

# **MEASUREMENT OF FUGITIVE DUST SUSPENSION AND REDEPOSITION UNDER DOÑA ANA COUNTY, NEW MEXICO CONDITIONS**

## **PROJECT NUMBER: A-02-7**

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### **NARRATIVE SUMMARY**

Wind-blown dust is an air quality and health concern in many areas, and there is a need to understand and quantify the impact of unpaved roads and similar fugitive dust sources on air quality where people live. Extensive studies of fugitive dust in the Central Valley of California have been funded by the US Environmental Protection Agency and by the California Air Resources Board, but much less research has been done along the US-Mexico border. This study focused on high altitude, arid sites in Doña Ana County, NM.

A goal of this study was to obtain quantitative data on the suspension and redeposition of dust. The research emphasis was on determining the effect of atmospheric stability and terrain irregularities on dust cloud behavior within 100 m downwind of an unpaved road.

Field experiments involved measuring dust deposition on both flat substrates and on artificial vegetation placed adjacent to a test road. Dust concentration, weather conditions, and vehicle activity data, combined with the particle deposition measurements provide an estimate of particle deposition velocity. The deposition velocity data were used as input into a two-dimensional computational model. The computational model was used to analyze data from two previously published field studies where dust flux was measured using towers located near an unpaved road and 100 meters downwind.

The results of this study show that atmospheric stability and surface roughness are important factors controlling the fraction of the initially suspended dust cloud that is actually transported long distances. These factors are not considered in current dust inventories, but may explain part of the systematic differences observed in the

fugitive dust contribution when comparing source inventories with receptor apportionment studies.

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## **INTRODUCTION**

Wind-blown dust is an air quality and health concern in many areas, and there is a need to understand and quantify the impact of unpaved roads and similar fugitive dust sources on air quality where people live. A goal of this study was to obtain quantitative data on the suspension and redeposition of dust. The research emphasis was on determining the effect of atmospheric stability and terrain irregularities on dust cloud behavior within 100 m downwind of an unpaved road. Extensive studies of fugitive dust in the Central Valley of California have been funded by the US Environmental Protection Agency and by the California Air Resources Board, but much less research has been done along the US-Mexico border. This study focused on high altitude, arid sites in Doña Ana County, NM combined with related data from sites in Texas and Utah.

Based on studies done by the Desert Research Institute (DRI) in Nevada and in the San Joaquin Valley, CA (Watson et al. 1996), showed a large (greater than 90%) decrease in dust concentration within 100 m of an unpaved road (Watson et al. 1996; Watson, Chow and Pace 2000). This rapid decrease in concentration with distance implies that dust control on roads near populated areas will be effective in reducing exposure. Extensive studies of fugitive dust in the Central Valley of California have been funded by the US Environmental Protection Agency and by the California Air Resources Board (Watson et al. 1998a; Watson, Chow and Pace 2000; Watson et al. 1998b).

Field experiments under this project were conducted on Vado Road in Doña Ana County, NM and at a test site on the Ft. Bliss military base. The Paso del Norte area climate is generally mild and semiarid, averaging 350 days of clear weather annually. The county has experienced numerous exceedances of the 24 h National Ambient Air Quality Standard (NAAQS) concentration limit for PM<sub>10</sub> of 150 µg/m<sup>3</sup> and is in violation of the PM<sub>10</sub> NAAQS (New Mexico Environment Department - Air Quality Bureau 2000). The test sites represent very arid regions, with soils that are quite susceptible to wind and vehicle pick-up.

## **RESEARCH OBJECTIVES**

Field experiments involved measuring dust deposition on both flat substrates and on artificial vegetation placed adjacent to a test road. Dust concentration, weather conditions, and vehicle activity data, combined with the particle deposition

measurements provide an estimate of particle deposition velocity. The deposition velocity data were used as input into a two-dimensional computational model. The computational model was used to analyze data from two previously published field studies where dust flux was measured using towers located near an unpaved road and 100 meters downwind.

