ARIZONA DEPARTMENT OF TRANSPORTATION

SOIL EROSION AND DUST CONTROL ON ARIZONA HIGHWAYS

Part III Progress Report - Field Testing Program

Report: ADOT-RS-10-141-III

Prepared by:
Dr. Hassan A. Sultan, C.E. Dept.
Arizona Transportation & Traffic Institute
College of Engineering
The University of Arizona
Tucson, Arizona 85721

October 1974

Prepared for:
Arizona Department of Transportation
206 South 17th Avenue
Phoenix, Arizona 85007

in cooperation with

The U.S. Department of Transportation
Federal Highway Administration
Washington, D.C.

SOIL EROSION AND DUST CONTROL ON ARIZONA HIGHWAYS

PROGRESS REPORT - FIELD TESTING PROGRAM

by

HASSAN A. SULTAN

Submitted to

The Arizona Department of Transportation
Highways Division
Phoenix, Arizona 85007

for

Research Project - Arizona HPR-1-10-(141)

Sponsored by

The Arizona Department of Transportation

in Cooperation with

The U.S. Department of Transportation

Federal Highway Administration

Arizona Transportation and Traffic Institute
College of Engineering
The University of Arizona
Tucson, Arizona 85721

November, 1974

PART III

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle	5. Report Date
Soil Erosion and Dust Control on Arizona Highways Progress Report Part III - Field Testing Program	November 1, 1974
	6. Performing Organization Code
7. Author(s) Hassan A. Sultan, Ph.D.	8. Performing Organization Report No.
9. Performing Organization Name and Address University of Arizona Arizona Transportation & Traffic Institute Tucson, Arizona 85721	10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address Arizona Department of Transportation & Federal Highway Administration, Washington, D.C.	13. Type of Report and Period Covered Progress Report, Part III June 1974 - November 1974 14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

Several chemical stabilizers were selected for use in a large scale field application, based on a laboratory testing program. Spray-on application of chemicals to control dust and wind erosion on untrafficable areas were made using eleven chemicals. Five chemicals were used on an unpaved road using a mixed-in application. Methods of field application are given. Details of monitoring techniques including HiVol dust collection, dust fall collection in cups, and extraction tests are discussed. Preliminary observations comparing the chemical applications among themselves and as compared to control sections, where water was used, are given. Evaluation will continue for approximately 12 months more.

17. Key Words	18. Distribution Statement
Chemical stabilization, Soil stabilization, Erosion control, Dust control, Wind Erosion, Traffic Erosion, Dust Collection. Field Application.	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

ACKNOWLEDGEMENTS

The writer wishes to thank Mr. Gene R. Morris and Mr. Benjamin W. Ong of the Arizona Department of Transportation and Mr. John Porco and Mr. R. E. Mullens of the Federal Highway Administration for their fine cooperation during the conduct of this study. Special thanks are extended to Mr. Jack Bagley of General Control Company, Tucson, Arizona, for his generous support and donation of time, equipment and material for field applications.

Appreciation is due to personnel of the Pima County Highway Department, and their chief Mr. D. A. DiCicco, for their assistance in the road application. The writer also acknowledges with thanks the donations of the many suppliers of chemicals for use in the field, especially the Arizona Refining Company, Armak, Ohm Research Products and Standard Oil Company. The assistance offered by the University of Arizona Agricultural Experiment Station in the use of their farm is gratefully acknowledged. Sincere appreciation is due to the many student assistants who worked on this project, particularly Mr. W. T. Park, Mr. A. El-Rustom, Mr. R. Knepper, Mr. S. Qaqish and Mr. T. McKenrick.

The excellent work of Mrs. Ellen LaMotte and Mrs. Vicki Gettel in typing the manuscript is apparent and appreciated.

ACKNOWLEDGEMENTS

The writer wishes to thank Mr. Gene R. Morris and Mr. Benjamin W. Ong of the Arizona Department of Transportation and Mr. John Porco and Mr. R. E. Mullens of the Federal Highway Administration for their fine cooperation during the conduct of this study. Special thanks are extended to Mr. Jack Bagley of General Control Company, Tucson, Arizona, for his generous support and donation of time, equipment and material for field applications.

Appreciation is due to personnel of the Pima County Highway Department, and their chief Mr. D. A. DiCicco, for their assistance in the road application. The writer also acknowledges with thanks the donations of the many suppliers of chemicals for use in the field, especially the Arizona Refining Company, Armak, Ohm Research Products and Standard Oil Company. The assistance offered by the University of Arizona Agricultural Experiment Station in the use of their farm is gratefully acknowledged. Sincere appreciation is due to the many student assistants who worked on this project, particularly Mr. W. T. Park, Mr. A. El-Rustom, Mr. R. Knepper, Mr. S. Qaqish and Mr. T. McKenrick.

The excellent work of Mrs. Ellen LaMotte and Mrs. Vicki Gettel in typing the manuscript is apparent and appreciated.

ABSTRACT

Several chemical stabilizers were selected for use in a large scale field application, based on a laboratory testing program. Spray-on application of chemicals to control dust and wind erosion on untrafficable areas were made using eleven chemicals. Five chemicals were used on an unpaved road using a spray-on application to control erosion and dust behind traffic. Three chemicals were also used on the unpaved road using a mixed-in application. Methods of field application are given. Details of monitoring techniques including HiVol dust collection, dust fall collection in cups, and extraction tests are discussed. Preliminary observations comparing the chemical applications among themselves and as compared to control sections, where water was used, are given. Evaluation will continue for approximately 12 months more.

