# EXECUTIVE SUMMARY

## BACKGROUND

This study documents the results of a Federal Lands Highway Technology Program roadway dust stabilization project at the Buenos Aires National Wildlife Refuge. Six dust control products were installed and monitored for two years. The results show that for this specific semi-arid desert location and granular non-plastic roadway material, the best performing product was a formulation of an organic non-petroleum plus water absorbing material.

Controlling dust is an issue that concerns both private and public sector owners of unsurfaced roadways. There are approximately 6,359,568 km (3,950,042 $mi^{(2)}$) of road in the United States. Of this total, about 2,327,332 km (1,445,548 mi), or 37% are unpaved. More specifically, of the 987,518 km (613,365 mi) of Federal Roads, 83.6% are unpaved. While the percentage of unpaved roads varies for each agency, each one shares the problem of dust generation from road user traffic. Stabilizing these unpaved roads and controlling dust is becoming a high priority as maintenance budgets continue to be woefully inadequate, as environmental concerns become more prevalent, and as quality road building materials are depleted and harder to procure. Owners of unsurfaced roadways face a big challenge. Identifying methods to effectively control dust on unsurfaced roads is a goal of the Federal Highway Administration (FHWA), Federal Lands Highway (FLH), and was the focus of this study conducted by the Central Federal Lands Highway Division (CFLHD).

Dust is defined as fine particulate material that can pass through a 75 µm (No. 200) sieve. It is material that has broken free from the unpaved roadway surface and floats in the air, carried by wind currents, until it finally settles to the ground. Dust can be particles of soil or rock. Road dust can be controlled, managed, reduced or even eliminated depending on the application, product, and strategy selected for the roadway.

A number of factors can contribute to the occurrence of dust. These include road material properties such as gradation, cohesion/bonding, and durability; construction controls such as level of compaction applied to the material and moisture (or lack there of) in the material; road use factors such as vehicle speed, number, weight, and wheels per vehicle; and environmental factors such as a dry climate.

There are several reasons to stabilize soil. The first is strength improvement to enhance load-bearing capacity. The second is dust control. The third is waterproofing to preserve the natural or constructed strength of a soil and to minimize the entry of surface water.

Soil stabilization materials can be applied by an admixture process or topically through surface penetration. In the admixture process, aggregate and soil materials are combined with the stabilizer product in one of three ways: 1) In-place mixing (blending the soil and stabilization materials with a reclamation machine), 2) Off-site mixing using stationary mixing plants, and 3) Windrow mixing using a grader. The second method of application is topical; that is, spraying a soil treatment material directly onto the existing roadway and allowing the palliative to penetrate.

A variety of stabilization and dust abatement products are on the market today. These products are classified by the United States Forest Service (USFS) into seven basic categories each with different attributes, applications, and limitations. The seven categories are 1) Water, 2) Water Absorbing, 3) Organic Petroleum, 4) Organic Non-Petroleum, 5) Electrochemical, 6) Synthetic Polymer, and 7) Clay Additives.

## PROJECT DESCRIPTION

To broaden the base of knowledge about dust control products and application methods, the CFLHD applied six different road stabilizer or dust palliative products on a road reconstruction project at the Buenos Aires National Wildlife Refuge (NWR) in south-central Arizona. The purpose of the study was to evaluate the products for long-term performance and to recommend those products with acceptable performance for use on other CFLHD projects. This evaluation addressed each product's performance for dust control, rutting, washboarding, raveling, and soil stabilization over a 24-month period.

Using windrow mixing, the six roadway dust stabilizers were applied to 150 mm (6 in) depth in 1.6 km (1 mi) long sections throughout the construction project. The selected products, listed in Table 1, represent most of the major categories of stabilizers or dust suppressants and were those products most commonly used and available in the CFLHD 14-state oversight region. A seventh, 6.0 km (3.7 mi) long section, was also monitored and included in the report. On this section, Magnesium Chloride was surface-applied as a dust suppressant only. Since Magnesium Chloride is CFLHD's conventional dust abatement product, it was included in the evaluation as a performance reference point for comparison with the other six roadway dust stabilizers and palliative products**.**

It was anticipated that all of the products selected for this study would effectively stabilize the roadway material thereby controlling dust for at least 12 months. If, over this period, the stabilization significantly saved the owner agency manpower, machinery, and material costs equal to or more than the cost of the stabilization, then the study would be considered a success.

