved roads are highlighted, as are the paved road sections. The average emission rate of the treated gravel section was approximately five times lower than the untreated gravel section. In both cases the average speed was near 20 mph. Spikes in the emission rate are observed at repeatable times for both treated and untreated sections, likely indicating road surfaces containing higher fractions of finer soil. Based on the reproducibility of the segment emission rate data, the precision of the measurements for both the treated and untreated sections was high, especially considering the potential operational variability from run to run. While standard deviations should not be calculated from three test runs, the precision of the measurement is about 20%, which is consistent with our much larger database from paved road measurements.

Figure 3. Map of the test segments used on SR88

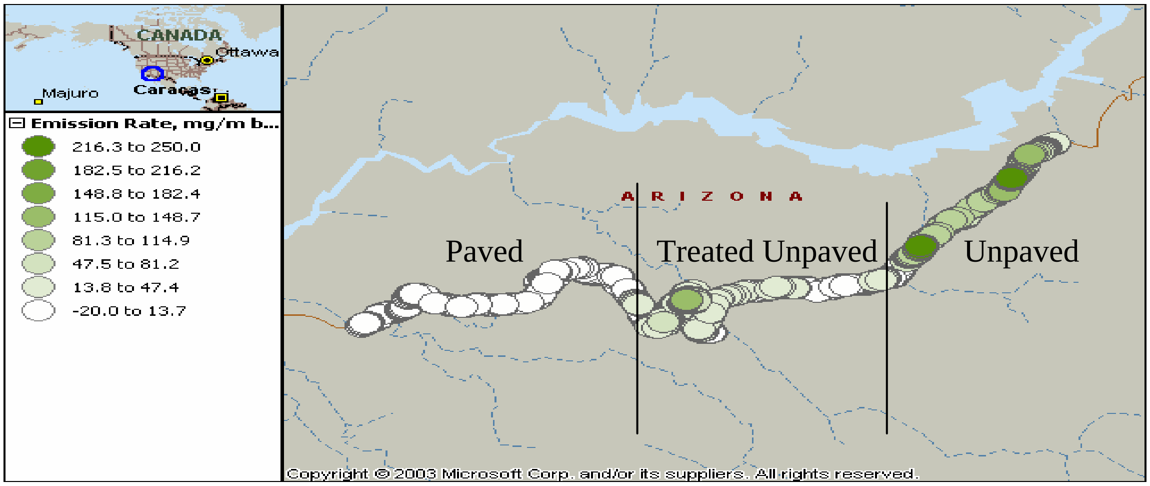


Figure 4. Time series plot of PM_{10} emissions during the test conducted on SR 88.

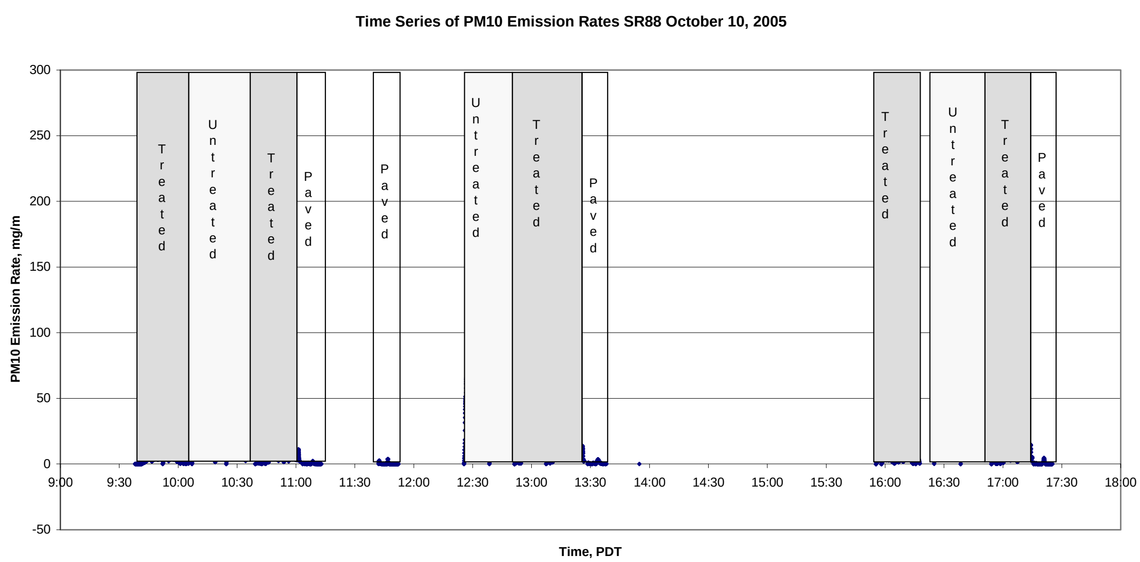


Figure 5 summarizes the data from SR 188 on a map. The higher emissions at the top and bottom of the section are from the unpaved segments while the much lower ones are clearly seen in the middle. Figure 6 shows the time series of PM_{10} emission rates calculated as a running ten-second average for periods when the running average speed was greater than 10 mph. The units are in mg/m. The data from treated and untreated unpaved roads are highlighted. The average emission rate of the treated gravel section was approximately sixty times lower than the untreated gravel section. In addition, the average speed on the untreated sections was nearly half that of the treated section (15.5 vs 32.5 mph). Spikes in the emission rate are again observed at repeatable times for but only untreated section. The PM_{10} emission rate from the treated section was nearly as low as the asphalt paved portion of SR88. Since SR88 had a higher traffic density than SR188, the emissions from its paved segment are expected to be lower than if a segment of SR188 were paved. We therefore conclude that the PM_{10} emissions from the treated portion of SR188 is what would be expected of asphalt pavement. Based on the replicate circuits, the precision of the measurement is also approximately 20%.

Figure 5. Map of the test segments used on SR188

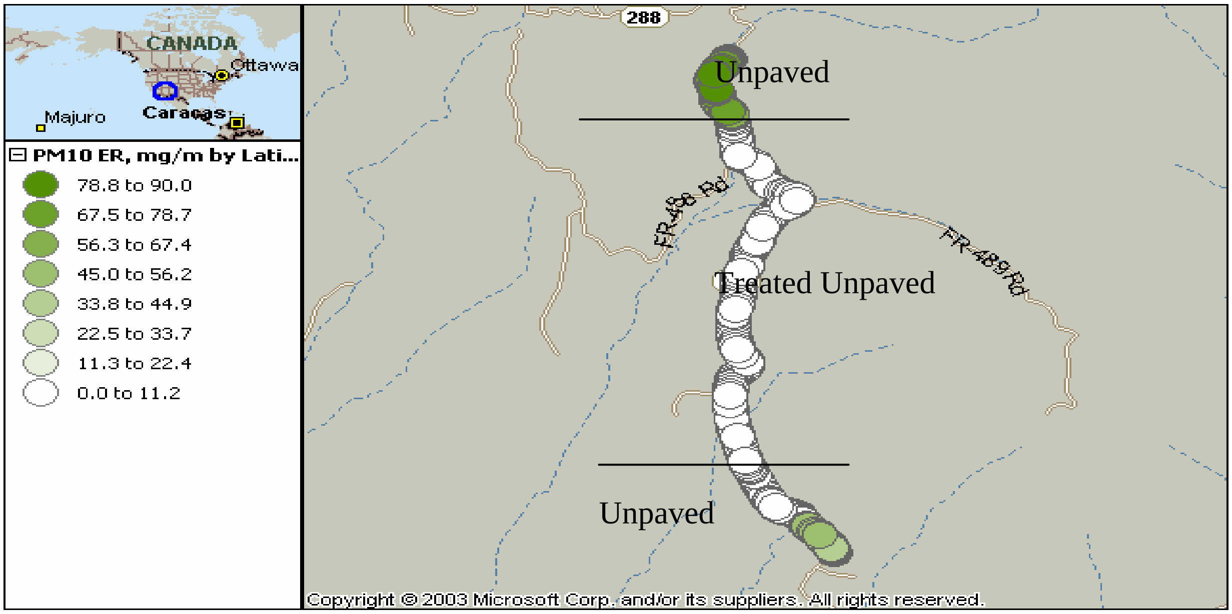
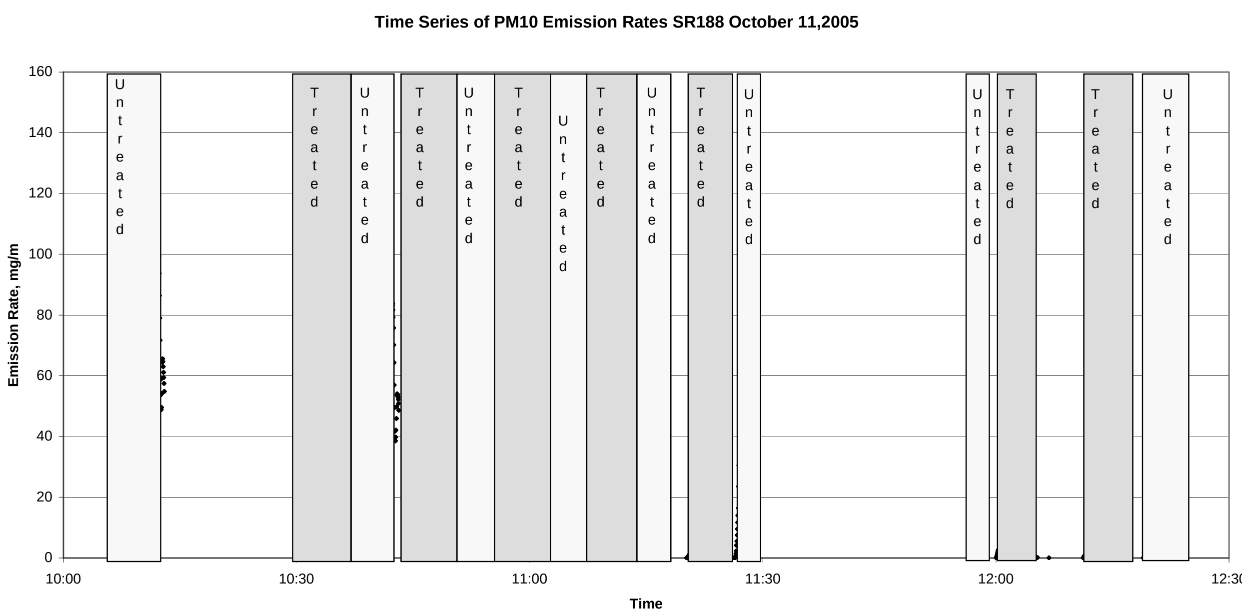


Figure 6. Time series plot of PM_{10} emissions during the test conducted on SR 188



Unpaved Mine Haul Road

Table 1 shows the average and standard deviation of the PM_{10} emission rate determined for each direction of the SCAMPER using the Ford Expedition as the test vehicle. The emissions generally increased during the day as the temperature increased, the relative humidity likely decreased (it was not measured), and possibly making the haul road drier. The overall average emission rate in the northwest direction was 0.51 mg/m, while in the southeast direction it was 0.52 mg/m. This shows that the PM_{10} emission potential for each direction is the same and that the measurement method is highly reproducible. The respective average standard deviations were 1.33 and 1.48 mg/m. Standard deviations higher than the mean have been routinely observed for the SCAMPER and are due to the rapidly changing emission rates due to road surface conditions.

Table 2 shows the average and standard deviation of the PM_{10} emission rate determined for each direction of the SCAMPER using the haul truck as the test vehicle. As noted with the tests using the Ford Expedition, the PM_{10} emission rates rose during the day as the temperature increased and the relative humidity decreased. Later in the day the PM_{10} emission rates tended to stabilize and then drop. The values for the haul truck were, as expected, considerably higher than that obtained using the Ford Expedition. The average emission rate for the NE direction (unloaded) was 4.2 mg/m while that for the southeast direction (loaded) was significantly higher at 6.98 mg/m.

Table 1. SCAMPER PM_{10} emission rate data for the Ford Expedition for each direction of each test run.

Date, Time (Local)	Direction	Emission Rate, mg/m	Std Dev Emission Rate, mg/meter	Average Speed MPH
10/30/06 10:47	NW	0.22	0.82	42
10/30/06 11:05	NW	0.09	0.12	44
10/30/06 12:02	NW	0.08	0.78	46
10/30/06 12:19	NW	0.17	0.92	47
10/30/06 12:39	NW	0.63	0.63	47
10/30/06 10:57	SE	0.01	0.15	43
10/30/06 11:15	SE	0.15	0.35	47
10/30/06 12:11	SE	0.15	1.16	48
10/30/06 12:33	SE	0.46	0.67	47
10/30/06 12:51	SE	0.68	1.01	48
10/31/06 12:46	NW	0.91	2.37	42
10/31/06 13:05	NW	1.21	3.58	40
10/31/06 13:23	NW	0.76	1.38	44
10/31/06 12:55	SE	1.19	3.81	44
10/31/06 13:15	SE	0.88	2.84	45
10/31/06 13:33	SE	0.61	1.84	44

Table 2. SCAMPER PM_{10} emission rate data for the haul truck for each direction of each test run.

Date/Time (Local)	Direction	Emission Rate, mg/m	Std Dev Emission Rate, mg/meter	Average Speed MPH	Comments
10/31/06 16:11	NW	7.32	9.94	40	Haul Truck
10/31/06 16:24	SE	2.38	4.89	35	Haul Truck
11/1/06 8:26	NW	1.49	3.25	42	Haul Truck
11/1/06 9:13	NW	3.93	11.78	43	Haul Truck
11/1/06 10:00	NW	2.56	7.91	39	Haul Truck
11/1/06 10:47	NW	4.56	7.13	36	Haul Truck
11/1/06 13:18	NW	8.21	3.09	33	Haul Truck
11/1/06 16:02	NW	4.43	8.36	29	Haul Truck
11/1/06 8:48	SE	4.91	13.71	35	Haul Truck, no background subtraction
11/1/06 9:35	SE	0.49	0.61	33	Haul Truck, no background subtraction
11/1/06 10:24	SE	1.40	3.08	33	Haul Truck, no background subtraction
11/1/06 13:41	SE	13.82	18.93	32	Haul Truck, no background subtraction
11/1/06 15:20	SE	12.87	8.25	33	Haul Truck, no background subtraction
11/1/06 16:26	SE	8.36	7.79	31	Haul Truck, no background subtraction
11/2/06 8:25	NW	0.15	0.34	29	Haul Truck, no front DT subtraction
11/2/06 10:49	NW	1.26	3.58	31	Haul Truck, no front DT subtraction
11/2/06 11:36	NW	3.87	6.99	31	Haul Truck, no front DT subtraction
11/2/06 13:54	NW	2.87	2.80	32	Haul Truck, no front DT subtraction
11/2/06 14:51	NW	3.45	3.59	30	Haul Truck, no front DT subtraction
11/2/06 8:52	SE	ND	ND	33	Haul Truck, no front DT subtraction
11/2/06 11:13	SE	2.88	5.79	32	Haul Truck, no front DT subtraction
11/2/06 11:58	SE	10.69	7.13	32	Haul Truck, no front DT subtraction
11/2/06 14:23	SE	15.95	22.38	32	Haul Truck, no front DT subtraction
11/2/06 15:29	SE	11.19	14.19	30	Haul Truck, no front DT subtraction
11/3/06 7:22	NW	0.63	0.71	32	Haul Truck, no front DT subtraction
11/3/06 8:34	NW	1.59	2.13	32	Haul Truck, no front DT subtraction
11/3/06 9:36	NW	2.70	3.56	33	Haul Truck, no front DT subtraction
11/3/06 11:22	NW	4.68	4.00	31	Haul Truck, no front DT subtraction
11/3/06 12:21	NW	11.24	7.04	33	Haul Truck, no front DT subtraction
11/3/06 12:57	NW	10.69	5.85	33	Haul Truck, no front DT subtraction
11/3/06 8:04	SE	1.01	1.09	29	Haul Truck, no front DT subtraction
11/3/06 9:05	SE	2.07	2.03	30	Haul Truck, no front DT subtraction
11/3/06 10:07	SE	4.13	4.86	29	Haul Truck, no front DT subtraction
11/3/06 11:53	SE	13.26	22.58	30	Haul Truck, no front DT subtraction
11/3/06 12:40	SE	6.00	6.53	30	Unloaded Haul Truck, no front DT subtraction
11/3/06 13:27	SE	7.26	7.73	31	Haul Truck, no front DT subtraction

Based on the weight of the vehicles and the AP-42 emission equation for paved roads, it would be expected that the PM_{10} emissions from the full haul truck would be 5 times that of the empty one and nearly 500 times that of the Ford Expedition. The PM_{10} emission rate ratios measured were considerable lower. Using the AP-42 equation for unpaved roads, the loaded haul truck's expected PM_{10} emission rate would be approximately 1.7 times the unloaded haul truck and 6 times that of the Ford Expedition. Thus, based on weight, the PM_{10} emission rates tend to follow the AP-42 expression for unpaved roads.