KEY WORDS: Chemical Stabilization, Soil Stabilization, Erosion Control, Dust Control, Wind Erosion, Traffic Erosion, Dust Collection, Field Applications.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

LIST OF APPENDICIES

CHAPTER 1

INTRODUCTION

This progress report presents a summary of the field application of the chemicals that were selected at the conclusion of the laboratory testing phase. Field testing program includes a spray-on application of chemicals on untrafficable areas which represents a wind erosion control or a dust control measure only. Road tests for a spray-on and a mixed-in application of chemicals were included for traffic erosion control and control of dust due to traffic.

Two interim final reports for this project have preceded this report and included the state-of-the-art review and the results of the laboratory testing phase, respectively. A final report will follow this progress report and will include details of the field application, the field monitoring program, results of the field monitoring and discussion of the field performance of the applied chemicals. The final report will be submitted at the conclusion of the project (November 1975) and completes the project.

Scope

The scope of this progress report is limited to a brief summary of the field test activities. This summary outlines the chemicals used for each application, the types of field applications, the methods used in applying the chemicals, the various monitoring tests used to evaluate the field performance along with a brief interim evaluation of chemical performance approximately three months after application.

CHAPTER 2

FIELD APPLICATIONS

Similar to the laboratory test program, the field program was designed to evaluate chemical performance in effectively controlling dust caused by wind only on untrafficable areas, along with chemical effectiveness in controlling dust caused by traffic abrasive forces on unpaved dirt roads. Accordingly two sites were selected for the two types of evaluation.

Dust Control Sites - Untrafficable

The restriction of untrafficability imposed on this application caused long delays in coming up with a site that can be protected from pedestrians, drag-racers, pranksters, animals, . . . among others. One site that was allocated by the ADOT Right of Way Division was prepared, cleared, fenced and marked by state signs prohibiting trespassing. Within five days the signs were removed and the fence broken and dismantled. Luckily this occured prior to the chemical application.

The assistance of the University of Arizona Agricultural Experiment Station (AES) was solicited to find a well fenced and protected area. A corner of the AES farm at the corner of Dodge Street and River Road was assigned for our use on this project.

AES Farm Site

Site Preparation. The northwest corner of the AES farm, at the intersection of Dodge Street and River Road, in Tucson was the location assigned for this site. An area of 120 feet by 220 feet was allocated as shown on Figure 1. The site has been previously used for farming and had been disc-harrowed several months prior and was relatively free of weeds. The assigned test area was levelled and smoothed over using a steel drag. The combination of these activities left the top 3 to 6 inches reasonably loose.

The site was fenced on the inside east and south sides using a post and rope type fence. The outside north and west sides were bounded by

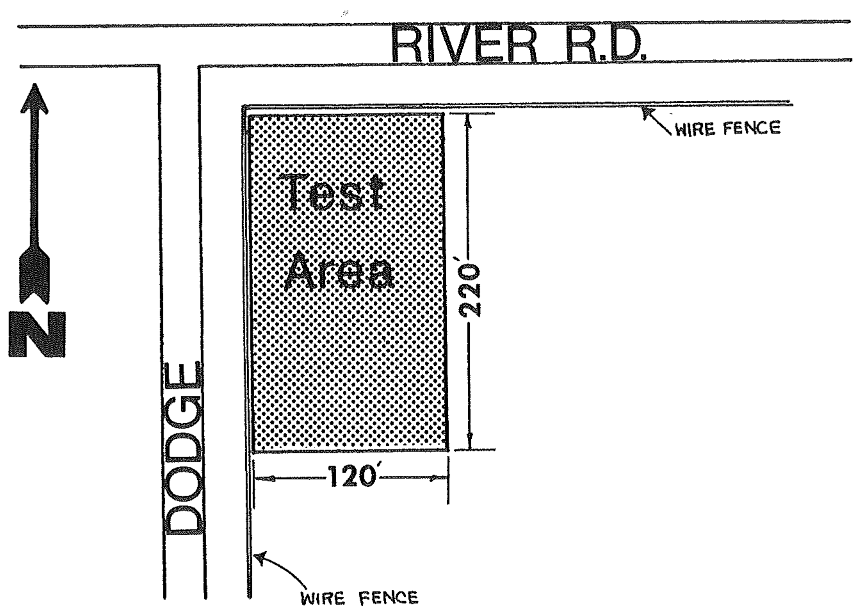


FIGURE 1: GENERAL SITE PLAN, AES FARM SITE

8-foot high chain-link fence. The site was divided into 14 plots of 20 feet by 40 feet each, as shown in Figure 2.

Chemicals Applied. As pointed out in the Final Interim Report - Part II, eleven chemicals were decided upon for use in the field application, in addition to the use of water for a control section. Each one of these chemicals is briefly discussed below. For each chemical, the outline includes its major constituents, the dilution ratio, the rate of application and the cost of application per square yard for the chemical only. The number given after the chemical name refers to the number assigned to each chemical during the laboratory testing program.

1. Water (0): Water was applied on a control section at the rate of 1/2 gsy.

2. Aerospray 70 (7): Its major constituent is a polyvinyl acetate resin. The dilution ratio is 1 to 20 in water, and the application rate is 1/2 gsy. The cost of the chemical application is 5.95 cents and 6.50 cents per square yard, F.O.B. Torrence, California and F.O.B. Tucson, Arizona, respectively.

3. Surfaseal (13): The composition was not given by the manufacturer. The recommended dilution ratio is 1 to 20 in water, and solution applied at 1/3 gsy. The cost of this chemical application is 6.3 cents and 6.78 cents per square yard, F.O.B. Daly City, California and F.O.B. Tucson, Arizona, respectively. At the time of application, the manufacturer was present at the site and requested dividing the allocated plot in two sections. One half was given the recommended application given above, while the other half received the same rate of application, but at a 1 to 10 dilution ratio. The cost of the latter application is 12 cents and 12.94 cents per square yard, F.O.B. Daly City, California, and F.O.B. Tucson, Arizona, respectively.