The tasks consisted of

- (1) Collect field data on dust deposition on simulated vegetation surfaces.
- (2) Prepare a technical report discussing these data and calculate values for the mixing and deposition rate coefficients in the Gillette Box Model which can be compared to values of these coefficients obtained at other sites in the Western US.
- (3) Train students from the U of U and UTEP in fugitive dust field measurements and dust transport calculations.

#### **RESEARCH METHODOLOGY/APPROACHES**

The A-02-7 project continued work on fugitive dust in Dona Ana County that has been funded by SCERP. An initial field samples were conducted in 2002 at Ft. Bliss in collaboration with other fugitive dust research. Processing of these samples and the data analysis was part of the current SCERP project. Field sampling was also done in November 2002 at an unpaved road in New Mexico about 10 miles north of El Paso. Passive deposition substrates were placed downwind from an unpaved road and exposed to vehicle dust while simultaneous dust concentration readings were made with a DustTrak. Electron microscopy (SEM) combined with the dust concentration measurements provide the data needed to calculate deposition rates on individual flat surfaces that can be compared to the limited field data and theoretical studies in the literature. This effort produced original data on vegetative deposition that will be published. Using support from A-02-7 graduate student Fang Yin has developed a 2-D model and is using it to study near-road vehicle-generated dust behavior. The model makes quantitative predictions of the effects of wind, atmospheric stability, and amount of vegetation, and is able to replicate the field data.

The details of the research are reported in the next three chapters. Each chapter is organized as a stand-alone technical report.

#### *CHAPTER 1 - MEASUREMENT OF DEPOSITION VELOCITY*

This chapter is based on the data submitted by Veranth for a section of the Western States Air Resources Council (WESTAR) report "Field Testing and Evaluation of Dust Deposition and Removal Mechanisms: Final Report." The objective of the WESTAR contract was to investigate a model, proposed by Dale Gillette of NOAA, to account for near-source deposition of dust from unpaved roads. The Gillette model was proposed as a way to correct regional - scale dust inventories for near-source sub-grid-scale effects.

The chapter presents data on particle deposition experiments. The deposition samples were collected at Fort Bliss, TX in April 2002 as part of a multi-project collaborative field study conducted by Desert Research Institute and the University of Utah. Students, supported by SCERDP, performed the microscopy, image analysis, and data reduction during the summer and autumn of 2002. This effort

leveraged SCERP and WESTAR funding to produce a document used in air quality policy development and a real-world training opportunity for students.

*CHAPTER 2. DEPOSITION VELOCITY SUMMARY REPORT: VADO ROAD*

The chapter documents the new data produced by A-02-7 regarding deposition of road dust on surfaces near the road. In contrast to the Chapter 1 study, the field experiment was conducted under calm, stable atmosphere conditions. This section is based on the technical reports compiled by the University of Utah and University of Texas at El Paso undergraduate students who did the microscopy, image analysis measurements, and data compilation. There are relatively few field studies that have measured deposition velocity, and this project has generated data that can be used to develop input parameters for computational modeling of near-source dust deposition.

*CHAPTER 3. SIMULATION OF NEAR-SOURCE TRANSPORT AND DEPOSITION OF ROAD DUST*

This chapter documents a computational modeling study conducted by University of Utah graduate student Fang Yin. Ms Yin developed a two-dimensional computational model that considers wind, atmospheric diffusion, and deposition on surfaces. The model was used to analyze data on dust transport collected by field studies at Dugway Proving Ground, UT and at Ft. Bliss TX. The model is able to explain the observed differences between the two experiments, and the model supports the hypothesis that surface roughness and atmospheric stability are important factors affecting road dust emissions.

**CONCLUSIONS**

The results of this 2002-03 SCERP study show that atmospheric stability and surface roughness are important factors controlling the fraction of the initially suspended dust cloud that is actually transported long distances. These factors are not considered in current dust inventories, but may explain part of the systematic differences observed in the fugitive dust contribution when comparing source inventories with receptor apportionment studies.