If one assumes 12% silt content, a typical value, and applies the AP-42 equation for unpaved roads for the haul truck, the PM_{10} emission rate is calculated to be 1,480 mg/m for an unloaded truck and 2,450 mg/m for the loaded truck. It is clear that the AP42 equation grossly over predicts the PM_{10} emission rate. It is not clear that the AP-42 paved road equation would be appropriate to predict PM_{10} emission rates of the haul road. This would require vacuuming of the road surface, which may not be compatible with this treated surface.

CONCLUSIONS

The effectiveness of using dust suppressants to reduce PM_{10} reduction from unpaved roads was quantified for segments of SR88 and 188. The suppressant applied to SR88 five months ago reduced PM_{10} emissions by a factor of five. The suppressant applied to SR188 a year ago reduced PM_{10} emissions by a factor of sixty. The SCAMPER was shown to collect reliable emission rates from unpaved roads with a precision of approximately 20%.

For the haul road measurements, the average PM_{10} emission rates were 4.2 and 7.0 mg/m for the unloaded and loaded haul trucks, respectively. The ratio of these emission rates are consistent with the weight variation predicted by the AP-42 equation for unpaved roads. The AP-42 PM_{10} equation for unpaved PM_{10} emission rates, however, over predicts the emission rates of this haul road by approximately a factor of at least 500. In addition, if the PM_{10} emission rates are to be calculated for 24-hour periods, the over prediction is likely to be higher, since the bulk of the PM_{10} emission rates measured by the SCAMPER were obtained in mid-day when PM_{10} emissions tended to be higher. We conclude that the use of the AP-42 equation for unpaved roads is not appropriate under these haul road conditions.

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AN EVALUATION OF STRENGTH GAIN IN SOIL~SEMENT AMENDED UNPAVED ROADS, SCOTTSDALE, AZ

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Abstract

Vinyl polymer stabilization agents, such as Midwest Industrial Supply's Soil~Sement, seem to greatly influence if not dominate the structural performance of sandy materials. So much so that the performance of Soil~Sement stabilized materials may be anticipated if not predicted.

Testing in Scottsdale, AZ during May, 2007 identified significant structural improvement provided by the Soil~Sement stabilization of a sandy unpaved, low volume roads. The stabilization provided for a significant increase in the road's resistance to deformation (stiffness). Historically, the stiffer and uniformly stiff a roadway is, the longer period of time between repairs. Within days of stabilization, stiffness had uniformly increased ~ 18% relative to what it was one day after agent installation. Generally, the stiffness exhibited was equivalent to a quality low traffic volume road paved with several inches of HMA (~ 20 MN/m). Two to three years after stabilization, stiffness uniformly increased ~ 50% to 65% relative to what it was one day after agent installation. Years into their life cycle, the Soil~Sement stabilized roads demonstrated a stiffness expected of a moderate volume paved road (~ 30 MN/m).

The stiffness gained with Soil~Sement stabilization was found to be well behaved as a function of time to a high degree of correlation. The predictability of the stiffness or strength gain appeared sufficient that it may be used as the basis of a performance specification.

Introduction

Two days of testing were conducted during 9 and 10 May, 2007 with the Midwest Samitron on five sections of Soil~Sement amended unpaved, low volume road in Scottsdale, AZ. Dennis Casamatta and Melvin Main of Midwest Industrial Supply, Inc. and Marty Koether of EarthCare Consultants performed the testing.

Objective

The objective of the testing was to determine if the performance of a Soil~Sement amended unpaved road was sufficiently well behaved to be predictable. This testing was intended as a precursor to the development of performance specifications and QC methods to control the installation of Midwest products using in-place stiffness.

Test Sites

Five sites were tested. These sites were:

- Site 1: Davis Rd., ~ 200' west of intersection Scottsdale Rd., ~ 1 day & 2 days old (days after Soil~Sement installation)
- Site 2: 71st St., ~ 200' north of intersection with Windstone, ~ 2 days old
- Site 3: Via Donna Rd., ~ 500' east of intersection with Scottsdale Rd., ~ 2 months old
- Site 4: 76 th St., ~ 200' south of intersection with Via Donna, ~ 2 yr. old
- Site 5: Via Donna Rd., ~ 50' east of Hayden, ~ 3 yr. old

The soil at each site was silty sand, AASHTO A-2-4. The soil at each site was amended with Soil~Sement to a depth of ~ 4 in. Water dilution rates varied with ambient temperatures and soil moisture at the time of application. The rate was usually 1:8 (1 part Soil~Sement to 8 parts water) however after rains it was 1:4 to account for wetter soil. The amount of undiluted product that was applied per unit area was the same regardless of dilution rate. The application rate for that depth was .36 gallons of Soil~Sement per square yard of treated soil. Of that, a total amount of 25% to 30% was used for a topical sealing of the amended road after compaction. This occurred in two or three topical coatings.

Tests Performed

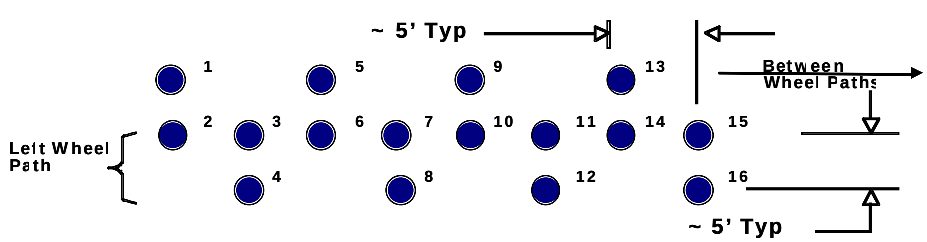
Sixteen Samitron measurements per ASTM D-6758 were made at each site (Figure 1). Measurements on all sites required the use of moist mortar sand to seat the Samitron, as the surface was often hard and dry. The measurement data is presented in Table 1.

Table 1: Measurement Data

Test Location	Stiffness MN/m Test Site 1 (~ 24 hr.)	Test Site 2 (~ 48 hr.)	Test Site 3 (~ 2 months)	Test Site 4 (~ 2 yr.)	Test Site 5 (~ 3 yr.)	Test Site 1 (~ 48 hr.)	All 48 hr. Data
1	17.21	17.53	19.56	26.85	25.39	27.42	
2	19.95	15.12	15.49	28.67	38.30	22.43	
3	18.04	15.96	24.44	24.80	30.23	15.74	
4	14.72	16.30	25.97	28.17	37.89	18.21	
5	13.98	19.94	28.87	26.50	28.65	24.63	
6	17.42	14.43	19.46	27.12	27.74	25.14	
7	16.34	24.45	25.87	21.74	20.47	21.62	
8	14.90	18.68	24.30	24.51	24.27	19.14	
9	16.89	21.62	26.96	31.51	33.29	18.69	
10	15.82	13.26	20.97	31.71	29.26	22.37	
11	18.00	22.33	22.69	25.34	23.32	23.61	
12	17.25	24.37	26.96	23.14	29.19	20.32	
13	17.36	23.12	26.09	31.71	34.61	23.51	
14	16.54	14.80	19.84	28.13	32.54	27.38	
15	19.40	20.98	20.91	27.68	27.68	27.22	
16	27.27	18.53	22.94	26.41	23.84	23.57	
Average	17.57	18.84	23.21	27.12	29.17	22.56	20.70
Standard Deviation	3.03	3.68	3.60	2.91	5.16	3.47	4.00
COV (%)	17.27	19.55	15.53	10.74	17.70	15.38	19.30
Ž re Site 1 Average, %		7.23	32.10	54.40	66.02	28.43	17.83

Figure 1

Sampling Pattern for All Sites



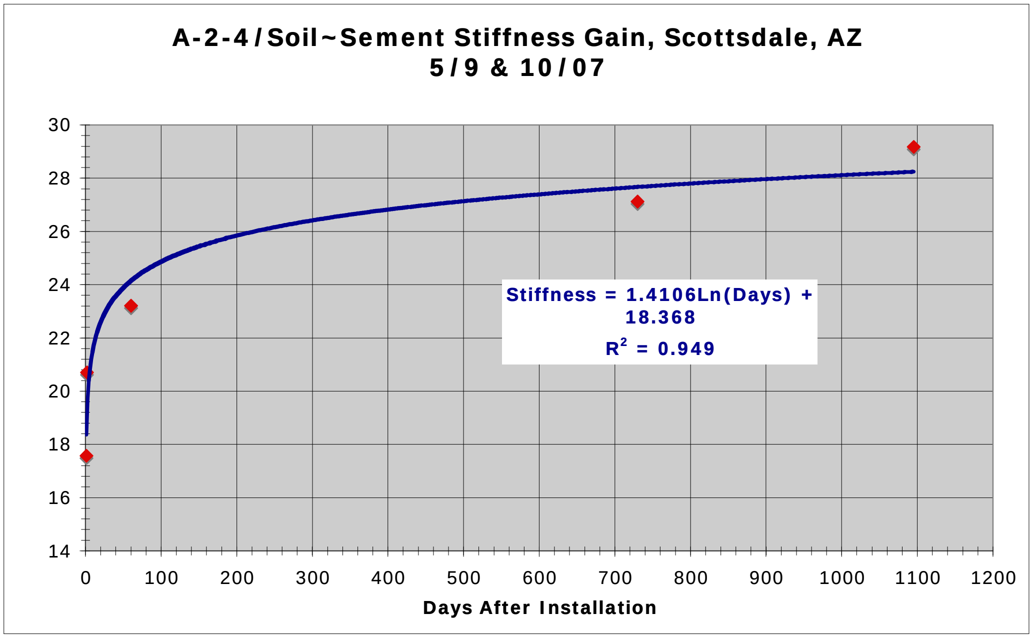
Results & Analysis

When the test results for the Soil~Sement amended silty sand are graphically represented, the mean stiffness for all five sites, representing 3 years of aging, lie on the same logarithmic curve with a high degree of correlation (Figure 2). Since the cure rate of most materials is logarithmic, this data strongly suggests that the rate of stiffness or strength gain is very consistent between the sites. It also suggests that the performance of the Soil~Sement amended road is predictable. The stiffness uniformity of is higher than most roads Midwest has evaluated. A uniformity represented by a coefficient of variation of ~ 13% for in-place stiffness is considered ideal by the FHWA. The largest coefficient for the Soil~Sement amended silty sand is 19.6%.

Site Conditions

The weather on May 9 and 10 was sunny and dry, temperature in the 80s and winds below 5 mph. During both days, low traffic volume was experienced (< 10 vehicles per hour).

Figure 1



Samitron Bias & Precision

Samitron operation was verified on its inertial isolated mass before each day of testing. A coefficient of variation (COV) of less than 1% about the expected value of stiffness was measured on the mass for 3 Samitron measurements. Samitron measurements were repeated at Site 1 to evaluate measurement precision. At this site, the COV for 3 measurements was 3.3%.

Conclusions and Recommendations

Samitron measurements are readily able to quantify the rate of strength (stiffness) gain for the Soil~Sement amended silty sand. Judging from the consistency and uniformity of the Samitron measurements, there is apparently good control of native material, stabilization (amendment with Soil~Sement) and compaction. Samitron measurements indicate that the rate of strength gain is predictable.

It is therefore possible to quantify from empirical Samitron data the needed roadway strength or stiffness. Using the Samitron, a prepared unpaved road can be evaluated as to whether it needs stabilization or not. If it does, then Samitron measurements can quantify the amount of stabilization (stiffening) achieved.

CBR measurements of stabilization on molded laboratory samples could be used to customize mixes for a variety of materials and related to expected in-place stiffness.[1] Using the Samitron on the same laboratory samples, cures rates (rate of strength gain) can also be defined. These laboratory measurements can be used to define the short-term strength gain of in-place stabilized materials and predict when the material can be released to loading and what its ultimate strength will be.

Following is a recommendation of how the in-place performance in terms of stiffness should be defined and evaluated for a Soil~Sement amended AASHTO A-2 soil. It is based on the testing in Scottsdale, AZ. It is assumed that the performance of the Scottsdale roads is satisfactory and typical. It is also preliminary until additional tests, like those done in Scottsdale, can be done on the same soil class on jobs elsewhere in the United States.

In-Place Stiffness Requirements & QC Measurements

At two different times early in the life of the installation separated by a minimum of 1 day (e.g., 1 and 3 days), stiffness measurements will be made on the roadway per ASTM D 6758. These measurements should be made every 500 ft. at random locations. The installation will be judged acceptable if the average of all measurements

Figure 3
Acceptable Stiffness Limits
Soil~Sement Amended ASSHTO A-2 Silty Sand

[1] Assessment Of In-Situ Test Technology For Construction Control Of Base Courses And Embankments, 2004, Murad Y. Abu-Farsakh, Ph.D., P.E., Khalid Alshibli, Ph.D., P.E, Munir Nazzal, and Ekrem Seyman, Louisiana Transportation Research Center, Baton Rouge, LA 70808, FHWA/LA.04/385

and all individual measurements are within the limits defined in Figure 3. The limits in this figure are valid for the same mix and construction methods as those used on the Scottsdale, AZ roads, from which the data in the figure came.

Investigation of Water Runoff and Leaching Impacts from Dust Suppressants

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Investigation of Water Runoff and Leaching Impacts from Dust Suppressants

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ABSTRACT

This project was funded by USEPA's Office of Research & Development through allocation of Regional Applied Research Effort funds. Supplemental funding and staff resources were provided by Clark County DAQEM and Maricopa County AQD. Six different dust suppressants, including four surfactants, one synthetic organic, and one synthetic polymer were evaluated for their impact on water quality, both runoff potential to surface water and leaching potential to ground water. From each County, one bulk sample of about 5 cubic yards and five one-gallon samples were collected. These soil samples were delivered to the San Diego State Soil Erosion Research Laboratory (SERL) for testing.

Soils were selected using soil maps contained in PM-10 plans and rules for the Las Vegas Valley and Phoenix for PM10 non-attainment areas. Staff from Clark County DAQEM and Maricopa County DAQM recommended specific locations from which the soil samples were collected.

SERL conducted: 1) pilot tests, 2) surface leaching (water runoff) tests, and 3) vertical migration tests. The surface leaching and column migration tests involved two soils in bulk quantity. The pilot tests involved both a pre-test of the bulk quantity soils and a separate test of 10 soils in small quantities.

1. INTRODUCTION

Fugitive dust accounts for 80% or more of particulate matter less than 10 microns (PM-10) in desert areas such as the Las Vegas Valley (Clark County, Nevada) and the Phoenix Metropolitan Area (Maricopa County, Arizona). Desert soils that tend to resist water have particularly high propensity for creating fugitive dust. These types of soils are

TDS pilot test results may be a facet of experimental design rather than an effect that would occur in surface runoff. Additional research could assess the actual potential of the two products to mobilize salts in surface runoff from multiple soil types.

Aquatic toxicity results were also generally favorable. No toxicity to fish was observed in any dust suppressant product runoff. No significant inhibition of algae growth was observed in the two or more samples per dust suppressant product that were successfully tested. A caveat to this favorable outcome is that the algae test protocol required fine filtration of samples that removed significant quantities of sediment to which the dust suppressant products may have adhered.