The cost and application rate of each product used in this study varied widely. No two manufactures recommended the exact same application rate. Because manufactures typically quote prices by the job depending upon the total quantity of product required, a simple price per gallon figure is difficult to pin point. In other words, price often will be reduced as the product quantity increases. A comparison using price per gallon is nearly impossible because price depends on varying market conditions as well as project location. Due to all of these factors, it is difficult to provide a detailed comparison of product costs. Finally, it should be noted that for this study, several manufactures either donated their products or sold them at a substantially reduced price to gain exposure from the work.

With this stated, a general comparison of product costs can be made by observing overall market prices and general cost data. The electrochemical enzyme products (Terrazyme and Permazyme in this study) are sold on the market at a cost significantly less than the other products used in this study. In a general comparison for a standard application, the enzyme products might cost approximately one-third of the chloride and sulfonated products (DC Caliber 2000, Mag/Lig, and

the Lignosulfonate in this study) and one-fourth to one-fifth the cost of the Soil Sement product. Again, it should be noted that these comparisons are suggestions based on general cost data and are subject to many variations. Contractors or other agencies that use the results of this study should perform their own market analysis of product costs based on the proposed application, climate, specifications requirements, availability, and project location. The relative costs and application rates of the products used in this study are reported in Table 1.

Performance monitoring of each product occurred at 6-month intervals for a 24-month period beginning in March 2003, six months after the products were applied. Each monitoring event consisted of a visual inspection for dust control, washboarding, raveling, potholing, rutting, and leaching. The evaluation team also performed on-site physical testing consisting of Dynamic Cone Penetrometer (DCP) measurements, Silt Load evaluations, Nuclear Density Gauge readings, and GeoGage Soil Stiffness tests. The results of these observations are summarized in Table1. In general, the higher the number reported, the better the performance.

**Table 1. Visual and physical value summary.**

| Test Section | Product | Visual Overall Average Score (x10) | Physical Overall Normalized Rank | Overall Average Score | Relative Cost | Relative Application Rate |
|---|---|---|---|---|---|---|
| **I** | **Mag/Lig** | 65 | 90 | 77 | Medium | High |
| **II** | **Caliber** | 73 | 92 | 83 | Medium | High |
| **III** | **Soil Sement** | 55 | 76 | 65 | High | Medium |
| **IV** | **Permazyme** | 50 | 78 | 64 | Low | Low |
| **V** | **Terrazyme** | 55 | 78 | 66 | Low | Low |
| **VI** | **Lignosulfonate** | 56 | 84 | 70 | Medium | High |
| **VII** | **Mag/Cl** | 54 | 89 | 71 | Medium | High |

Each product's performance was fully acceptable throughout the 24-month study although, based on the levels of observed washboarding, some sections appeared to need a reapplication and blading to bring them back to full performance. Before stabilization, the owner agency had to grade, blade, or work the roadway at least every three months. During the entire 24-month study, they were requested not to maintain the roadway surface at all. Though some sections did need to be graded after 24 months, the owner agency had been saved from performing six to seven grading maintenance events.

In this report, the rating and performance of the electrochemical enzyme products, Permazyme and Terrazyme, deserve some special qualification. These electrochemical products are formulated to perform and react with materials containing clay particles. They are dependent on fine clay mineralogy to reach and achieve maximum performance for dust abatement and soil stabilization. Because the material used for borrow on this source was a "non-plastic" material containing no clay particles, these two products would probably not be optimal choices even though costs may be lower.

The tables, figures, and discussions in subsequent chapters show how each of the products performed in relation to the others. It is not the intent of this study to imply that any one product

failed to adequately perform simply because its subjective visual rating values gave it a relative rank lower than another product. This project was considered a success for all products.