4. Petroset SB (20): This is a butadiene-styrene rubber and resin tacifier in an oil-water emulsion. The dilution ratio is 1 to 25 in water, and solution applied at 1.0 gsy. The cost of this chemical application is 5.8 cents and 6.61 cents per square yard, F.O.B. Borger, Texas and F.O.B. Tucson, Arizona, respectively.

5. Coherex (21): This is an emulsion consisting of 60% semi-liquid natural petroleum resins and 40% wetting solution. The dilution ratio is 1:7 in water, and solution applied at 1.0 gsy. The cost of this chemical

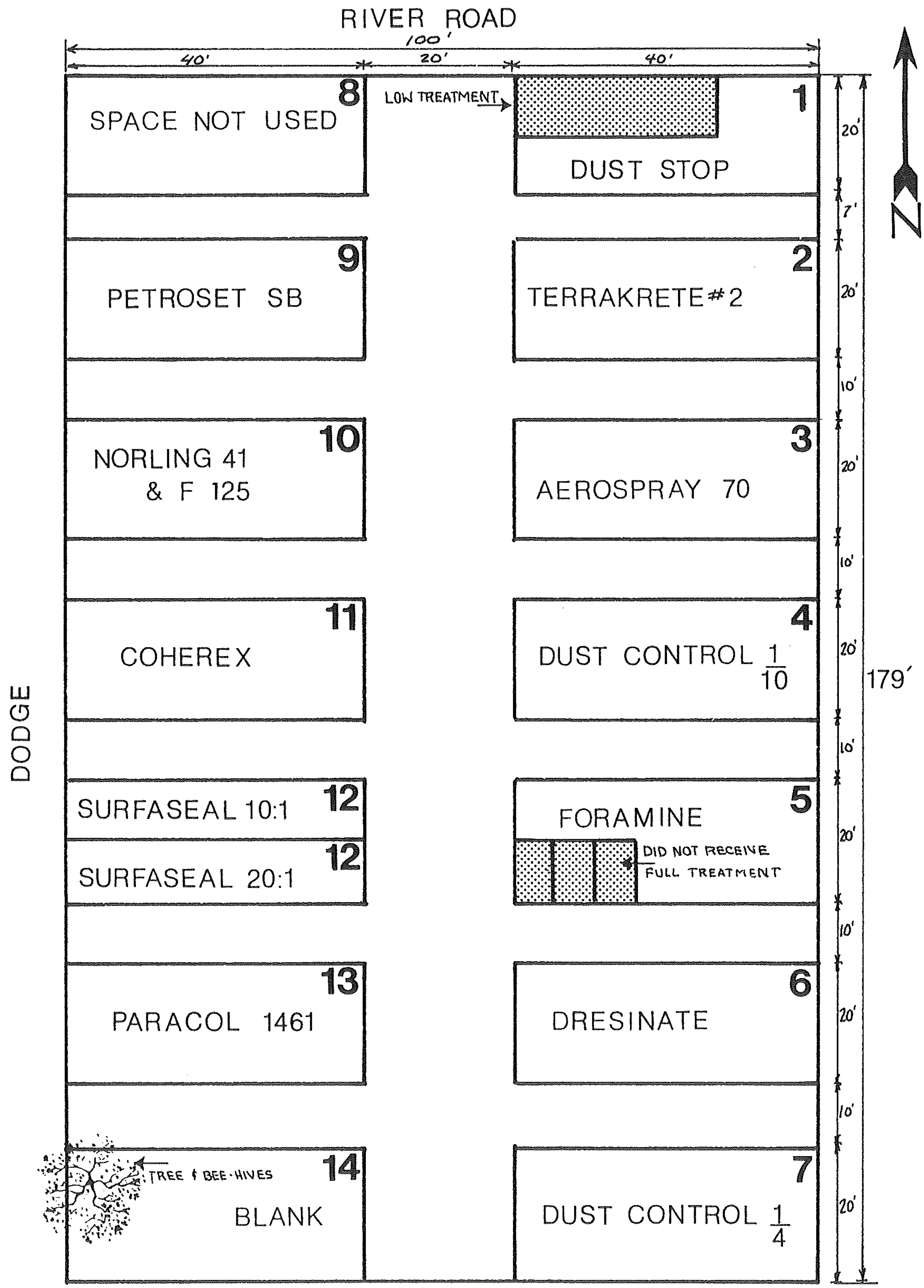


FIGURE 2- LOCATION OF TEST PLOTS, AES FARM SITE

application is 2.9 cents and 5.8 cents per square yard, F.O.B. Bakersfield, California and F.O.B. Tucson, Arizona, respectively.

6. Dresinate DS-60W-80F (25): This is a dispersion of thermoplastic resin and viscosity reducer. The dilution ratio is 1 to 9 in water, and solution applied at 1.0 gsy. The cost of this application is 3.4 cents and 5.95 cents per square yard, F.O.B. Portland, Oregon, and F.O.B. Tucson, Arizona, respectively.

7. Paracol 1461 (26): This is a wax thermoplastic resin blend. The dilution ratio is 1 to 9 in water, and solution applied at 1.0 gsy. The cost of this application is 3.9 cents and 6.52 cents per square yard, F.O.B. Portland, Oregon and F.O.B. Tucson, Arizona, respectively.