Toxic effects to the invertebrate *Daphnia magna* were observed in some samples, however, most runoff samples from the surfactants showed no significant impact. For the limited instances when an adverse effect on daphnia survival was observed in surfactant runoff relative to control test runoff, variability among control test results renders the effect inconclusive.

Runoff from Durasoil and EnviroKleen showed a significant impact to *Daphnia magna* survival rates across all tests. This effect was not a classic toxic response but related to physical entrapment of the daphnia in an insoluble product layer. However, the entrapment observed within small laboratory test containers does not represent an effect likely to occur in an open water body, given various potentially mitigating factors. Furthermore, any such effect would likely be localized to a small area. Pure product tests with Durasoil and EnviroKleen showed that the physical entrapment effect does not extend to a smaller invertebrate also commonly used in toxicity testing, *Ceriodaphnia dubia*.

The results of this study should in no way be construed to support the use of substitute dust suppressant products that have not undergone similar testing and may have other and/or more significant potential impacts to water quality or aquatic life than the limited effects observed in this study.

prevalent in Clark County, Maricopa County, and other arid areas. The use of dust suppressants other than water can be beneficial, and in some cases necessary, to adequately control fugitive dust at earthmoving/construction sites. They also reduce the quantity of water needed for adequate dust control, thereby contributing to water conservation. Without the use of dust suppressant products, earthmoving of soils with high potential to create fugitive dust in hot temperatures may require constant watering to comply with fugitive dust regulations.

The purpose of this research was to identify dust suppressant products with minimal to no adverse impacts on water quality and aquatic life relative to use of water alone. Simulated stormwater runoff from small-scale soil plots treated with six dust suppressant products was evaluated for water quality and aquatic toxicity. The study also evaluated the quality of water leached through soils treated with dust suppressant products.

Funding was provided by USEPA's Office of Research & Development through allocation of Regional Applied Research Effort funds. Supplemental funding and staff resources were provided by Clark County DAQEM and Maricopa County AQD.

2. STUDY DESIGN

The study design replicated, to the extent possible, conditions under which dust suppressants are typically applied at construction sites in desert climates. This included use of soils from Arizona and Nevada, a simulated 5-day earthmoving period with soil disturbance and repeated product applications, and heating soils to desert temperatures during the day. Emphasis was placed on dust suppressant applications to control dust during active earthmoving, e.g., rough grading. Surface runoff tests incorporated different combinations of two product application scenarios, three rainfall intensities, and three rainfall time periods (up to 2 months following product application).

2.1 Soil Selection and Collection

Clark County DAQEM and Maricopa County AQD recommended specific locations for soils collection by reviewing soil maps contained in PM-10 plans and rules for their respective areas. The maps classify soils by texture and corresponding severity of dust-emitting potential. The following soils were collected for use in the study:

- Two (2) five cubic yard soil samples -- from one site in Maricopa County, Arizona and one site in Clark County, Nevada
- Ten (10) one gallon soil samples -- from 5 sites in Maricopa County and 5 sites in Clark County

Soil for the surface runoff and vertical migration experiments was collected "in bulk" from a single site in Maricopa County and a single site in Clark County. Approximately 5 cubic yards was removed from each site by backhoes digging to a depth of 1 foot. Soils for the pilot experiment were collected from five sites in Maricopa County and five sites in Clark County. The ten sites are intended to represent a general survey of random soil types and particulate emissions potential. At each of the ten sites, 1-2 quarts of soil to a 1-inch depth were collected.

Once the soils were delivered to SERL, the two bulk soils were re-mixed to ensure homogeneity for segmenting into individual test trays and columns. Each bulk soil was placed on a clean tarp, spread into a square approximately 1 foot deep. The soil was then divided into four equal quadrants using stakes and string lines. Next, 30-gallon plastic garbage cans (previously cleaned with reverse osmosis water) were filled with equal parts of soil from each quadrant. The garbage cans were labeled, covered and transferred inside for storage.

2.2 Dust Suppressants and Application Scenarios

USEPA Region 9, Clark County DAQEM, Maricopa County AQD, and EQM selected 6 dust suppressant products with good potential for minimal impacts on water quality and aquatic life. Table 1 shows the products selected, along with product-to-water ratios and application rates recommended by the manufacturers (for Jet-Dry, the product-to-water ratio and application rate were recommended by a representative of the construction industry).

Table 1. Dust Suppressant Products and Recommended Product Application Rates

Product	Manufac-turer	Suppress-ant Type	Product-To-Water Ratio	Applica-tion Rate
Chem-Loc 101 (CL)	Golden West Industries, Inc.	Surfactant w/ ionic and anionic properties	1.0 gal per 5,000 gal water	4,000 gal per 2 acres
Enviro RoadMoisture 2.5 (ERM)	Envirospeci alists Inc.	Surfactant (non-ionic alcohol ethoxylate)	1.0 gal per 2,500 gal water	4,000 gal per 2 acres
Durasoil (DS)	Soilworks, LLC	Synthetic Organic	Product not diluted with water	1 gal/30 ft^2 & 1 gal/185 ft^2
Jet-Dry (JD)	Reckitt Benckiser	Surfactant	1.0 gal per 2,000 gal water	4,000 gal per 2 acres
Haul Road Dust Control (HR)	Midwest Industrial Supply	Surfactant	1.0 gal per 2,000 gal water	4,000 gal per 2 acres
EnviroKleen (EK)	Midwest Industrial Supply	Synthetic Polymer	Product not diluted with water	1 gal per 40 ft^2 & 1 gal per 250 sq. ft^2

Two application rates were provided for Durasoil and EnviroKleen, one in lower quantity appropriate for an earthmoving activity, the other in higher quantity appropriate for soil stabilization. Product manufacturers provided samples of their dust suppressants for use in the study

Half of the dust suppressants were designated for testing on the Arizona bulk soil (CL, ERM, and DS) and the other half for testing on the Nevada bulk soil (JD, HR, and EK) in the surface runoff and vertical migration experiments.

In order for the study to replicate real-world dust suppressant use, an experimental design was developed to assess the effects of repeated product applications and simulated soil disturbance. A 5-day period was selected as a typical length of time to accomplish rough grading at a construction site. The study design included raking of soil to a 1-inch depth in order to simulate disturbance necessitating product re-application.

Two re-application scenarios for the 5-day period were developed for each dust suppressant product, to which we refer as “Application Scenario A” and “Application

Scenario B". For the surfactants (all products except EnviroKleen and Durasoil), Application Scenario A involved applying product each day throughout the 5-day period while Application Scenario B involved applying product only on Days 1, 3 and 5. Soil was raked once a day for both application scenarios at approximately 90 degrees relative to the direction of the previous day's raking. For the synthetic products (EnviroKleen and Durasoil), Application Scenario A involved applying a lower quantity of product each day (see Table 2-5) along with soil raking once per day. Application Scenario B involved applying a higher quantity of product (see Table 2-5) in a one-time application and no soil raking.

All soils in the test trays were heated during the day to mimic desert conditions. This was done with appropriately spaced heat lamps to increase the temperature of the soils to approximately 86-104 degrees Fahrenheit for 12 hours each day. Soils were heated during both the 5-day dust suppressant application period and throughout the aging periods (up to 2 months).

2.3 Surface Runoff, Surface Leaching, and Pilot Experiments

The study analyzed surface runoff and subsurface leaching from soils treated with dust suppressants for nine standard water quality parameters: (1) pH, (2) Total Dissolved Solids (TDS), (3) Electrical Conductivity (EC), (4) Dissolved Oxygen (DO), (5) Total Organic Carbon (TOC), (6) Total Suspended Solids (TSS), (7) Nitrate, (8) Nitrite, and (9) Phosphate. In addition, surface runoff was tested for toxicity to aquatic life (fish, algae, and invertebrates). Furthermore, pilot tests with soils collected from multiple locations in Arizona and Nevada were conducted to gauge the potential of dust suppressant products to mobilize pre-existing salts and/or metals in soils.

2.3.1 Surface Runoff Experiment

The surface runoff tests were performed on a 3-meter wide by 10-meter long tilting test bed with overhead rainfall simulators. The test bed was outfitted with eight platforms designed to hold removable soil trays (i.e., "test plots") 14 inches wide, 25 inches long, and 4 inches deep. The soil trays were suspended in the center of the platforms and, during the experiment, tilted to a 33% slope. Rainwater was applied to the soil trays using a Norton Ladder Rainfall Simulator, developed at the USDA-ARS National Soil Erosion Research Laboratory. Nozzles are spaced 1.1 meters apart and at least 2.5 meters above the soil surface.

The rainwater used in the experiment was tap water treated with reverse osmosis, henceforth referred to as “RO-water”. RO-water was used for three purposes: 1) as artificial rainwater to generate surface runoff from soil test plots; 2) as a dust control alternative applied to soil test plots to represent “untreated” control scenarios; and 3) to dilute products where specified in the dust suppressant application scenarios.

The surface runoff experiment involved 3 simulated rainfall events representing a range of desert climate precipitation capable of creating stormwater runoff (0.7 in/hr for a duration of 150 minutes, 1.3 in/hr for a duration of 80 minutes, and 2.4 in/hr for a duration of 44 minutes). The rainfall events were timed to occur at three different periods, i.e., “ages”, following dust suppressant application.

AGE 0 - immediately following the 5-day application period
AGE 1 - one month following the 5-day application period
AGE 2 - two months following the 5-day application period

The purpose of including rainfall event scenarios one or two months following product application was to capture any biodegradation effects that may occur over time. Given the combination of the various test parameters, a total of 126 soil trays were prepared -- 18 for each of the six dust suppressants plus 18 untreated (RO-water alone applied).

Following application of dust suppressants according to either Application Scenario A or B, the soil trays were placed on the tilting test bed to undergo one of the three simulated rainfall events at one of the three aging cycles. The untreated soil trays were subject to the same experimental parameters as soil trays treated with dust suppressants.

Surface runoff from each soil tray was directed into a plastic flume discharging into a 4 liter, wide-mouth sample bottle. Thus, a water runoff sample was generated for each of the 126 trays.

2.3.2 Vertical Leaching Experiment

The vertical leaching tests were conducting using 4-inch diameter vertical flow columns. The vertical leaching tests were conducted using the same 5-day application scenarios as in the surface runoff tests (including dust suppressant re-application, soil raking, and soil heating), except dust suppressants were applied in lower quantity due to the smaller container size. Another difference was that RO-water was applied to the top of each soil column and held at constant head. This simulates a circumstance in which rainwater has collected into a puddle or pond and gradually infiltrates.

A total of 80 soil columns were prepared -- 12 for each of the six dust suppressant products plus 8 untreated columns (RO-water alone applied). Effluent from the bottom of each soil column was collected in 4-liter, wide-mouth sample bottles.

2.3.3 Pilot Experiment

For the pilot tests, 1-2 quarts of soil collected from five locations in Arizona and from five locations in Nevada were placed into 4-inch diameter by 2-inch depth cylinders. The intent of these tests was to evaluate sensitivity of select water quality parameters to differences in soil chemistry to gauge the potential of dust suppressant products to mobilize salts and/or metals that may pre-exist in soils.

Dust suppressants were applied to each of the soil cylinders. Following this one-time application, the cylinders were stored for 24 hours. Next, 300 ml of RO-water was applied to each cylinder and the entire soil-water mixture was transferred to a 1-liter sample bottle. The soil-water mixture was then analyzed for pH, Electrical Conductivity, and Total Dissolved Solids.

All six dust suppressant products plus water-only control tests were evaluated on all 10 soil samples. The pilot experiment generated a total of 140 results for each of the 3 water quality parameters tested.

3. STUDY RESULTS

Overall, water quality results for the dust suppressant products were favorable, showing concentrations similar to water-only control tests on untreated soils for the majority of parameters evaluated. For a subset of parameters and dust suppressant products, average results were higher relative to control tests. However, considerable variation among control sample values warrants conservative data interpretation, particularly in cases where average results for dust suppressant products were only marginally higher.

A trend was observed for Total Suspended Solids (TSS) values in surface runoff from soils treated with Durasoil and EnviroKleen. TSS reflects the quantity of sediments suspended in water and resulting water clarity. TSS concentrations corresponding to these two products were significantly higher relative to control samples (on average, five times higher in Durasoil runoff and twice as high in EnviroKleen runoff). The higher TSS values appear to relate to the products' soil binding characteristics and the tendency for larger dirt clumps to form and be released in surface runoff relative to tests involving untreated or surfactant-treated soils. In a real-world setting, overland runoff typically travels some distance, creating opportunity for heavier dirt clumps to settle out prior to reaching a water body. Also, use of an on-site retention pond as a stormwater best management practice would likely prevent off-site runoff.

Results from the subsurface leaching tests show no potential impact from the dust suppressants on groundwater quality for the parameters evaluated. (While subsurface leaching TSS results from a couple of products were higher than control samples, TSS is generally not a concern for groundwater quality.)

In pilot tests on multiple soil types that examined the water quality of a soil/water/product mixture (as opposed to surface runoff), Total Dissolved Solids (TDS) concentrations for two products -- Enviro RoadMoisture 2.5 and Durasoil -- were significantly higher than control samples. TDS refers to inorganic solids dissolved in water, such as mineral salts. In contrast to these results, TDS values observed in surface runoff tests involving Enviro RoadMoisture 2.5 and Durasoil were not higher relative to control samples. The high

DUST CONTROL AND THE UNITED STATES MILITARY

Presented at the 2008 Road Dust Management Practices and Future Needs Conference

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DUST CONTROL AND THE UNITED STATES MILITARY

Abstract

This paper addresses experiences and concerns with dust mitigation procedures used by the U.S. military. The paper describes the current criteria published for the military on dust mitigation and details a research program established to provide updated guidance for the U.S. Marine Corps to address specific requirements in recent combat operations. This criteria was recently extended to include applications for the U.S. Army and U.S. Air Force. The paper also points out future areas of research that are needed, including addressing environmental concerns, providing guidance for dust mitigation in non-traffic areas, developing environmental and performance approval procedures, erosion control, and updating military criteria.

Introduction

The United States military often operates in austere environments with little or no improved infrastructure. These types of battlefields are tactically desirable to minimize collateral damage during warfare. However, this scenario requires transport vehicles that maintain high mobility in complex terrains and environmental conditions. By their aggressive nature, these vehicles are often prone to dust generation during movement.

Dust generation has been a problem for the military for many years. Since the period of World War I and II, aggressive tank treads have caused heavy dust generation on unpaved surfaces. In Vietnam, heavy dust clouds were often a problem with the increased use of rotary wing aircraft. More recently, dirt airstrips for landing C-130 and C-17 cargo planes produce unmistakable dust signatures during takeoff and landing events. The dust generated during all of these maneuvers impacts operational requirements, produces safety hazards, increases maintenance requirements, and creates an additional threat during missions.

Dust Mitigation Practices

The current criterion for dust mitigation for the U.S. military is given in UFC 3-260-17 (1). This document was accepted for criteria in 2004 but contains the body of Army TM 5-830-3 dated 1987. The recommendations made in this document do not reflect recent advances in technology and current industry practices. The information appears to be dated well beyond the 1987 publication date. This observation is especially evident by photos below (Figure 1) that describe particular causes of dust. The U.S. military is operating more sophisticated equipment today that requires special considerations for dust mitigation treatments.