The deposition velocity data and computational modeling will be used in future studies to better predict air quality impacts from vehicle-generated soil dust.

**RESEARCH BENEFITS**

This section is a brief summary of the results from three years of SCERP funding to Veranth as PI for a study of wind-blown dust in Doña Ana County, NM, Projects A-00-7, A-01-7, and A-02-7. To date, this work has supported two graduating MS students and two current PhD candidates at the U of U. The SCERP funding has been acknowledged in two published peer-reviewed dust emission and transport papers and another paper is in preparation. The SCERP project lead a contract with Western States Air Resources Council to produce a report for air quality regulators on the current science regarding vehicle-generated dust emissions and near-source deposition.

Major scientific results from this work are: 1) Experimental evidence that atmospheric stability and surface roughness are important factors in the actual vehicle-generated dust transport. These parameters are not considered in the current EPA emission factor calculation methods leading to a systematic bias in inventory-based models. 2) Quantitative data for the decrease in dust concentration at breathing height with increasing distance from an unpaved road. This study was

done in a semi-rural subdivision in Doña Ana County and is relevant to the rapidly growing urban fringe of cities in the border region. 3) Development of methods for measuring the rate of particle deposition on vegetation and similar surfaces. 4) Experimental data from the border region showing the difference in particle deposition rates under windy springtime conditions and under calm, overcast early winter conditions. 5) Development of a 2-dimensional computational model that incorporates the important physical effects observed in the field experiments. The results has been communicated in the following:

Peer-Reviewed Publications from this work:

Labban, R., J. M. Veranth, E. Pardyjak, F. Yin and V. Etyemezian (2003). Dust Emission from Unpaved Roads. Air and Waste Management Association, San Diego, CA, Refereed Paper 70089, Session AB-1b.

Veranth, J. M., G. Seshadri and E. Pardyjak (2003). "Vehicle-generated fugitive dust transport: Analytic models and field study." Atmospheric Environment 37(16): 2295-2303.

A paper based on the current year's field study and computational modeling results will be submitted in 2004.

Agency Report

Etyemezian, V., J. Gillies, H. Kuhns, D. Nikolic, J. Watson, J. Veranth, R. Labban, G. Seshadri and D. Gillette (2003). Field Testing and Evaluation of Dust Deposition and Removal Mechanisms: Final Report. Western States Air Resources Council (WESTAR),

National Conference Presentations

American Association for Aerosol Research, Portland OR, October 2001.

American Association for Aerosol Research, Charlotte NC, October 2002.

Specialty PM Meeting & 4<sup>th</sup> Colloquium on PM and Health, Pittsburgh, PA, April 2003

American Association for Aerosol Research, Anaheim, CA, October 2003.

Training and Capability Building: A University of Utah Master's Degree student, Gauri Seshadri, was supported throughout her graduate studies by the University of Utah portion of SCERP projects A-00-7, A-01-7, and A-02-7. Seshadri is co-author on a publication in Atmospheric Environment and is now working in as an air quality engineer for Steigers Corporation, Littleton CO. The A-02-7 project provided thesis research support for Master of Science in Public Health student Jared Mowrer. The A-02-7 project is currently supporting Chemical and Fuels Engineering PhD candidates Fang Yin and Raed Labban and U of U undergraduate Erin Kaser. The A-02-7 SCERP funding provided a research opportunity for UTEP undergraduate students Emerald Laija, Hector Guevara, Lisa Garcia, Eduardo Duran, Jennifer Dominguez, and Sandra Campos. Adrian Vasquez and Luisa Manzanares from Centro de Investigación en Materiales Avanzados (CIMAV) participated in the project planning and field measurements.

Interaction with Air Quality Agencies: Several results of interest to air quality regulators have come from the SCERP-funded studies. Results of vehicle-generated dust flux downwind of a road were included in the data set used to prepare a technical report that has been submitted to the Western States Air Resources Council (WESTAR). One result, obtained from comparing the Dugway, UT and

Jornada Road, NM investigations, is a demonstration that atmospheric stability and surface roughness (terrain irregularities and brush) are important variables in the behavior of road dust. There has been ongoing collaboration between Veranth's SCERP-funded work and New Mexico Bureau of Air Quality engineers. Periodic meetings have been held with Brad Musick and Dave Dubois to discuss air quality and atmospheric dust research.