8. Terrakrete #2 (27): This is a vinyl acetate acrylic copolymer. The recommended dilution is to make a 6 percent solution in water, and apply it at 1/2 gsy. The cost of this application is 5.6 cents and 6.26 cents per square yard, F.O.B. Torrence, California and F.O.B. Tucson, Arizona, respectively.

9. Dust Control Oil (37): This is a mixture of petroleum resin and a light hydrocarbon solvent. It is pointed out that this chemical actually did not pass the laboratory test criteria, however it was included in the field study due to its superior performance observed by the principal investigator in another field study; Sultan (1974). Two rates of application were used for this chemical. The first application was using 1/4 gsy at a cost of 3.8 cents and 10.9 cents per square yard, F.O.B. Richmond, California and F.O.B. Tucson, Arizona, respectively. The second application was using 1/10 gsy at a cost of 1.52 cents and 4.36 cents per square yard, F.O.B. Richmond, California and F.O.B. Tucson, Arizona, respectively.

10. Dust Stop (38): This is an acrylonitrile butadiene styrene co-polymer. The dilution ratio is 1 to 20 in water, and solution applied at 1/2 gsy. The cost of the application is 2.6 cents and 3.36 cents per square yard, F.O.B. Dover, Delaware and F.O.B. Tucson, Arizona, respectively.

11. Foramine 99-194 (41): This is a urea-formaldehyde resin in water solution. Recommended application was to add 0.18 lb. of water to each 1.0 lbs. of chemical, and apply the solution at 1.0 lb.per square yard. In the field however, additional water had to be added to the same recommended chemical amount in order to be able to spray the solution .

The field solution was applied at 1/4 gsy which included 0.82 lb. of the chemical. The cost of this application is 6.8 cents and 10.1 cents per square yard, F.O.B. Tacoma, Washington, and F.O.B. Tucson, Arizona, respectively.

12. Norlig 41 + F125 (46): This is a mixture of Norlig-41 solution and Formula 125 solution. Norlig 41 is a solution of chemicals and a lignin sulfonate base. Formula 125 is mainly a sodium methyl siliconate with other additives. The recommended application is a mix of (1:4) solution of Norlig 41 in water and (1:40) solution of F125 in water at the ratio of 4:1, respectively; and applied at 1.0 gsy. The cost of this application is 9.1 cents per square yard, F.O.B. Tucson, Arizona.

Method of Field Application. The chemical solutions were applied in the field using a John Bean mobile sprayer (50 gallons capacity) provided by General Control Company of Tucson, Arizona. The machine, as calibrated was found to have a pumping capacity of 3 1/4 gallons per minute. The pumping rate was checked periodically during the field application and was found to remain at about the same rate. The field plots were then divided into subsections 3-feet by 10-feet. For each of the subsections, the following spraying arrangements were made:

Rate of Application (gsy)	No. of Spray Applications for Each Subsection	Time of Each Application (Seconds)
1.0	3	20
1/2	1	30
1/4	1	15
1/6	1	10
1/10	1	6

A photograph taken during the chemical spray application at the AES-Farm is shown as Figure 3. It is pointed out that after every application, the sprayer tank and hose were rinsed clean with water, before starting the next chemical solution. Dust Control Oil had to be rinsed with gasoline. The chemicals were applied in the field between May 20-22, 1974.

FIGURE 3: FIELD SPRAY APPLICATION, AES FARM SITE

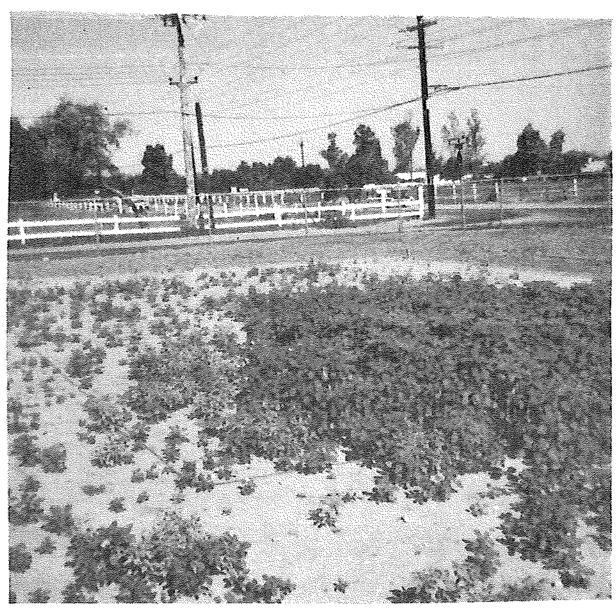


FIGURE 4: WEED GROWTH ON PETROSET SB PLOT AES FARM SITE, 8/10/74

The mechanical, physical and chemical properties of the surface soil encountered at the farm area are given in Table 1 along with those of other field soils encountered in the other sites of the field program.

ADOT Yard Site

Two months after the application of the chemicals in the AES site, during which the summer thunderstorms started accompanied with above normal rainfall, weeds started to grow profusely. By the middle of August (two-and-a-half months after application) the weeds grew to knee-high levels on some of the plots as shown in Figure 4. For an actual field application this may not be considered a problem since weeds also tend to afford an additional measure of dust control. However, on a test site it did present a problem since it obscured the conditions of the sprayed surfaces. Accordingly, another site was sought to be sprayed with the chemicals along with a weed control agent.

A new site was selected adjacent to the ADOT District Maintenance Yard, west of I-10 and north of Grant Road. The site was cleaned of light grass growth and, to our knowledge, was never used for agricultural purposes before. The site was prepared similar to the AES Farm site. A site plan for the new Yard Site is given as Figure 5. Several of the plots were avoided since they were located at a low-elevation zone and may be flooded during the evaluation period after heavy rainfalls.