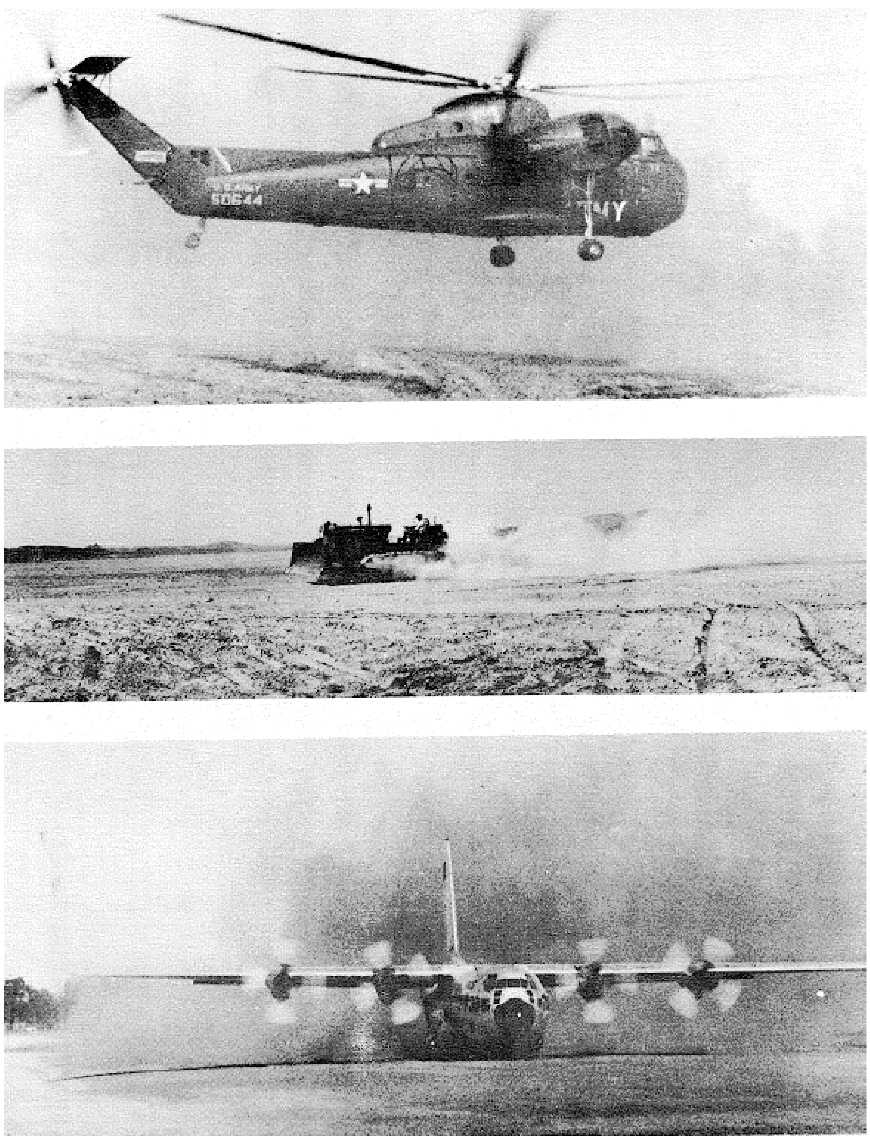

Figure 1. Excerpt from UFC dust control manual

The lack of relevant criteria for mitigating dust subsequently translates into inadequate practices by personnel in the field. Dust has been a significant obstacle during current operations in Iraq and Afghanistan, and many materials and techniques to combat the problem have been attempted with varying degrees of success. The lack of proper guidance for these techniques has led to two often occurring results.

First, products have been purchased to solve a dust problem that they are not capable of solving. For example, using a chloride salt in the extreme desert conditions in Iraq where humidity is low will lead to poor performance because the salt cannot absorb enough moisture from the air to function properly. This type of improper application wastes time and resources and causes frustration on the part of the user.

The other common occurrence is the improper application of an acceptable product, leading to product distrust and abandonment. For example, a user may spray a surface treatment of a diluted polymer emulsion on very soft, loose sand and then operate heavy equipment in the area. The equipment will break the crust of physically bound soil and expose loose material that becomes airborne. The user experiences distrust in the product because it did not perform as expected, but the problem was that a useful material was placed in an ineffective manner.

These types of situations were commonly experienced by military personnel in Iraq and Afghanistan. Military personnel often relied on innovative solutions executed with makeshift equipment to provide adequate results. While some units were able to meet requirements, the lack of proper guidance created great inefficiency for the military as a whole.

Recent Research Activities

The U.S. Marine Corps recognized complications caused by dust during the early stages of operations in Iraq and Afghanistan. They also recognized the fact that they did not possess the capability to combat the problem. This realization led to expedited funding to develop a system that could fill immediate and future dust mitigation needs. The U.S. Army Engineer Research and Development Center embarked on a three-year developmental research program to provide products, equipment and application recommendations for the Marines. The multifaceted research program addressed several specific concerns.

First, the Marines had no capabilities for distributing chemical dust palliatives. The construction inventory of the Marines is very limited and relies on assets of the Navy Seabees and other units to provide engineering and construction support. A distribution system had to be developed and fielded if the Marines were going to provide their own dust mitigation capability. The development process involved down-selecting candidates from commercially available distribution equipment for other industries and subjecting selected equipment alternatives to field evaluations under predetermined criteria. Recommendations were made for the modification of the equipment for specific Marine requirements during the acquisition phase. The final systems, a skid-mounted hydroseeder and a tow-behind hydroseeder, were delivered to the units responsible for dust mitigation along with a comprehensive training program on the equipment use.

Product recommendations and application guidance were simultaneously being developed through a series of field evaluations. These trials addressed specific needs for dust mitigation on unpaved roads and helicopter landing pads. Results from these tests were used to provide guidance on selecting chemical dust palliatives and for determining effective application procedures.

Field trials for selecting chemical dust palliatives for helipads took place at the U.S. Marine Corps Air Station, Yuma, AZ (2,3). The site for these tests is physiographically located in southwest Arizona in an arid environment. The soil consisted of a poorly graded sand with silt according to the Unified Soil Classification System. After removing vegetation from the testing site, the soil was very loose to a depth of approximately one foot. Twenty helipad locations were surveyed for treatment with a variety of products at multiple application rates. Treated areas were subjected to landings with multiple types of rotary wing aircraft and analyzed for product effectiveness (Figure 2). Results were compared to an untreated control section. Two different sequences of tests were performed at this site. Data were used to determine appropriate products and minimal application rates for providing adequate dust mitigation under both small attack/utility helicopters and their larger, heavier cargo counterparts.

Figure 2. CH-46 Helicopter landing on treated helipad.

Other field evaluations were designed to provide guidance for mitigating dust on unpaved roads. One study took place in Douglas, AZ on a 3.2-mile section of road paralleling the border between the U.S. and Mexico used by the U.S. Border Patrol for surveillance (4). This particular climatic region was also considered arid. Traffic on the road consisted of lightweight trucks at a frequency of approximately 60 per day. Road test sections of 500 feet in length were treated with a variety of products (Figure 3). The evaluation also included a comprehensive evaluation of application procedures for identifying the most durable treatment option. Test sections were monitored at 30, 60, 90, and 180 days to provide data for making recommendations on desirable products and application procedures on unpaved roads in arid environments.

Figure 3. Treating road section in Douglas, AZ with chemical dust palliative.

An additional test of dust palliatives on unpaved roads was executed on training routes at Fort Leonard Wood, MO (5). This facility represented a temperate climate and is used to train U.S. Army personnel to operate large wheeled vehicles in convoys (Figure 4). Heavy dust concentrations are generated by these large vehicle movements. Again, multiple 600-foot long test sections were marked and treated with a variety of products to monitor the long term performance for each material. Data collections at 1, 3, and 8 months were performed to evaluate the products. Knowledge gained from these test sections was used to support previous research results and determine climatic considerations for product use.

Figure 4. Dust generation caused by military convoys operating on unpaved road.

Additional dust mitigation tests were performed to minimize dust during aircraft operations on semi-prepared airfields. Three airfields were treated with select dust palliatives to mitigate dust along the runway edges during aircraft operations. These data were used to supplement guidance for roads and helipads.

The field evaluation portion of the U.S. Marine Corps research program provided the data for complete operational dust mitigation guidance. The procedures and recommendation were compiled in a dust mitigation handbook that was published and distributed to the Marine units along with the distribution equipment (6). The initial field handbook was specifically tailored to meet the needs of the Marines, and a second edition was published that provide a more comprehensive guide for the other services (7).

Knowledge Gaps and Future Needs

The research program executed for the U.S. Marine Corps addressed many operational concerns for dust problems within the military. However, the program specifically identified solutions for Marine Corps problems. Additional needs of the other services should be addressed to provide comprehensive solutions for the military as a whole. Many of these needs could be addressed without significant effort by utilizing the knowledge base from the work that has been accomplished.

While the research described previously made great strides to combat dust in operational environments, areas of additional concern have been identified. First, even in the operational environment, adequate research has not been performed to address dust control in non-traffic areas. These areas are also prone to dust generation from loose surface soil that can be picked up and transported by wind. These areas were a nuisance at large base camps in Iraq and Afghanistan. Product application quantities required for adequate treatment would be significantly reduced from those recommended for traffic areas. These reductions need to be quantified through research.

Additionally, research performed under the Marine Corps program did not address compliance with air quality standards set by the U.S. Environmental Protection Agency (EPA). The work considered all dust to be the same. Any dust was assumed to be detrimental to military operations. Further research should characterize the dust by the size and how it is classified in EPA guidance. This work would be required to provide better recommendations to military installations in the U.S. on how to control dust for meeting air quality regulations. Further, a study focused on air quality compliance issues would be more beneficial to personnel tasked with routine dust mitigation efforts on these installations where no external threats exist. These installations often only need to address the environmental and safety concerns posed by dust generation, while current recommendations focus on sustaining adequate maneuverability.

Furthermore, many of these dust palliatives may be effective in minimizing surface soil erosion by binding near surface particles until the area can be re-vegetated using conventional means. Research is needed to define the erosion resistance requirement, test products for suitability, and provide cost-effective application guidance.

Limited work was performed on the individual dust palliatives to determine their impact on the environment. The ERDC research focused on the environmental assessment of a few select products identified during the program described above (8). The suppliers of these products are often not intimately aware of chemical composition of the product and any precautions that should be considered with their use in different environments. Any use of dust palliatives should be preceded with environmental approval, but the approval is generally left to the specific governing body where dust mitigation is required. A central authority should assess all market products and clear those that are deemed environmentally friendly. This approval could then be passed along at the local level to expedite projects.

Along with the environmental approval, an approved product list should be established for military use. A set of criteria needs to be developed that allows interested vendors to submit materials for testing. Acceptance to the list would need to be followed with periodic conformance checking to ensure quality control of the manufacturing process. The products approved for use should be awarded national stock numbers for easy procurement by military personnel through the Defense Logistics Agency and GSA schedule for other government agencies.

Finally, results from recent and future research programs should be incorporated into the UFC manuals to update the criteria. This step is essential for providing users in the military with current best practices knowledge. Periodic updates should be performed to ensure that criteria does not become out of date and includes any recent advances in technologies.

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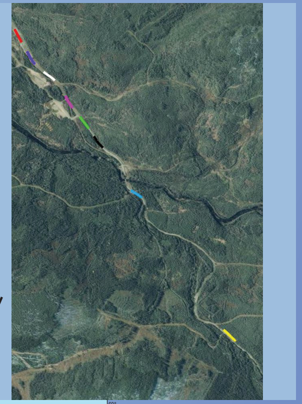
Field Study of Granular Materials Treated with Dust Suppressants And Behaviour Evolution under Traffic and Climate

Philippe Poulin, Pascale Pierre & Sylvain Juneau

Montmorency Forest

Located 50 kilometers north of Quebec City, this unpaved road runs across the University Laval experimental forest. Seven different products have been applied on 100 meters sections. The quality of runoff water as well as road conditions and levels of dust are monitored there.



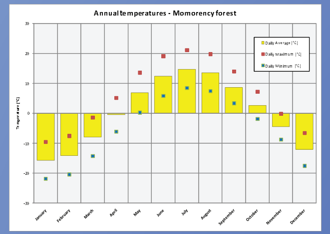
Aerial view of the Montmorency forest Sections. The control sections is located apart to avoid contamination with products. Run-off water is collected over 7 sections with products that are also tested at Rivière-aux-Rats.

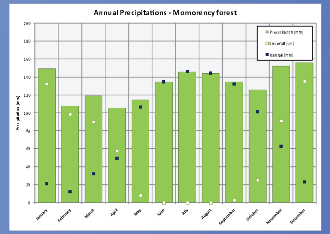
Rivière-aux-rats Forest

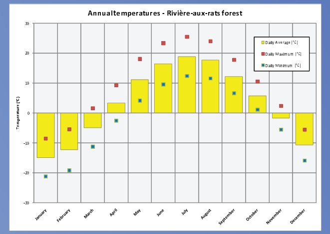
The forest road 25 that connects cities of La Tuque and Parent is mostly used by logging truck. 6 different products have been applied onto 500 meters long sections. The effect of heavy traffic is studied and the road conditions and dust levels are measured here.

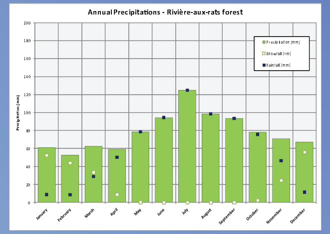
Aerial View of route 25 in Rivière-aux-Rats forest. The last two sections on the left have been backfilled and compacted this spring. One of them has then been treated with Soil Sement, a stabilization product.

Climate Characteristics









Products

Calcium chloride

DOWFLAKE Xtra manifactured by Dow Chemical is made of 83-87% calcium chloride flakes. It reduces dust by continuously absorbing moisture from the air, keeping the surface slightly damp and binding dust particles to larger aggregate of the road.

Calcium chloride (85% flakes)	
Calcium chloride	85,0%
Alkali chlorides	4,1%
Magnesium chloride	0,03%
Specific Gravity (38% Solution)	1,39
PH (38% Solution)	

Solnat

Solnat is a natural brine produced by Junex. It is an extremely salty water that has been buried deep underground for the last 400 million years. This clear and odourless liquid contains several valuable ingredients including calcium, magnesium, sodium and potassium.

Solnat 270	
Calcium chloride	60,0%
Alkali chlorides	38,0%
Magnesium chloride	2,0%
Specific Gravity (270 Solution)	1,18
PH (270 Solution)	5,5

Solnat 340	
Calcium chloride	60,0%
Alkali chlorides	38,0%
Magnesium chloride	2,0%
Specific Gravity (340 Solution)	1,22
PH (340 Solution)	3,5

Road Oyl

Road Oyl from Midwest Industrial supply is a resin-modified emulsion that acts as flexible pavement binder. It is made from natural products such as pine rosin and pine pitch in water

Road Oyl	
Solubility in water	Dilutable
Odor	musty, woodsy
Appearance	light brown liquid
Specific Gravity	0,9 - 1,1
PH	6 - 9

X-Hesion

X-hesion is a non-chloride proprietary formulation of agriculturally derived complex organic polymers. It is made by Envirotech services. These polymers function to stabilize road base materials by binding the base materials together while maintaining a road surface that is flexible and water resistant.

X-Hesion	
Solubility in water	Dilutable
Odor	Organic Odor
Appearance	Off white, tan
Specific Gravity (38% Solution)	1,04 - 1,30
PH	7 - 9,5

Dust Stop

Dust Stop is a dust suppression and erosion control product developed by Cypher International Ltd. It is derived entirely from natural grains and minerals and is completely food grade. It has also been specially formulated to provide quick film forming ability, more film tack and adhesion, improved film strength, moisture absorbion, flexibility and high bond strength.

Dust Stop	
Solubility in water	partial
Odor	Light polymer
Appearance	Light Brown powder
Specific Gravity	1,5 - 1,9
PH	6,9

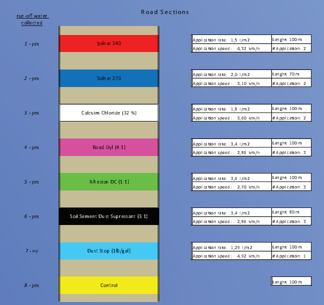
Soil Sement

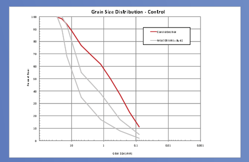
Soil-Sement is a polymer emulsion that produces dust control, erosion control and soil stabilization. Soil-Sement provides excellent bonding, cohesion, versatility, cost-effectiveness, environmental compliance and superior overall performance.