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## REFERENCES

- CFR (1997). "National Ambient Air Quality Standard for Particulate Matter." Federal Register **62**(138): 38652-38760.
- Claiborn, C., A. Mitra, G. Adams, L. Barnesberger, G. Allwine, R. Kantamaneni, B. Lamb and H. Westberg (1995). "Evaluation of PM10 Emission Rates from Paved and Unpaved Roads using Tracer Techniques." Atmospheric Environment **29**(10): 1075-1089.
- EPA (1995). AP-42, Chapter 13, Appendix C.1 Procedures for sampling surface/bulk dust loading. Washington, D.C., U.S. Environmental Protection Agency.
- EPA (1998). Emission factor documentation for AP-42 Section 13.2.2, unpaved roads. Washington, D.C., U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards.
- Etyemezian, V. 2002. Telephone conversation. Salt Lake City. 24 July
- Hesketh, H. E. and J. Frank L. Cross (1983). Fugitive Emissions and Controls. Ann Arbor, Ann Arbor Science.
- Hinds, W. C. (1982). Aerosol Technology: Properties, Behavior, and Measurement of Airborne Particles. New York, John Wiley & Sons.
- Levenspiel, O. (1972). Chemical Reaction Engineering. New York, Wiley.
- New Mexico Environment Department - Air Quality Bureau (2000). Natural Events Action Plan - briefing document, New Mexico Environment Department: 1-6.
- Panofsky, H. A. and J. A. Dutton (1984). Atmospheric Turbulence Models and Methods for Engineering Applications. New York, Wiley.
- Perry, R. H. and C. H. Chilton (1973). Chemical Engineers' Handbook. New York, McGraw Hill.
- Seinfeld, J. H. and S. N. Pandis (1998). Atmospheric Chemistry and Physics — From Air Pollution to Climate Change. New York, Wiley.
- Veranth, J. M., E. Pardyjak and G. Seshadri (2002). "Vehicle Generated Dust Transport: Analytic Models and Field Studies." Atmospheric Environment.
- Veranth, J. M. and G. Seshadri (2001). Fugitive Dust Transport Under Arid Conditions: A Field and Modeling Study in Dona Ana County, New Mexico. Salt Lake City, SCERP.
- Watson, J. G., L. Ashbaugh, G. Casuccio, J. C. Chow, S. Francis, P. Gaffney, J. Fine, T. Gill, J. Gillies, R. Higashi, P. K. Hopke, A. Kennedy, D. Lowenthal, K. Magliano, P. Roth, J. Sagebiel, D. Shrimp, T. VanCurren, B. Zielinska, S. Ziman and T. Zobeck (1998a). The Fugitive Dust Characterization Study: Potential Methods and Research Need for Receptor Methods to Distinguish Among Fugitive Dust Sources, Desert Research Institute.
- Watson, J. G., J. C. Chow, J. A. Gillies, H. Moosmüller, C. F. Rogers, D. D. and J. C. Derby (1996). Effectiveness demonstration of fugitive dust control methods for public unpaved roads and unpaved shoulders on paved roads, Desert Research Institute.
- Watson, J. G., J. C. Chow and T. G. Pace (2000). Fugitive Dust Emissions. Air Pollution Engineering Manual. W. T. Davis. New York, Wiley: 117-135.
- Watson, J. G., D. W. Dubois, R. DeMandel, A. Kaduwela, K. Magliano, C. McDade, P. K. Mueller, A. Ranzieri, P. M. Roth and S. Tanrikulu (1998b). Aerometric

Monitoring Program Plan for the California Regional PM<sub>2.5</sub>/PM<sub>10</sub> Air Quality Study, Desert Research Institute.