This time a weed control agent "Princep-80W" which includes an 80 percent Simazine active ingredient was added to the chemical solution. This chemical agent was recommended and donated by General Control Company of Tucson, Arizona. The recommended rate of application for Princep-80W was set at 10 lbs. per acre. During the application, enough material was mixed in water then added to the chemical water solution. This Yard-Site was sprayed on September 28-29, 1974. Properties of the surface soils at this site are given in Table 1.

Road Test - Spray Treatment

Near the completion of the laboratory testing phase, the City of Tucson was contacted to allocate an unpaved road for our use in the field testing. It took the City personnel about three months before deciding on a particular road. However, the allocated road proved to be unsuitable due to its close proximity to several subdivisions which would make our

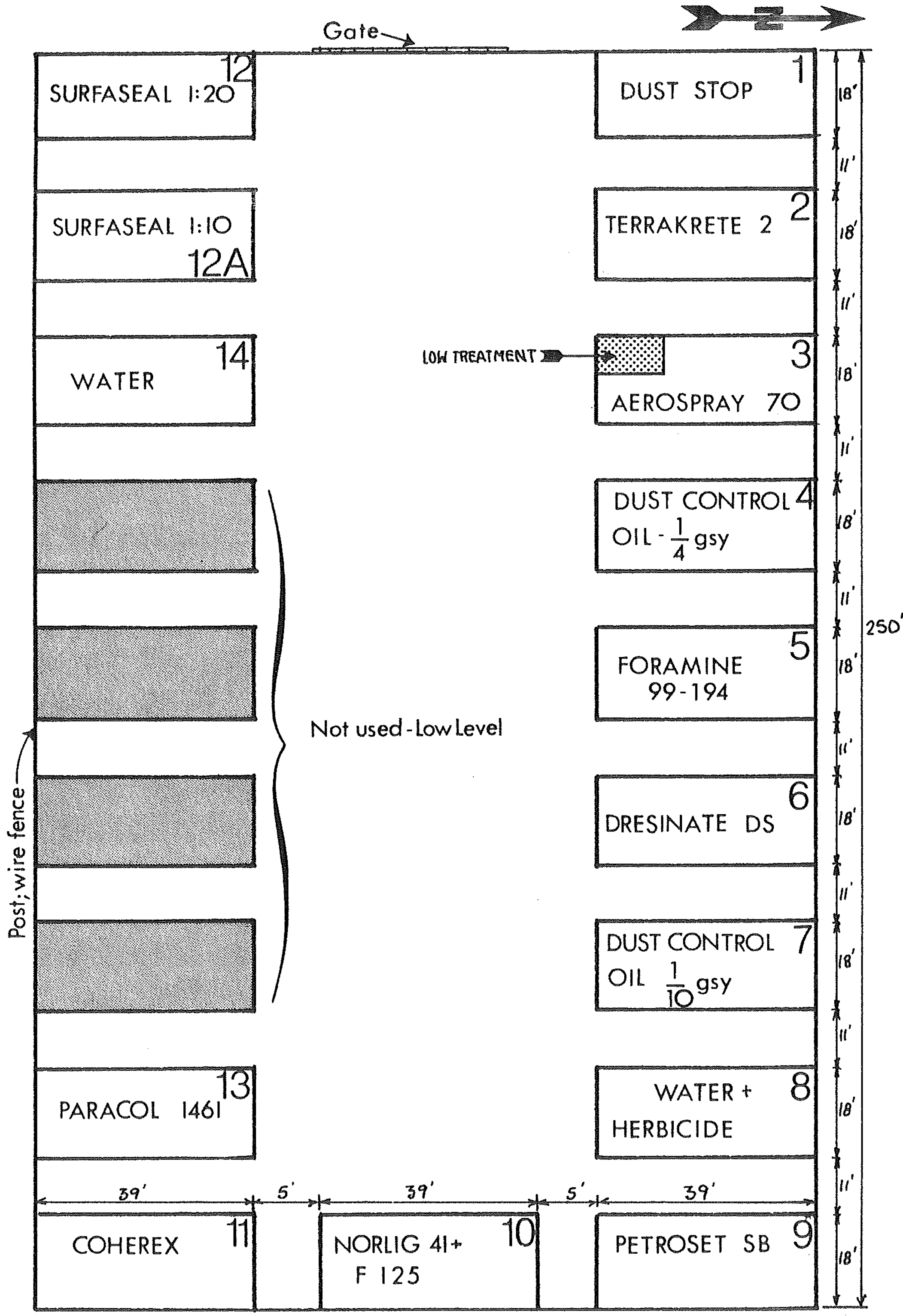


FIGURE 5 - SITE PLAN, ADOT YARD-SITE

field monitoring instruments (the collection cups mainly) quite vulnerable to vandalism.

The Pima County Engineer was then contacted to allocate an unpaved road for our use and South Wilmot Road (South of I-10) was selected from a few choices given to us. In addition the County Engineer agreed to provide equipment and personnel to work with us for the field application.