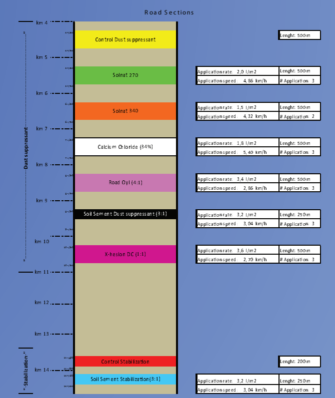
Soil Sement	
Solubility in water	Dilutable
Odor	Characteristic acrylic odor
Appearance	Milky white liquid
Specific Gravity	1,01 - 1,15
PH	9,5 - 10

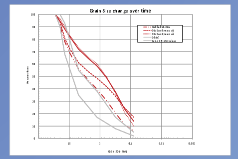
Transportation of dust suppressants and stabilization product to remote sites is costly and it has to be planned to be efficient.

Road Characteristics









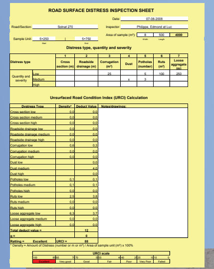
	Rivière-aux-Rats bridge monthly traffic in 2007											
	January	February	March	April	May	June	July	August	September	October	November	December
ATV-Snowmobile-Bicycle	68	4	4	35	168	127	134	92	167	43	87	35
Car - Pick-up	880	1415	1288	745	4702	5383	4368	4338	5300	4091	1662	1104
Truck	1240	1189	7848	1332	94	304	737	718	2595	2827	1586	1323

Because a pay toll bridge controls access to this forest road, we were able to get statistics on the road traffic. However, the table below does not include traffic from a sawmill nearby that represents roughly 1500 trucks and 2000 pick-ups during summer

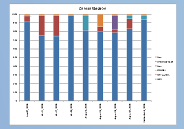
Follow-up

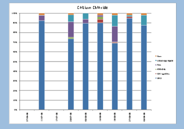
URCI

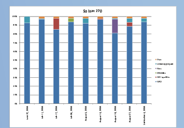
The Unsurfaced Road Maintenance Management (URCI) has been developed and published by Office of the Chief of Engineers, United States Army. It's a rating method that measures the surface integrity and operational conditions.

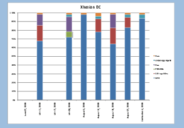


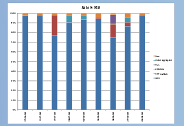
Ruts are caused by a permanent deformation in the road. They result from repeated heavy truck passes along the same path, especially when the soil is soft.

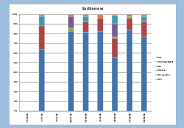


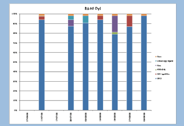












Dust Levels

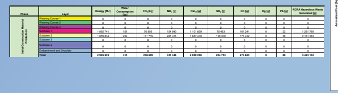
Dust Generated by a pick up truck	Worst →								Best
July 11, 2008	Control	Control S	Soil Sement S	Soil sement	Road Oyl	Solnat 270	Solnat 340	Xhesion	Cacl2
August 5, 2008	Soil Sement S	Control	Soil sement	Control S	Xhesion	Road Oyl	Solnat 340	Solnat 270	Cacl2
August 19, 2008	Control	Soil Sement S	Control S	Soil sement	Road Oyl	Xhesion	Solnat 340	Solnat 270	Cacl2
September 3, 2008	Control	Soil Sement S	Control S	Soil sement	Xhesion	Road Oyl	Solnat 270	Solnat 340	Cacl2
18 septempbre 2008	Control	Control S	Soil Sement S	Soil sement	Solnat 270	Xhesion	Road Oyl	Solnat 340	Cacl2

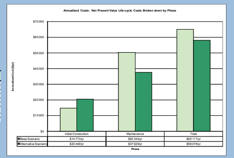
Run-off water

Run-off water is collected at the center of the 100 meters road sections in Montmorency forest road. Runoff water reclamation systems were installed on the shoulder and in the ditch of the road. The runoff water of each test sections (reference and treated) are collected each week. The runoff water samples are analysed in order to verify if the application of dust reducing has induced broad fluctuations.

Environmental and costs effects

PaLATE (Pavement Life-cycle Assessment Tool for Environmental and Economic Effects) developed in UC Berkeley is a software that will be modified to be use in unpaved road management.





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Control of Fugitive Dust Emissions In Surface Mining Operations

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ABSTRACT

A significant environmental problem in surface mining is the control of fugitive dust. Fugitive dust is defined as dust that is generated from non-point sources or non-stationary sources such as haulage equipment or blasting operations. In many mining operations the control of fugitive dust is an important facet of the surface mining operation. While fugitive dust from mine haulage equipment, blasting, and general movement of mine materials is generally considered the main source of fugitive dust, a significant source of fugitive dust can also be generated from the fine-grained material in the mine milling process. Typical mine milling operations generate a significant quantity of waste products or tailings, which consists of finely ground rock from the processed ore. It is common for the tailing's average particle size to be in the 20-micron range. In this size range the particles are very susceptible to dusting during dry windy conditions. Since the tailings are exposed to atmospheric conditions, it is common for dusting to occur during dry conditions in the summer months. However, it has been observed that significant dusting can also occur during freezing periods as well. In fact, some of the largest fugitive dust events have occurred immediately after freezing conditions in the fall time of the year when cyclical freeze-thaw occurs. When this type of dusting happens, personnel at the mines generally refer to the dusting as a dry freeze event. Technically, the "dry freezing" is the sublimation of the near surface ice frozen in the tailings where the ice under a given set of temperature and pressure conditions transforms from a solid directly into a gas. The thermodynamics of sublimation of ice have been studied by a number of researchers and is an important process in the processing of food products as well as related the generation of dust on coastal roads during the winter time. To study fugitive dust a portable wind tunnel was constructed and used to assess various dust control strategies. The working section of the wind tunnel was 1 m wide, 1.2 m high and 10 m long. Sustain wind speeds of 19.1 m/sec (31 mph) were achieved. The paper will present the results of our testing program on three different tailing basins using a number of dust control agents and paper waste from two paper mills.

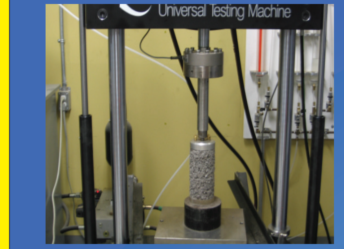
Field Test Program of Stabilization on a Principal Forest Road

By Luc Beaulieu, Pascale Pierre & Sylvain Juneau

1- Laboratory tests and results

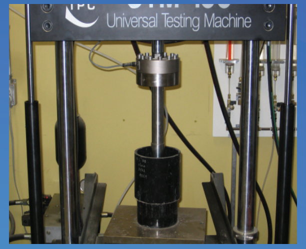
Test

Compressive strenght

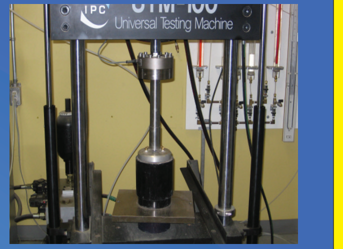


Direct shear

Bearing capacity

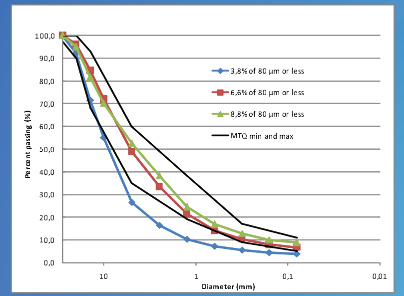


Resilient modulus



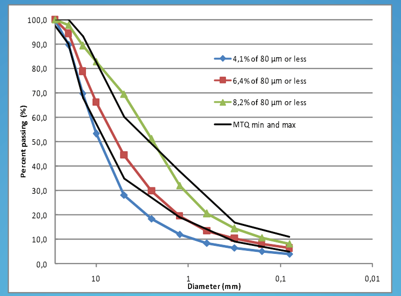
Mineralogy and grading

1- Limestone



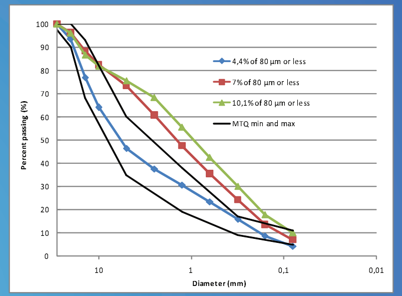
*Ministry of Transportation of Quebec (MTQ)

2- Basalt



*Ministry of Transportation of Quebec (MTQ)

3- Granitic gneiss



*Ministry of Transportation of Quebec (MTQ)

Products tested

Stabilization agents

Polymer emulsion: 1,4 | 2,4 | 3,4 (l/m²)

Cement: 1,5 | 3,5 | 4,5 | 6 (%)

Dust supressants

Calcium chloride: 1,2 | 1,8 | 2,3 (l/m²)

Natural brine: 1,3 | 1,5 | 1,8 (l/m²)

Example for granitic gneiss (7% of 80 µm or less)

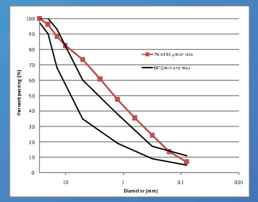
Aggregate geotechnical properties

Caracterisation tests	Results		MG-20B MTQ requirements
Grading	$\%_{under\ 80\ \mu m}$: 4,4%		-
Modified proctor	Proctor (% optimum moisture content) 4,5%	Dry density 2212 kg/m³	-
Bearing capacity	Load at 2,5 mm 18,4 kN	Load at 5 mm 20,7 kN	-
Los Angeles test	$\%_{abrasion}$: 50,9%		≤ 50 %
Micro-Deval test	Micro-Deval result : 12,7%		≤ 25 %
Absorbtion (aggregate> 5 mm)	Relative density : 2,67	$\%_{absorption}$: 0,82%	-
Absorbtion (aggregate< 5 mm)	Relative density : 2,64	$\%_{absorption}$: 0,22%	-
Methylene blue value test	Absorption result : 0,046 cm³/g		≤ 0,20

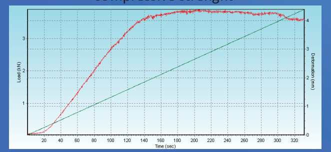
*Ministry of Transportation of Quebec (MTQ)

Grading of the aggregate

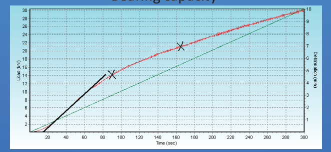
Sieve (mm)	Weight (g)	Percent passing (%)
28	0	100
20	859,8	93,5
14	2212,9	76,9
10	1713,8	64,0
5	2322,7	46,5
2,5	70,3	37,6
1,25	54	30,7
0,630	57,4	23,4
0,315	58,4	16,0
0,16	56,6	8,8
0,08	34,9	4,4



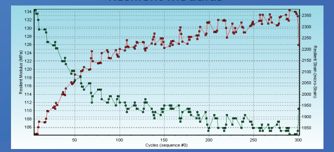
Compressive strenght



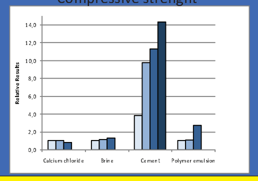
Bearing capacity



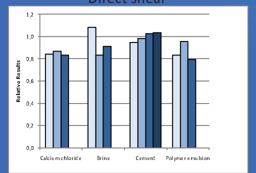
Resilient modulus



Compressive strenght

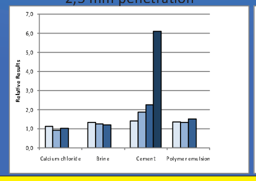


Direct shear

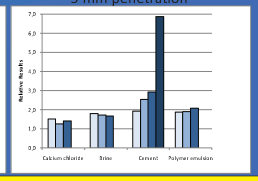


Bearing capacity

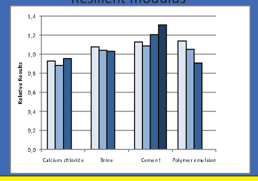
2,5 mm penetration



5 mm penetration



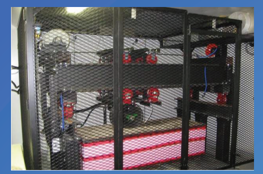
Resilient modulus



2- Tests in controlled conditions

Mechanical and climate laboratory road simulator

- To-and-fro movement (6 km/h)
The system is in fonction 24 hours/7 days and make about 200 000 cycles per week.



- Tire pressure controlled
A maximun pressure of 830 kPa (120 psi) can be applied.

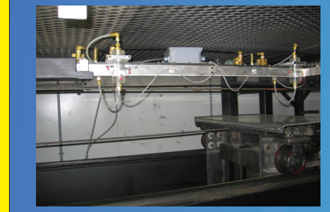
- Load controlled
A pneumatic wheel with a standard truck-size tread travels back on forth on tha sample.

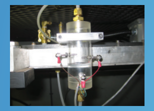
- Frost and thaw cycles
The sample is isolated on all its surface except the top to create real conditions of frost and spring thaw.

- Breaking and accelaration simulation
The moving wheel produces similar surface shear stresses as an accelerating or breaking vehicle.

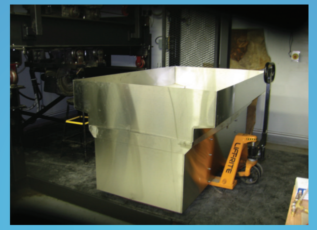
- Programmable side movement
The whole surface of the sample is used during the test to create real conditions environment.

- Rain cycle
The rain drops have a mean diameter of 3 mm, the mean space between them is 2,5 mm and they reach the sample surface with an average speed of 6 m/s.

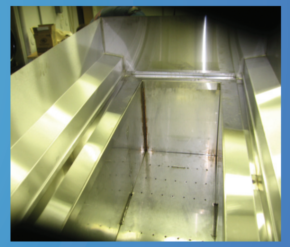




- Characteristic of the sample
There are sensors at different levels in the road sample to make sure that the load and the humidity of the sample are always known.

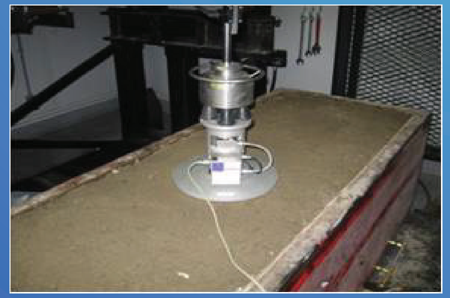


- Independant catch of run-off and percolation waters
This allows to study the permeability of the ground and the amount of stabilization agents catch in the run-off and percolation waters.
The washability of the product can thus be studied.