## CONCLUSIONS

### Assessment Methodology

The visual assessment was an acceptable method to compare performance of the products relative to each other at a single point in time; however it was limited for comparing product performance over time. The physical tests provided objective values over time but not all parameters of interest could be measured with physical objective tests. Thus, a combination of comparative visual and objective physical tests was used. As shown in Table 1, both methods appear valid as there is a clear correspondence between the average values of both the visual and physical observations. A summary of these average values may imply a higher level of precision than actually existed; so products have been simply grouped, and three groups are evident from the overall average scores. The Caliber product with the highest score is in the first group, the Mag/Lig is in the second, and all of the other products are in the third group. Similarly, from the overall average scores, there may be a desire to draw the conclusion that Caliber was a great product and Permazyme was not. This is not a correct conclusion. All products performed at an acceptable level under this study, and the Refuge benefited by not having to conduct six or seven maintenance activities over the 24-month period.

### Performance Levels

Although varying levels of performance can be distinguished among the products at this particular project site, the order of observed performance may not be the same on another project where conditions such as specific soil type, climate, level of traffic, and rate of product application are different. The previously published literature on the effectiveness of these product categories also notes that product performance varies in relation to soil type, composition, climate, and traffic.

### Supplier's Role

Specifications for the use of some of these products are not yet developed for either surface or full-depth stabilization. Therefore, it was beneficial to have the product manufactures participating and providing recommendations for use and application. As was done under this study, a soil investigation and classification is needed to provide adequate information to the manufactures so that the site conditions can be matched with the best products. In addition, a physical sample of the proposed material for this roadwork should be given to each manufacturer.

### Need for Special Contract Requirements (SCRs)

No single product is the only solution. Because all of the tested products performed well, these and additional products should be available for use on FLH projects. SCRs are needed in order

to employ these newer products until such time that the FP-03, Standard Specifications for Federal Projects can be changed.

### Stabilization Depth

With the observed drop in performance by the end of the study of the Mag/Cl surface application, it would appear that stabilization of a soil to a depth of 150 mm (6 in) is more effective and longer performing than surface applications. However, to prove this theory, the study should have employed a comparison of both surface and full-depth stabilization for each product. It could be further speculated that treating the roadway depth to half of what actually occurred would have also resulted in satisfactory results, but this is currently unsupported. This said, it appears there is a need in future studies to define a minimum effective depth of stabilization to provide for cost effective treatments, or to determine the cost effective balance between full depth stabilization and repeated applications of surface treatments.

### Product Selection

Even though some product selection guidance already exists, education in the proper selection and specifying of roadway dust stabilizers is needed for Federal Lands Division designers and construction personnel as well as for Federal land management units that have road maintenance capabilities. Current selection processes start with the product, and show how they can be applied. For example, the USDA Forest Service publication entitled *Dust Palliative Application and Selection Guide* provides a table that indicates what kinds of soils and conditions best suit a particular class of products. A process that would work better would start first with identifying the composition and classification of the soil for a specific project, move to inputting climate, traffic, and environment requirements, then finally identify the best product or product class to use. While this study provided average scores for the products as well as relative costs and relative application rates, a different product selection process is needed to assist in deciding which product to use for a specific application.

### Environmental Effects

No deleterious effects on the vegetation were observed for any of the products; however no physical environmental monitoring tests were done to conclusively verify this. Other non-visual effects may be measurable with other physical environmental monitoring tests. It must be acknowledged that at other locations with different conditions, some products may not be compatible with existing vegetation or may not be allowed by local agencies. There is a need to evaluate the various products' potential for environmental impacts.

## RECOMMENDATIONS

- Develop SCRs to specify and allow the use of various dust and roadway stabilization products.

- Develop and employ a process for continued evaluation and validation of these and other products available in the FLH's jurisdictions. Include studies to define a minimum effective

depth of stabilization to provide for cost effective treatments or to determine the cost effective balance between full depth stabilization and repeated applications of surface treatments. Consider partnering with the US Fish and Wildlife Service (F&WS) to evaluate environmental impact of the products.

- Perform further investigations using these same products with different types of soils, climates, and conditions to refine product selection processes. Further refine assessment parameters to strengthen objectivity and performance tracking over time.

- Collect additional information to develop more precise economic product comparisons based on initial and installation costs; application rates; and product effectiveness in terms of stability, dust mitigation, and longevity.

- Develop a selection chart for the optimum match of a product category with the site-specific parameters of soil type, composition, classification, climate, traffic, and environment.

- Develop and provide training for designers and field personnel on the application and use of these products.

- In partnership with the F&WS, incorporate environmental effects testing into future product comparison and monitoring projects on Federal lands.