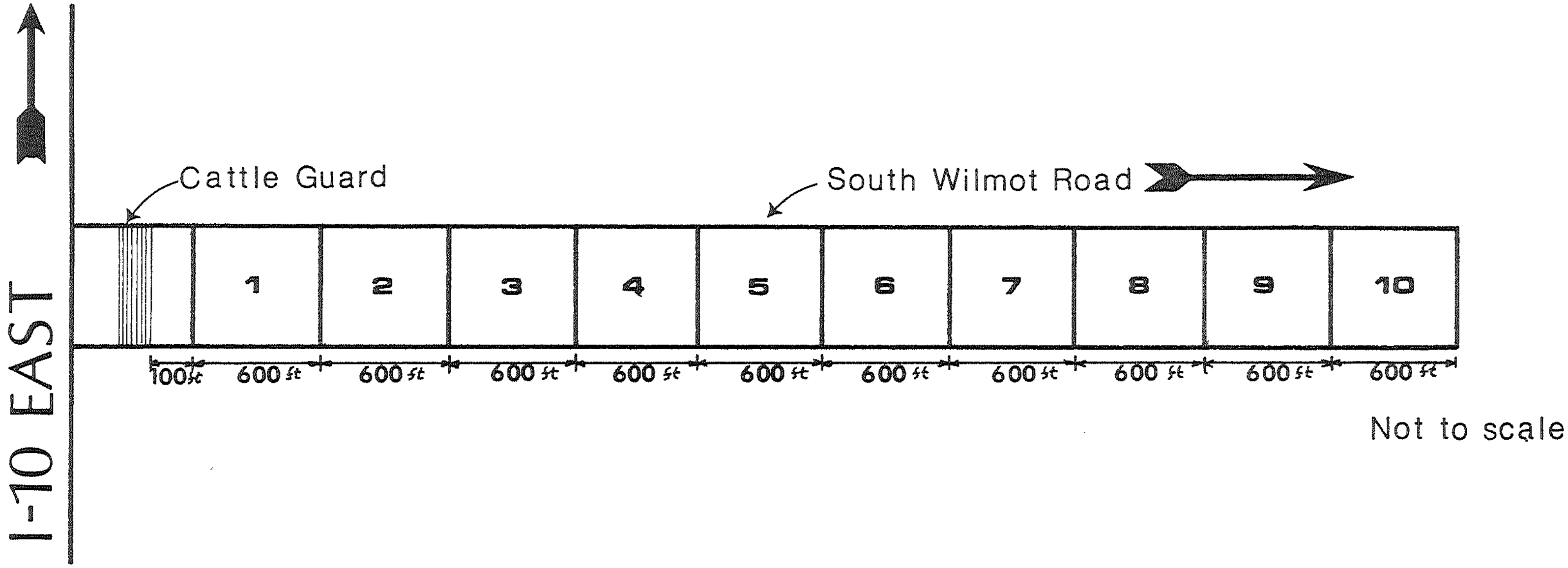
Site Preparation

The road test site on South Wilmot Road was selected just south of I-10. The first test section starts at approximately 100 feet south of the cattle guard across the road. Ten sections (600-feet long and 28-feet wide) were marked along the road and are referred to as sections no. 1 through 10 going southward, as outlined in Figure 6. Properties of surface soils at the road site are given in Table 1.

For the spray applications, the surface of the road was usually prepared by surface blading (no ripping) leaving a nominally loosened surface layer. The chemical solution was prepared in a boot truck and sprayed on the surface through the spray bar. It is pointed out that the boot truck was equipped with a circulating pump that continued to mix the chemicals during application. After spraying, the surface was usually rolled using a rubber tire roller. The field preparation and application for section no. 1 is shown in Figure 7 (surface blading), Figure 8 (chemical spray) and Figure 9 (surface rolling).

Chemicals Applied

As pointed out in the Final Interim Report, Part II, five chemicals were decided upon for uses in the field application for traffic erosion, using the spray-on application. In addition water treatment was used for one control section. Figure 6 includes the outline of the sections allocated for the chemical treatments. Each one of these chemicals is briefly discussed below. For each chemical the outline includes its major constituents, the dilution ratio, the rate of application and the cost of application per square yard for the chemical only. A brief description of the field application is also given. The number given after the chemical name refers to the number assigned to each chemical during the laboratory testing program.



SPRAY TREATMENT Section

1 DUST CONTROL OIL

2 AEROSPRAY 70

3 WATER (CONTROL)

4 FORAMINE 99-194

5 DUST BOND AND F125

6 CURASOL-AE

MIXED-IN-DEPHT TREATMENT Section

7 DUST BOND AND F125

8 REDICOTE-E52 EMULSION

9 WATER (CONTROL)

10 DUST CONTROL OIL

FIGURE 6- WILMOT ROAD TEST LAYOUT

FIGURE 7: ROAD SURFACE PREPARATION, SPRAY-ON APPLICATION

FIGURE 8: CHEMICAL SPRAY-ON APPLICATION

FIGURE 9: SURFACE COMPACTION, SPRAY-ON APPLICATION

TABLE 1: FIELD SOILS PROPERTIES

Soil Property	Wilmot Road Soil	AES-Farm Soil	ADOT-Yard Soil
Specific Gravity	2.64	2.60	2.60
Liquid Limit, %	21.0	24.5	29.0
Plasticity Index, %	5.6	4.5	18.2
St. AASHTO, δ_{max} pcf	124.0	-	-
St. AASHTO, W_{opt} %	11.0	-	-
Mod. AASHTO, δ_{max}, pcf	131.0	-	-
Mod. AASHTO, W_{opt}, %	8.0	-	-
pH value	8.0	7.7	8.3
Soluble Salts, ppm	238.0	1820	987
Nitrates (NO_3), ppm	9.4	1258	18.2
Phosphates (PO_4), ppm	2.7	26.4	8.2
Sulfates (SO_4), ppm	18.0	150	306
Organic Matter, %	0.05	0.79	0.5
Percent Passing, 2 microns	8	15	5.0
Percent Passing #4	99	96	96
Percent Passing #200	28	47	60

1. Water (0): Section number 3 was sprayed with 1/2 gsy of water and rolled.

2. Aerospray-70 (7): Its major constituent is a polyvinyl acetate resin. The laboratory dilution ratio is 1 to 10 in water, and the application rate is 1.9 gsy. The cost of this chemical application is 43.2 cents and 47.17 cents per square yard, F.O.B. Torrence, California and F.O.B. Tucson, Arizona, respectively.