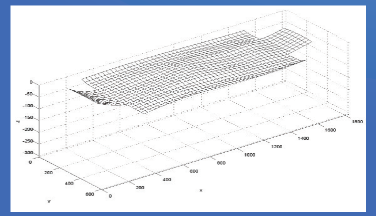
Example of the results

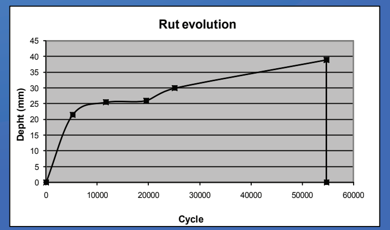
- Falling weight deflectometer



- Rut measurement

-3D picture or the rutting surface





3- Field performance

Sections realization

Traffic

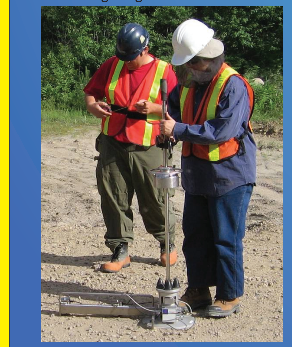
Layer 1

Replacing surface aggregate

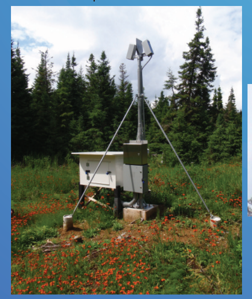
Compaction

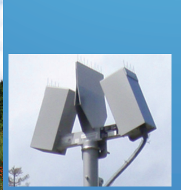
Results

Falling weight deflectometer



Precipitation Occurence Sensor System





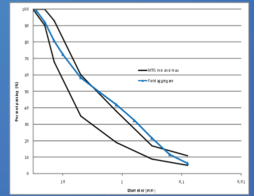
Aggregate geotechnical properties

Caracterisation tests	Résultats		MG-20B MTQ requirements
Grading	$\%_{under\ 80\ \mu m}$: 6,4%		-
Modify proctor	Proctor (% water) 4,5%	Dry density 2130 kg/m³	-
Portance capacity	Load at 2,5 mm 16,185 kN	Load at 5 mm 5,651 kN	-
Los Angeles test	$\%_{abrasion}$: 48,36%		≤ 50 %
Micro-Deval test	Micro-Deval result : 17,2%		≤ 25 %
Density and absorbtion (aggregate> 5 mm)	Relative density : 2,67	$\%_{absorption}$: 1,17%	-
Density and absorbtion (aggregate< 5 mm)	Relative density : 2,65	$\%_{absorption}$: 0,42%	-
Methylene blue	Absorption result : 0,071 cm³/g		≤ 0,20

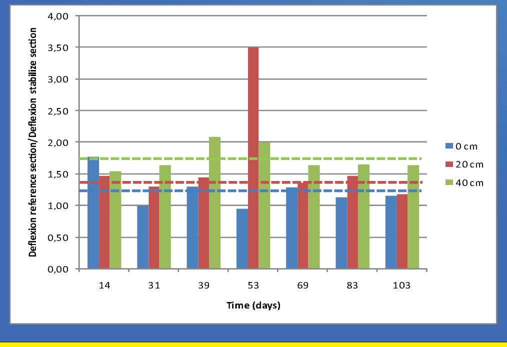
* The aggregate had a water content of 6,8% when the field was stabilized
*Ministry of Transportation of Quebec (MTQ)

Grading of the aggragate

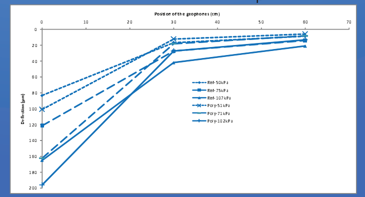
Sieve (mm)	Weight (g)	Percent passing (%)
28	108,6	99,0
20	784,6	92,0
14	1250,5	80,9
10	929,7	72,6
5	1583,0	58,5
2,5	58,9	49,8
1,25	54,0	41,9
0,630	64,7	32,4
0,315	73,2	21,6
0,16	67,2	11,8
0,08	36,7	6,4

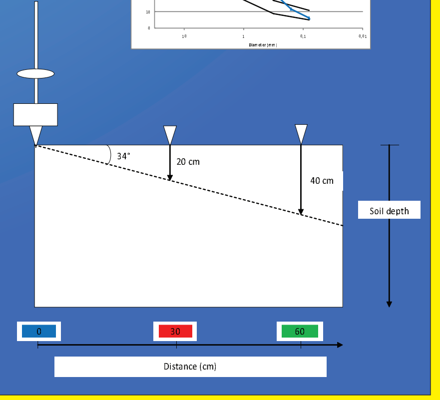


Relative results for the deflexion



Deflection of the field for the reference and the stabilized section at different pressure





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Best Practices for Dust Control

Sponsored by the Minnesota Local Road Research Board

Principal Researcher: Ed Johnson – Mn/DOT Road Research
Technical Liaison: John McDonald – Faribault County Engineer

PROJECT AT A GLANCE

Variables

- ⋆Traffic volume
- ⋆Surface material type
- ⋆Gradation
- ⋆Surface aggregate sand equivalency and plasticity
- ⋆Palliative type
- ⋆Palliative application rate

Performance measures

- ⋆Dust control efficiency
- ⋆Surface moisture content
- ⋆Surface characteristics – rutting, etc.

Phase-I

- ⋆Subject roads were in the county road system
- ⋆22 half-mile treatment and control sections
- ⋆Standard rates of application
- ⋆Low traffic volume
- ⋆Minnesota river gravels and limestone
- ⋆3 types of dust palliatives

Phase I outcomes

- ⋆Dust control efficiency is maximum for aggregate surface moisture contents of 3 – 4%
- ⋆Calcium and magnesium chloride performed similarly
- ⋆Organic polymer product performed poorly on river gravel
- ⋆Application method must be calibrated

Phase-II

- ⋆Subject roads were in municipal and county road systems
- ⋆half-mile treatment and control sections
- ⋆Variable rates of application
- ⋆High and low traffic
- ⋆Minnesota river gravels and limestone
- ⋆1 type of dust palliative – magnesium chloride

Phase II outcomes

- ⋆High application rates can retain excess moisture during wet weather
- ⋆Control efficiency depends on application rate
- ⋆Agencies report palliative applications reduce maintenance costs

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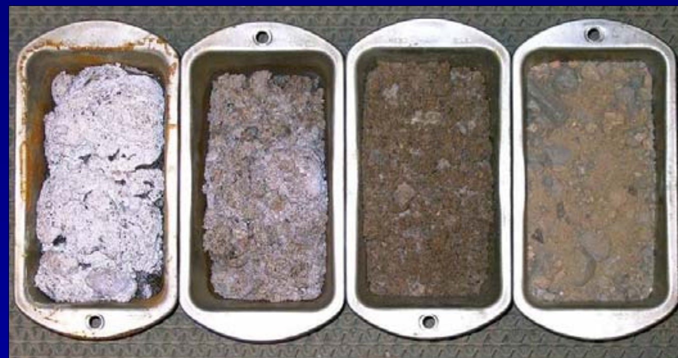
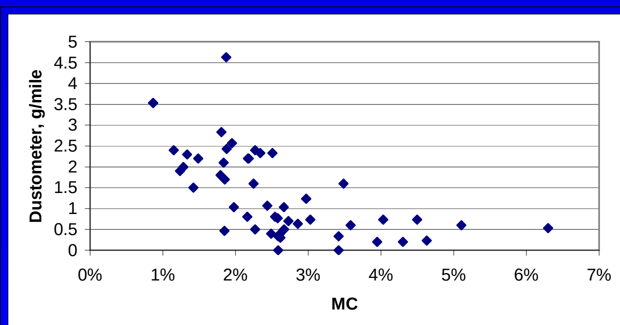
Minnesota LRRB:
Best Practices for Dust Control



0.5 gsy | 0.3 gsy | 0.2 gsy | 0.0 gsy

Dust control application of 30 percent MgCl2 solution
Samples oven dried 48 hours



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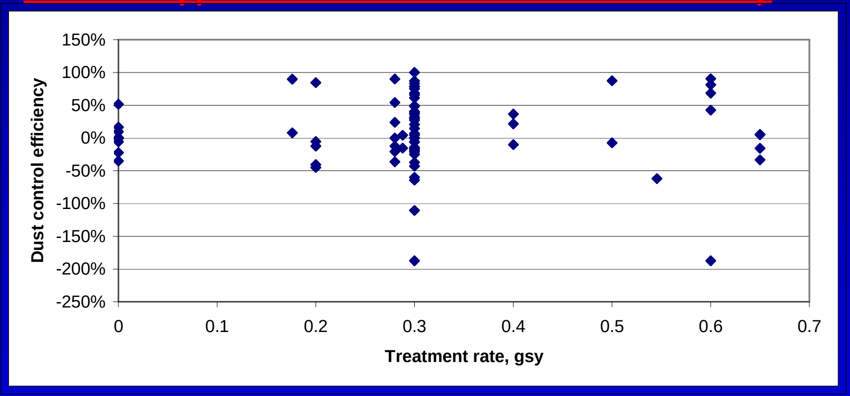
Measurement Parameters and Relationship to Control Efficiency

Correlations

Correlation Parameter	Avg Dust	Avg MC	Application Rate, gsy	% Passing #200	Sand Equiv	Dust Control Efficiency	Moisture Control Efficiency	Age
Avg Dust	1.000							
Avg MC	-0.427	1.000						
Rate, gsy	-0.153	0.200	1.000					
% Passing #200	-0.140	0.258	0.374	1.000				
Sand Equiv	0.070	-0.029	-0.348	-0.835	1.000			
Dust Control Efficiency	-0.546	0.261	0.164	0.078	-0.037	1.000		
Moisture Control Efficiency	-0.248	0.328	0.343	0.203	-0.170	0.379	1.000	
Age	0.053	-0.295	-0.080	-0.053	-0.108	-0.296	-0.171	1.000

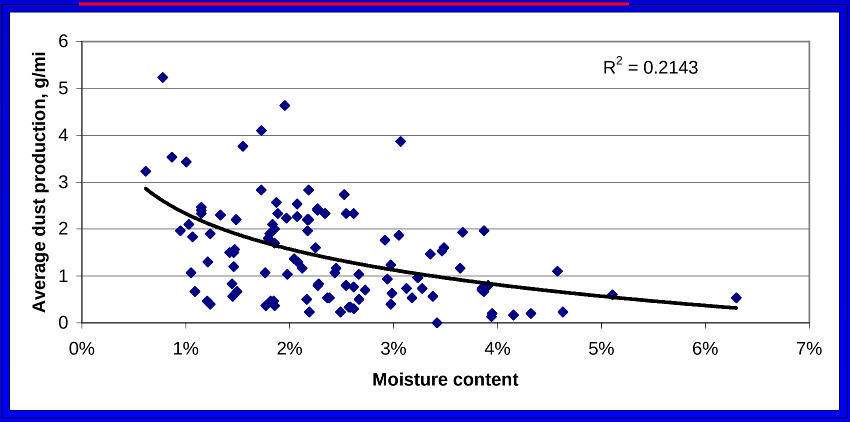
Product Application Rate and Control Efficiency



$$\text{Dust CE} = 100\left(1 - \frac{Dt}{Dc}\right)$$

Dust CE = percentage dust control efficiency
Dt = mean value of dust sample, g/mile treated
Dc = mean value of dust sample, g/mile control

Dust Production at Moisture Levels



Residual Effect Compared to New Treatment (Phase II)

	NO TREATMENT	NEW TREATMENT
NO TREATMENT	1.000	
NEW TREATMENT	0.067	1.000
TREATED + RESIDUAL	-0.006	-0.259

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Local Technical Assistance Program

National LTAP & TTAP Programs — Serving America's Local Road & Bridge Agencies

UNIVERSITY OF WYOMING

New Thinking

Dust Suppression by Incorporating Reclaimed Asphalt Pavement (RAP) into Gravel Roads

George Huntington, P.E.

Scott Koch, E.I.T.

Khaled Ksaibati, Ph.D., P.E.

Objective: Assess the performance of unpaved roads surfaced with reclaimed asphalt pavement (RAP) blended with virgin aggregate.

- ***Dust generation***
- ***Surface performance***

Background: RAP has been used as a surfacing additive on Wyoming's unpaved roads, streets, and alleys for many years. Recent State legislation compensates the Department of Transportation (WYDOT) for RAP donated to Wyoming counties. WYDOT and local governments wish to evaluate the performance of blended RAP and virgin aggregate as a surfacing material for unpaved roads, with a particular emphasis on its ability to reduce dust loss.

Drilling traffic on Schoonover Road

Experimental Sections

Section	County	Road	RAP %	CaCl, psy	R-Value	LL	PI	CV, psi	ADT	Heavy Trucks	85th%, MPH	Blending Method	Surfacing Date	CaCl Date
A0	Laramie	Atlas	0	–	19	27	12	392	50	3%	55	–	April 14, 2008	–
A2	Laramie	Atlas	71	–	78	–	–	–	50	3%	55	Blade	April 28, 2008	–
A1	Laramie	Atlas	82	–	73	–	–	–	50	3%	55	Blade	April 29, 2008	–
P0	Laramie	Pry	0	–	26	27	11	164	50	12%	56	–	April 14, 2008	–
P1	Laramie	Pry	69	–	68	–	–	–	50	12%	56	Blade	May 1, 2008	–
S2	Johnson	Schoonover	50	–	*	–	–	–	188	74%	51	Pugmill	June 3, 2008	–
S1	Johnson	Schoonover	50	1.64	*	–	–	–	188	74%	51	Pugmill	June 4, 2008	June 19, 2008
S0	Johnson	Schoonover	0	1.64	*	24	5	*	188	74%	51	–	May 12, 2008	June 19, 2008

** Materials testing in progress*

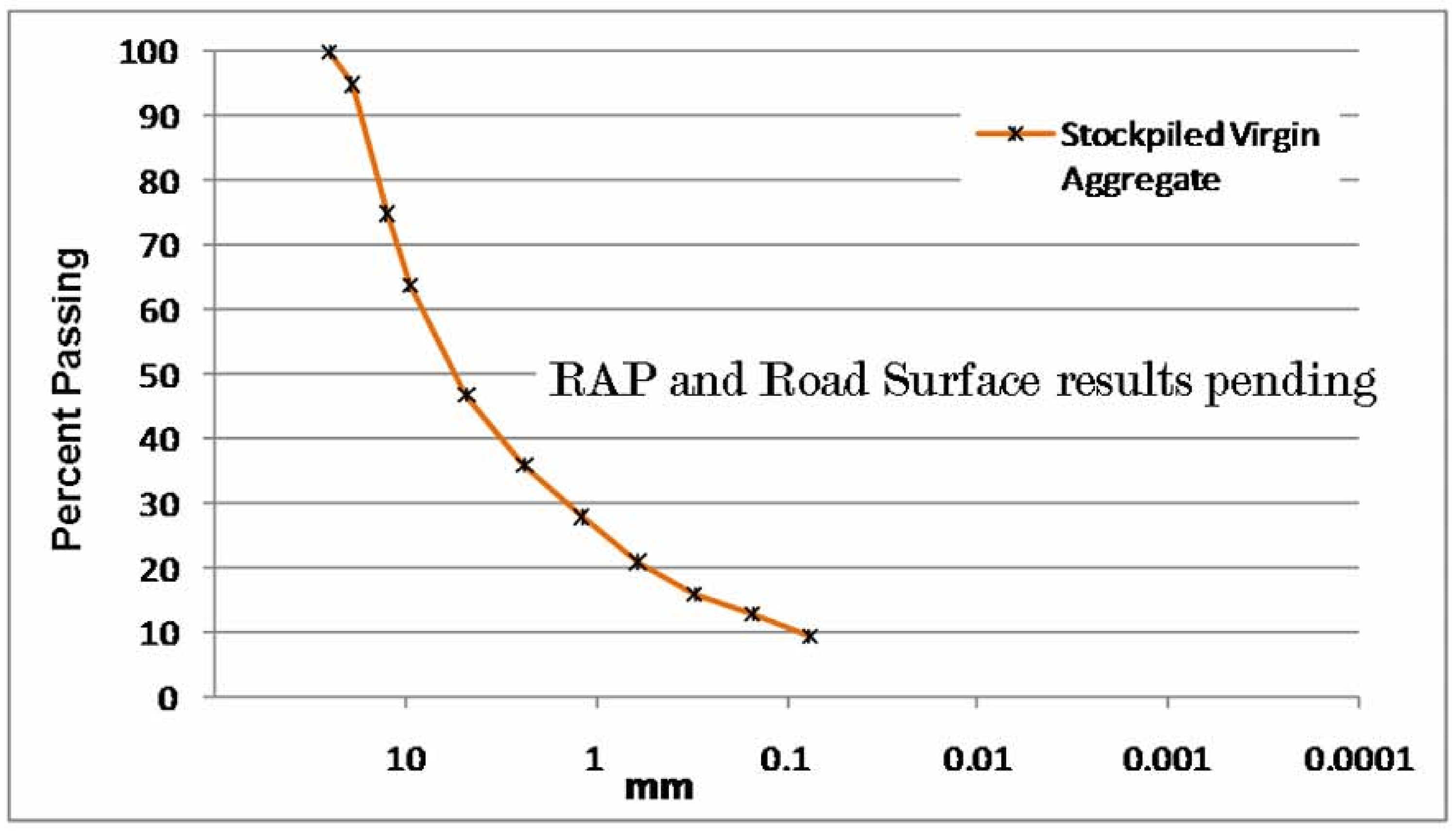
Dust Monitoring

Dust was monitored using the 'dustometer' developed at Colorado State University.