For the field application, the boot truck was filled with 800 gallons of water, 270 gallons of chemical were added using a transfer pump, then an additional 800 gallons of water were added. The solution was then sprayed at 1.0 gsy on the surface of the road using four passes at 1/4 gsy each. This rate of application was decided upon since larger rates caused heavy flooding of the surface. The surface was rolled immediately without noticeable tracking.

This field application is thus a dilution of 1:6 in water, with the solution rate of application at 1.0 gsy. The amount of chemical per square yard in the field application is about 84% of that given in the laboratory test. Thus the chemical cost of the actual field application is 36.3 cents and 39.6 cents per square yard, F.O.B. supplier and F.O.B. Tucson, respectively.

3. Curasol AE (9b): This is identified as a polymer dispersion. The laboratory dilution is 1 to 5 in water applied at 1.0 gsy. The cost of this chemical application is 43.3 cents and 45.8 cents per square yard, F.O.B. Los Angeles, California and F.O.B. Tucson, Arizona, respectively.

For the field application, the boot truck was filled with 800 gallons of water, 270 gallons of chemical were added using a transfer pump, then an additional 800 gallons of water were added. The solution was then sprayed at 1.0 gsy on the road surface using four passes at 1/4 gsy each. The surface was rolled immediately without noticeable tracking.

This field application is thus a dilution of 1 to 6 in water instead of 1 to 5 as in the laboratory test. Accordingly, the amount of chemical and its cost is about 87% of that given in the laboratory test. The chemical cost of the actual field application is 37.67 cents and 39.84 cents per square yard, F.O.B. supplier and F.O.B. Tucson, respectively.

4. Dust Bond 100 (18b): This is a mixture of lignin sulfonate and other chemicals. The laboratory rate of application is at 1.0 gsy

undiluted. This chemical application costs 36 cents per square yard, F.O.B. Tucson and supplier. Since Dust Bond 100 was used to represent the group of lignin sulfonate products as waterproofed with Formula 125, ten gallons of F-125 were also used in the field to achieve the same rate of F-125 application given in chemical No. 46 (Norlig-41 and F-125).

For the field application, the boot truck was filled with about 1,900 gallons of Dust Bond. The chemical was sprayed on the road surface at about 1.0 gsy, until there was about 200 gallons left. Two hundred gallons of water were then added along with ten gallons of Formula 125, and the mix was spread evenly on the road surface. The surface was rolled about one hour after spraying, due to high surface moisture, for about half an hour, then left until the following morning since the surface was still quite wet for rolling. The following morning, the rolling continued until sufficient compaction was achieved.

The cost of the field chemical application (Dust Bond 100 + Formula 125) is 41.3 cents per square yard, F.O.B. supplier in Tucson, Arizona.

5. Dust Control Oil (37): This is a mixture of petroleum resin and a light hydrocarbon solvent. The laboratory rate of application is 0.6 gsy undiluted. This chemical application costs 9.0 cents and 25.8 cents per square yard, F.O.B. Richmond, California and F.O.B. Tucson, Arizona, respectively.

For the field application, the chemical was sprayed on the road surface at 1/2 gsy and rolled immediately without any tracking observed. The cost of this actual field application is 7.5 cents and 21.5 cents per square yard, F.O.B. supplier, and F.O.B. Tucson, Arizona, respectively.

This treatment looked and still does (September 1974) very satisfactory.

6. Foramine 99-194 (41a): This is a urea-formaldehyde resin in a water solution. Laboratory application calls for 4.1 lbs. of the chemical per square yard with enough water to make a sprayable solution. The cost of this chemical application is 34.0 cents and 50.57 cents per square yard, F.O.B. Tacoma, Washington and F.O.B. Tucson, Arizona, respectively.

For the field application approximately 720 gallons of the chemical were transferred to the boot truck in addition to about 1,150 gallons of water. The solution was sprayed at 1.0 gsy on the road surface. It is pointed out that the chemical appeared to have hardened somewhat in the drums due to the 103° F. temperature that lasted three days before the field application. Attempts to roll the surface after application were unsuccessful due to severe tracking. It was about two hours later when the section was rolled with tracking still observed. The road condition after rolling was not very good.

The cost of the field application is the same as for the laboratory test, given above.

Road Test - Mixing Treatment

Four sections of the road (7 through 10) were used for the mixing application of chemicals. Three chemicals and water (control) were used.

Site Preparation

The road surface was given a light water spray and then the surface was ripped, using the ripper attached to the grader, to a depth of about three inches. It was decided to aim for a three-inch stabilized, mixed and compacted mat due to the unavailability of a Seaman mixer and based on previous field results reported by Hoover (1971). In a previous study, Hoover (1971) reported difficulties in mixing and compacting a ripped four-inch thick layer and recommended future use of three-inch thickness. After the road surface was ripped up, additional water was sprayed to reduce surface tension effects, then a portion of the required chemical application was sprayed on the surface. The loosened surface soil was then bladed to the sides of the roads forming two windrows. Each windrow was then spread back on the road surface,sprayed with more chemical and water if necessary and then bladed to form a windrow in the middle of the road. When all the required chemical and enough water (to reach optimum moisture in the field) were added a continuous operation of surface mixing by the blade was done. After complete mixing two side-windrows were formed. The mixed soil was then spread on the surface and compacted in two lifts, forming a slight crown near the center. The field preparation for section no. 9 (water) is shown in Figure 10 (ripping), Figure 11 (water spraying) and Figure 12 (surface blading and mixing).