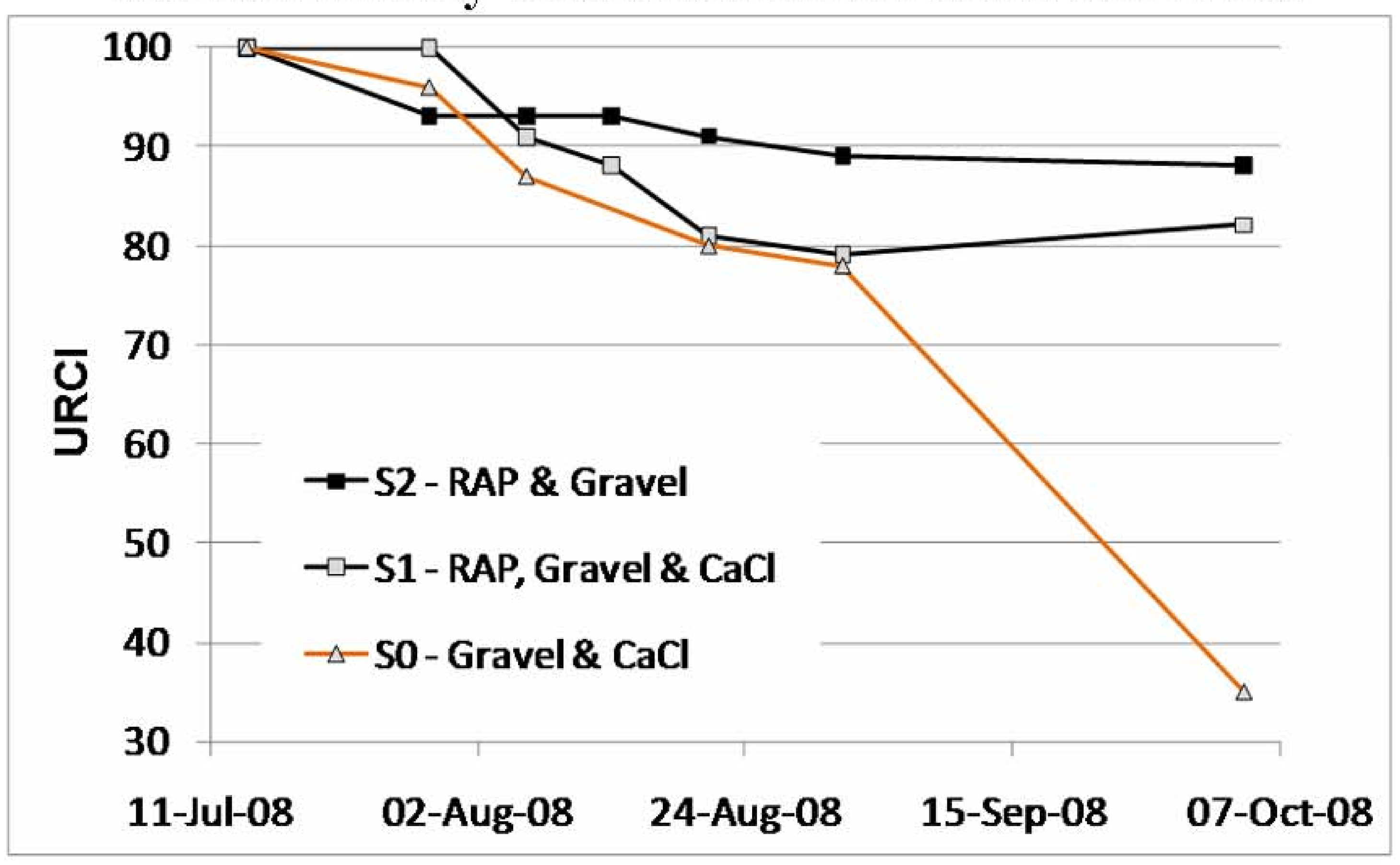
- Test vehicle: 2001 ½ ton Chevy Suburban
- Test speed: 40 mph (64 km/hr)
- Tire pressure: 50 psi (345 kPa)
- Filter type: Whatman EPM 2000 Glass Microfibre Filters

Johnson County
Schoonover Road

Johnson County Initial Gradations



Johnson County Unsurfaced Road Condition Index*



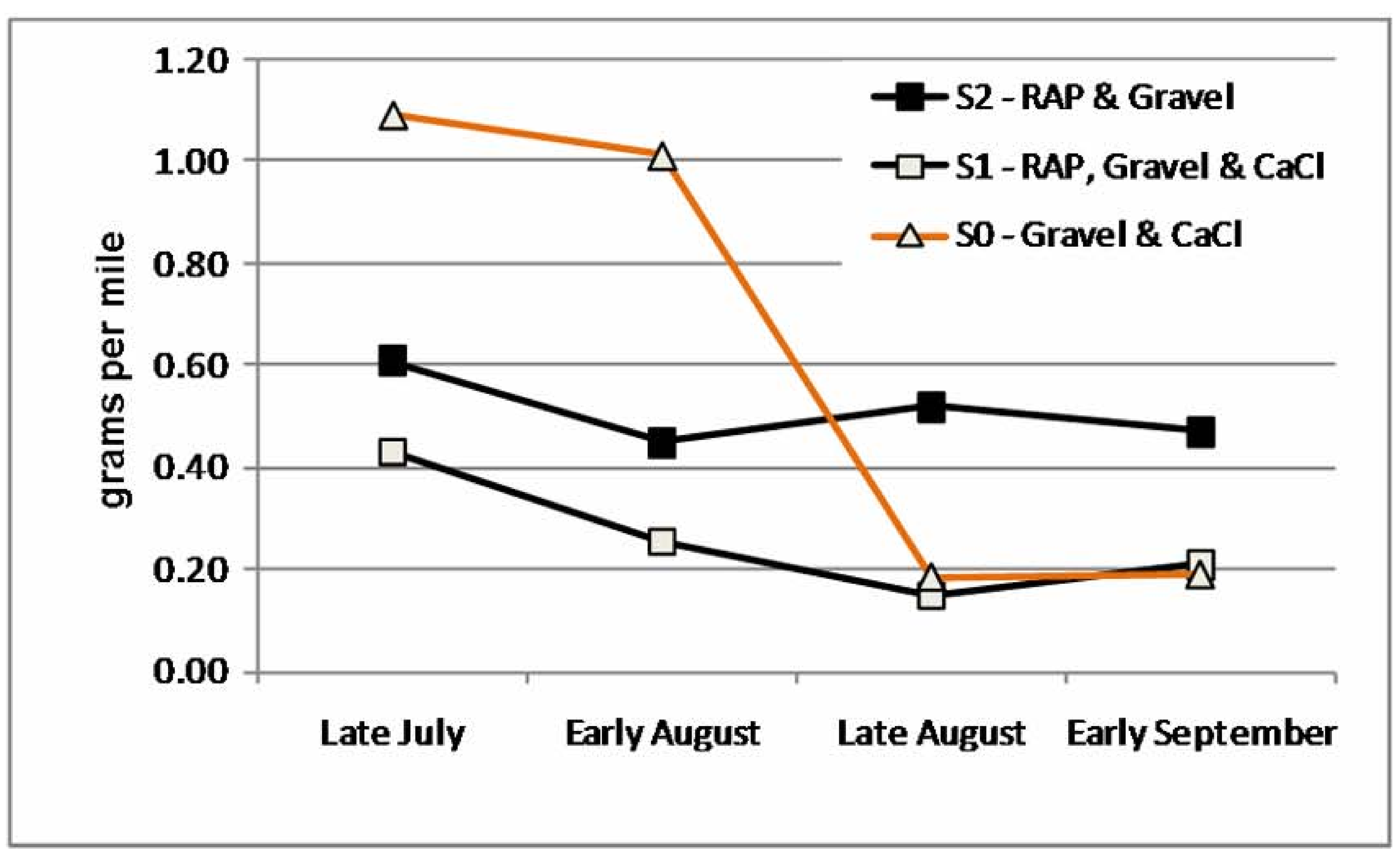
Distresses with Deduct Values*

Schoonover Road, Johnson County

	Pugmill Blended					
	S2 RAP & Gravel	S1 RAP, Gravel & CaCl		S0 Gravel & CaCl		
Date	*Loose Aggregate*	*Ruts*	*Loose Aggregate*	*Corrug-ations*	*Ruts*	*Loose Aggregate*
July 14, 2008	0	0	0	0	0	0
July 29, 2008	7	0	0	0	4	0
August 6, 2008	7	7	2	0	5	8
August 13, 2008	7	8	4	--	--	--
August 21, 2008	9	12	7	0	10	10
September 1, 2008	11	12	9	0	10	12
October 4, 2008	12	9	9	24	29	12

* As determined using the method presented in ***'Unsurfaced Road Maintenance Management'*** by Robert A. Eaton and Ronald E. Beaucham, USACE-CRREL Special Report 92-26, December 1992.

Johnson County Dust Measurements



Johnson County RAP and virgin aggregate blending site.

Compacted, pugmill blended RAP and aggregate on Schoonover Road.

Spreading RAP and aggregate blend on Schoonover Road section S2.

Compacted, pugmill blended RAP and aggregate on Schoonover Road.

RAP blend sections with and without CaCl flakes. Water was applied, then flakes, then additional water.

Schoonover Road section S0 aggregate control with CaCl three months after placement

Closeup of CaCl flakes

Blended RAP with CaCl three months after placement.

Blended RAP without CaCl three months after placement.

Conclusions

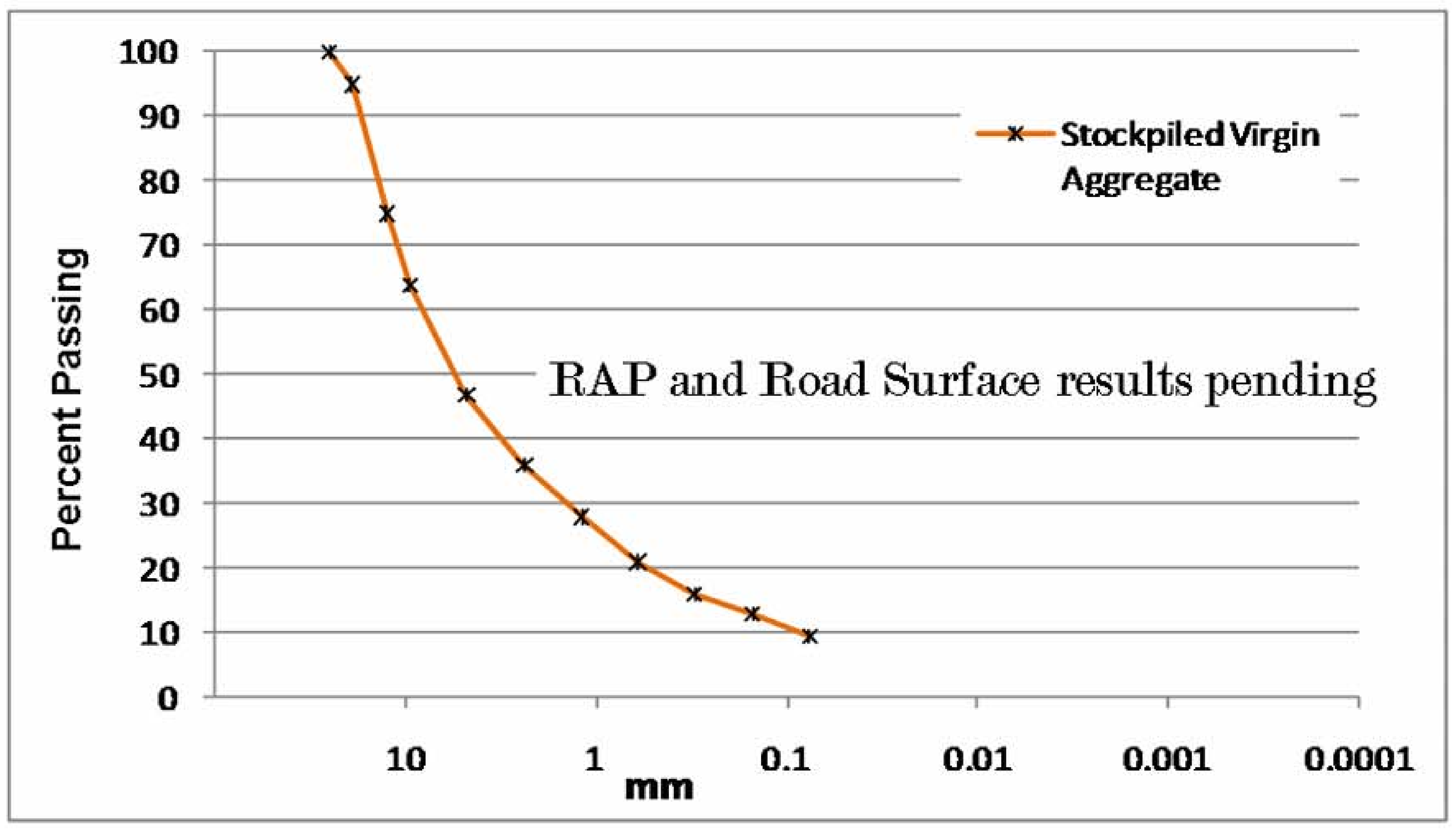
- RAP reduced dust loss in both the short and long terms.
- Much of the dust loss occurred shortly after placement.
- Blade mixing leads to considerable segregation, while pugmill mixing provides significantly better blending.
- RAP and gravel blends hold up significantly better under heavy truck traffic than gravel alone.
- RAP and gravel with CaCl exhibit significantly more rutting than RAP and gravel without CaCl under heavy truck traffic.
- RAP and gravel resist moisture damage better than gravel with CaCl.

Recommendations

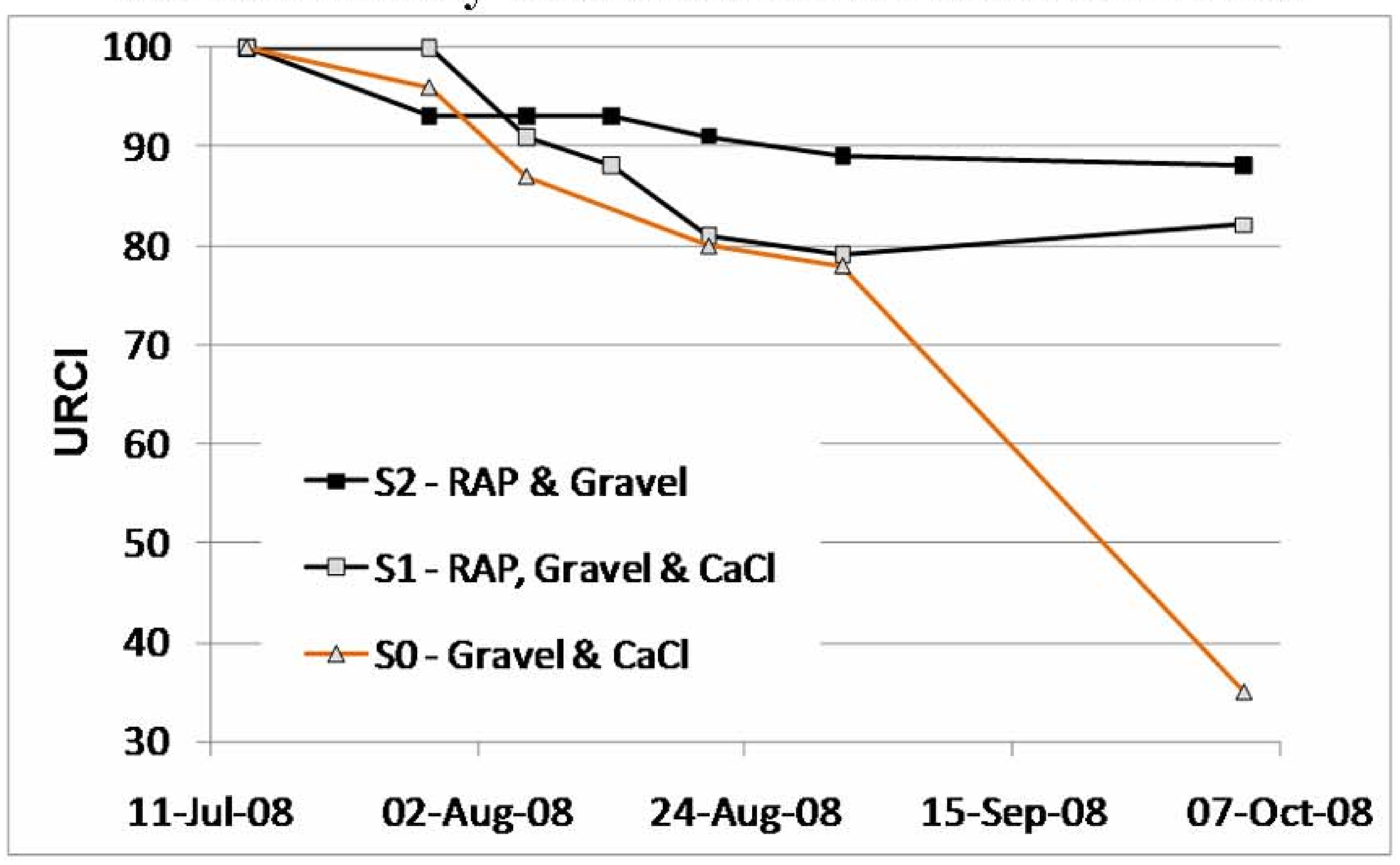
- RAP performs well when blended with gravel under heavy truck traffic.
- RAP and gravel should be blended in a pugmill, not in place on the road since significant segregation occurs with blade mixing.
- CaCl when added to a RAP and gravel blend reduces dust loss but compromises strength when wet, leading to rutting.

Johnson County
Schoonover Road

Johnson County Initial Gradations



Johnson County Unsurfaced Road Condition Index*



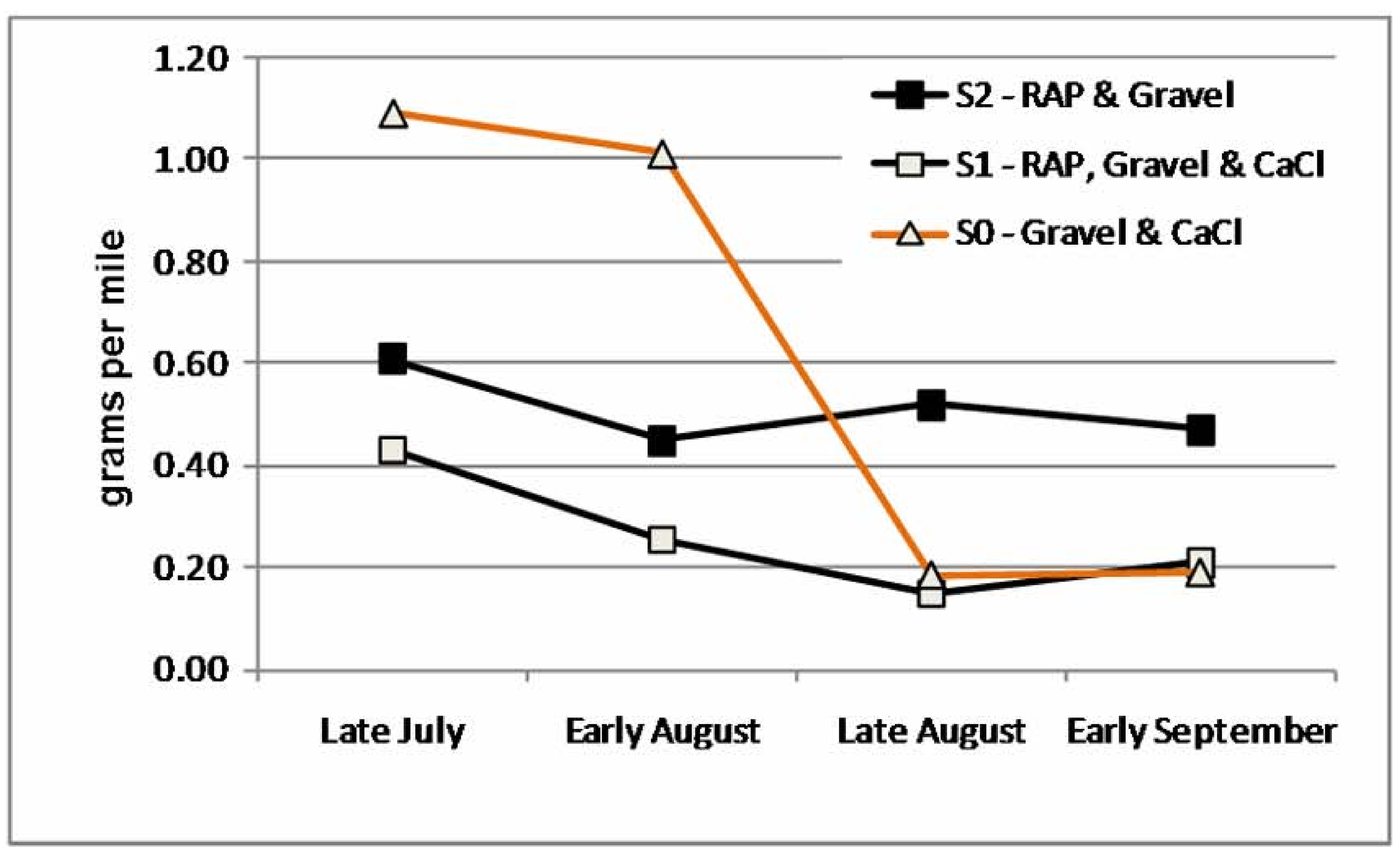
Distresses with Deduct Values*

Schoonover Road, Johnson County

	Pugmill Blended					
	S2	S1		S0		
	RAP & Gravel	RAP, Gravel & CaCl		Gravel & CaCl		
Date	*Loose Aggregate*	*Ruts*	*Loose Aggregate*	*Corrug-ations*	*Ruts*	*Loose Aggregate*
July 14, 2008	0	0	0	0	0	0
July 29, 2008	7	0	0	0	4	0
August 6, 2008	7	7	2	0	5	8
August 13, 2008	7	8	4	--	--	--
August 21, 2008	9	12	7	0	10	10
September 1, 2008	11	12	9	0	10	12
October 4, 2008	12	9	9	24	29	12

* As determined using the method presented in ***'Unsurfaced Road Maintenance Management'*** by Robert A. Eaton and Ronald E. Beaucham, USACE-CRREL Special Report 92-26, December 1992.

Johnson County Dust Measurements



Johnson County RAP and virgin aggregate blending site.

Compacted, pugmill blended RAP and aggregate on Schoonover Road.

Spreading RAP and aggregate blend on Schoonover Road section S2.

Compacted, pugmill blended RAP and aggregate on Schoonover Road.

RAP blend sections with and without CaCl flakes. Water was applied, then flakes, then additional water.

Schoonover Road section S0 aggregate control with CaCl three months after placement

Closeup of CaCl flakes

Blended RAP with CaCl three months after placement.

Blended RAP without CaCl three months after placement.

Conclusions

• RAP reduced dust loss in both the short and long terms.
• Much of the dust loss occurred shortly after placement.
• Blade mixing leads to considerable segregation, while pugmill mixing provides significantly better blending.
• RAP and gravel blends hold up significantly better under heavy truck traffic than gravel alone.
• RAP and gravel with CaCl exhibit significantly more rutting than RAP and gravel without CaCl under heavy truck traffic.
• RAP and gravel resist moisture damage better than gravel with CaCl.

Recommendations

• RAP performs well when blended with gravel under heavy truck traffic.
• RAP and gravel should be blended in a pugmill, not in place on the road since significant segregation occurs with blade mixing.
• CaCl when added to a RAP and gravel blend reduces dust loss but compromises strength when wet, leading to rutting.

Measurement of Road Dust Emissions: The TRAKER and PI-SWERL Tools

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Abstract

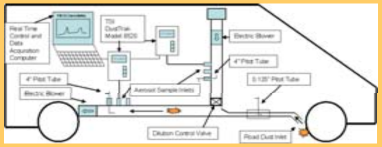
In some regions of the U.S., fugitive dust emissions are responsible for up to 60% of ambient PM_{10}[1]. Dust emissions from paved and unpaved roads can account for a substantial fraction of overall dust emissions. Facility-scale, local, and regional emission inventories are needed to estimate the contribution of road dust to the measured ambient PM_{10} and to ensure compliance with State Implementation Plans (SIPs), operating permits for facilities prone to dust emissions (such as mines and quarries), and transportation conformity rules.

The US EPA has provided guidance in its AP-42 document for estimating PM_{10} and $PM_{2.5}$ dust emissions from paved and unpaved roads[2]. Based on this guidance, measurements or estimates of silt loading and silt content have been widely used to estimate road dust emissions. However, use of silt parameters has several shortcomings: 1) On paved roads it is time-consuming and somewhat unsafe to conduct measurements due to the requirement that traffic be diverted around the measurement locations. 2) The silt parameter (roughly defined as particles smaller than 75 microns in physical diameter) is not a direct indicator for PM_{10} content (defined as particles with aerodynamic diameters smaller than 10 microns). 3) Because of the difficulty of making measurements, it is not always possible to obtain a large number of measurements to adequately represent spatial as well as temporal variations that are known to exist over a roadway network.

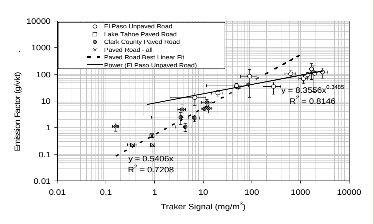
These shortcomings have motivated the development of vehicle-based platforms for more direct measurement of road dust emissions from both paved and unpaved roads. The TRAKER (Testing Re-entrained Aerosol Kinetic Emissions from Roads) is one such system that has been developed and improved over the last decade [3,4,5,6,7,8,9,10]. The principle of the TRAKER is that dust concentrations measured behind the front tires of a test vehicle are related to emissions of PM_{10}. Use of the TRAKER greatly facilitates measuring road dust emission factors over large areas.

More recently, the use of a wind tunnel-type device, the PI-SWERL, on paved roadways has been pioneered by researchers at UNLV. Providing a somewhat different measurement method than the TRAKER, the PI-SWERL allows for quantifying emissions associated with aerodynamic entrainment of particles, benefits of surface treatments, as well as effectiveness of near-road control measures.

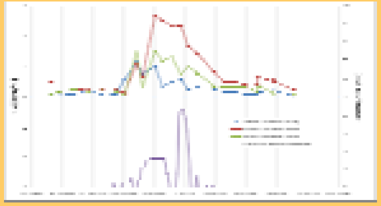
TRAKER: Testing Re-entrained Aerosol Kinetic Emissions from Roads



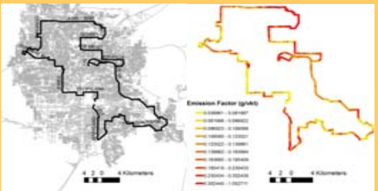
The most recent version of the TRAKER utilizes a 2003 Dodge Sprinter van platform. Air from behind the front tires is drawn in through a sampling line and measured with nephelometer-style instruments with a 1-second time resolution. Using an onboard GPS, the automated system logs location, speed, and road dust emission potential. On unpaved roads, the air sample is diluted with background clean air to avoid overloading the sensors. The system is completely automated, requiring minimal user intervention once measurements begin.



Using an upwind/downwind tower technique similar to the one used to derive the AP-42 silt equations[2], studies[7,11,12] have shown that the relationship between the TRAKER measurement and emission factors is linear for paved roads. On unpaved roads where emissions are much higher (indicated by the white circles in the figure above), the emission factor scales with the cube root of the TRAKER signal.



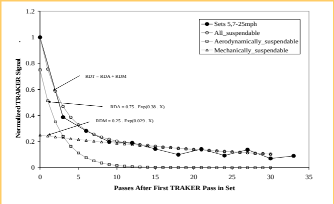
Time series of TRAKER emission factors (upper traces) and snowfall measurements (lower trace) on paved roads at Lake Tahoe, Nevada[12]. Traction control materials have a clear effect on emissions.



Route map of TRAKER measurements as part of a paved road study in Las Vegas, Nevada (left) and measured emission factors by road segment (right)[13].

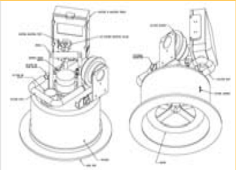
Unpaved road dust emissions measured using the TRAKER dilution system in the Paso Del Norte region (June, 2008). Green dots correspond to paved roads traversed en route to unpaved roads.

Emission inventory for all paved roads on a segment by segment basis for Boise, Idaho[8]. A subset of roads with different characteristics (roadway type, urban/rural, summer/winter) were measured with TRAKER. Roadway characteristics were then used in conjunction with a traffic demand model to assign emission factors to every road segment in the network.



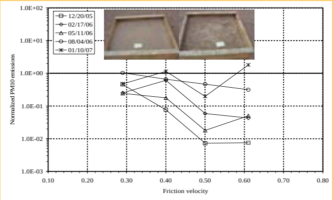
Measurements on a controlled surface in Clark County, NV[11] led to a hypothesis of two distinct mechanisms for road dust emissions: aerodynamic suspension and mechanical lifting by tires. Aerodynamic emissions previously observed for emissions from unpaved shoulders when trucks pass.

PI-SWERL: Portable In-Situ Wind ERosion Laboratory

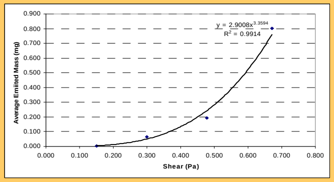


The PI-SWERL (US Patent 7,155,966) measures the amount of dust emitted from a surface when a known amount of wind shear is applied. A flat annular blade inside the chamber rotates at prescribed speeds to simulate different amounts of surface shear stress. Although it uses a different principal of operation, it can be thought of as analogous to a miniature wind tunnel.

The PI-SWERL was collocated with the University of Guelph large field wind tunnel at seventeen sites in the Mojave desert, spanning graveled roads to silty playas[14]. Agreement between the two methods of estimating dust emissions was good with a correlation coefficient of 0.76 and a nearly 1:1 slope.



PI-SWERL data: PM_{10} dust emissions from a chemically treated test plot (right photo) normalized to dust emissions from a test plot that has not been treated (left) over 1 year exposure[15] . X-axis: friction velocity (m/s) – a measure of surface wind shear.



PI-SWERL data: rapid non-linear increase in PM10 emissions with increase in aerodynamic shear (Pascals, N/m^2, proportional to wind speed or tire stress) applied to paved road surface[16], indicating value of keeping speed limits low.

Summary

TRAKER and PI-SWERL are relatively new tools for measuring, characterizing, and understanding road dust emissions. TRAKER is a mobile system for measurement of road dust emissions from paved and unpaved roads. Advantages over silt sampling methods include the ability to measure over many miles of road, measurement of PM_{10} instead of a surrogate parameter, and increased safety for personnel conducting sampling.

PI-SWERL allows for elucidation of effects of specific road characteristics with respect to dust emissions. It can be used to assess the effect of pavement properties on dust emissions, potential for windblown dust on unpaved roads, effectiveness of surface treatments on reducing emissions, emissions from road shoulders, and potential for aerodynamically driven emissions for vehicles traveling at different speeds.

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Acknowledgements

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