Each of the chemicals used is briefly discussed below. For each chemical the outline includes its major constituents, the dilution ratio,

FIGURE 10: ROAD SURFACE RIPPING

FIGURE 11: WATER SPRAY OF ROAD SURFACE

FIGURE 12: BLADE-MIXING OF SURFACE SOIL

rate of application,and the cost of application per square yard (chemical only) for a three-inch mat. The number given after the chemical name refers to the number assigned to each chemical during the laboratory testing program.

1. Water (0): Water spray was given as discussed above, with final moisture content measured at 9.5 percent. Field density reached was about 120 pcf. No tracking during compaction was observed.

2. Redicote E-52 (6): This is a cationic CSS-1h asphalt emulsion. Laboratory application calls for an 8.4 percent emulsion by dry weight of the soil compacted with enough water to reach optimum moisture content.

For the field application 4500 gallons were used for the three-inch compacted mat. At 120 pcf dry density, this gives 7.44 percent emulsion, and 2.41 gsy for a three-inch mat. The cost of this field application is 53 cents per square yard, F.O.B. supplier in Tucson, Arizona.

This treatment looked and still does (September 1974) very satisfactory.

3. Dust Bond 100 (18): This is a mixture of lignin sulfonate and other chemicals. The laboratory rate of application is at 1.0 gsy undiluted, for a two-inch compacted mat. About 2000 gallons of the chemical were sprayed at about 1 gsy, along with ten gallons of Formula 125, for a compacted three-inch mat. This rate of field application costs 41.3 cents per square yard, F.O.B. supplier in Tucson, Arizona.

4. Dust Control Oil (37): This chemical did not pass the laboratory test requirements, but was used as the supplier donated the chemical for field use.

The field application rate was at 1/2 gsy undiluted for a three-inch compacted mat. The cost of this chemical application is 7.5 cents and 21.5 cents per square yard, F.O.B. Richmond, California and Tucson, Arizona respectively. Two days after the field application, the first 150 feet of the treated section (No. 10) was sprayed with a surface application of 1/10 gsy of Dust Control Oil. This first section will be identified as section (10a), while the rest of the Dust Control Oil section as (10b).

CHAPTER 3

FIELD EVALUATION PROCEDURES

The field evaluation procedures were designed to monitor the degree of dust control and traffic erosion control on the test sites. It is pointed out that the field evaluation and monitoring techniques used in this phase were developed and/or modified by the principal investigator, due to the lack of well defined and widely accepted standardized tests that can be used for such monitoring.

Evaluation of Dust Control Sites

The field evaluation techniques used for evaluating the performance of the chemical application on the dust control sites (untrafficable) were similar to those developed and reported previously by the principal investigator, Sultan (1974). The methods of evaluation are briefly outlined below; and are conducted on a bi-weekly basis whenever the weather permits.

Sampling of Wind Blown Dust

A small Dayton Pole Blower was used as a wind simulator to stir dust particles off the surface. The blower was placed on an inclined steel support such that the air flow would hit the ground surface at an angle of about 40° with the horizontal. The wind velocity at the mouth of the blower was about 12 mph and reduces to approximately 8 mph at the point of impact on the ground. A High Volume Air Sampler (Harding and Hendrickson 1964 and Air Sampling Instruments 1966, pp. B-1-22- to B-1-26) was placed at a distance of four feet away from the blower along the direction of wind flow. A glass fiber (Gelman Type A) filter paper 8 in. x 10 in. in size was used to collect the dust particulates on it (Air Sampling Instruments 1966 p. B-2-4). This instrument and filter paper type are used by Pima County Air Pollution Control Division. The same kind of instrument or very similar to it is being used by most air pollution agencies including the

National Air Pollution Control Administration.

Sampling was conducted with the wind blower on, and the High Volume Sampler (HiVol) drawing air at a flow rate of about 50 cfm over a 5 min. period. Both the blower and the HiVol were operated using a gasoline driven electric generator. A schematic drawing of the test set-up is given in Figure 13. The development and modification of this test and the reasoning behind the chosen parameters are given in Appendix A.

After the 5 min. dust collection, the filter paper was removed from the HiVol and weighed in the laboratory. The difference between its final and original weights indicates the amount of dust collected as measured to the nearest milligram (mg). The amount of dust particulates collected during the 5 min. period was computed in micrograms per cubic meter ($\mu g/m^3$) since this unit is the one used by most agencies as a measure of the concentration of dust particulates in the atmosphere.

In the days when the atmosphere seemed to have a reasonably high dust particulate concentration, one reading of the HiVol for a 5 min. period without the blower operating was taken. All readings taken during the corresponding days were corrected by subtracting the atmosphere reading from the actual readings.

In order to evaluate the relative amount of dust fallout from untreated areas on the treated plots, a plywood sheet 4.0 feet by 6.0 feet is placed on the ground and left in the field continuously. A Hi-Vol reading is always taken for this plywood sheet in order to take into consideration the amount of accumulated dust other than wind stirred up dust.

Sampling for Extraction Test

Soil samples from the surface of the treated zones were obtained and used in an extraction test to determine the amount of benzene soluble organic matter present. Comparing the extracted amounts obtained from samples taken at different periods after application, a quantitative evaluation of the degree of leaching of the chemical is obtained.

A tin cup, 2 3/4 in. in diameter and 5/16 in. high, was pushed into the surface soil using a rubber mallet until its top was flush with the ground surface. The surface soil around the perimeter of the cup was then removed with a narrow spatula. A 3 in. wide spatula was then pushed underneath the cup to support the soil within it. The cup, with the soil

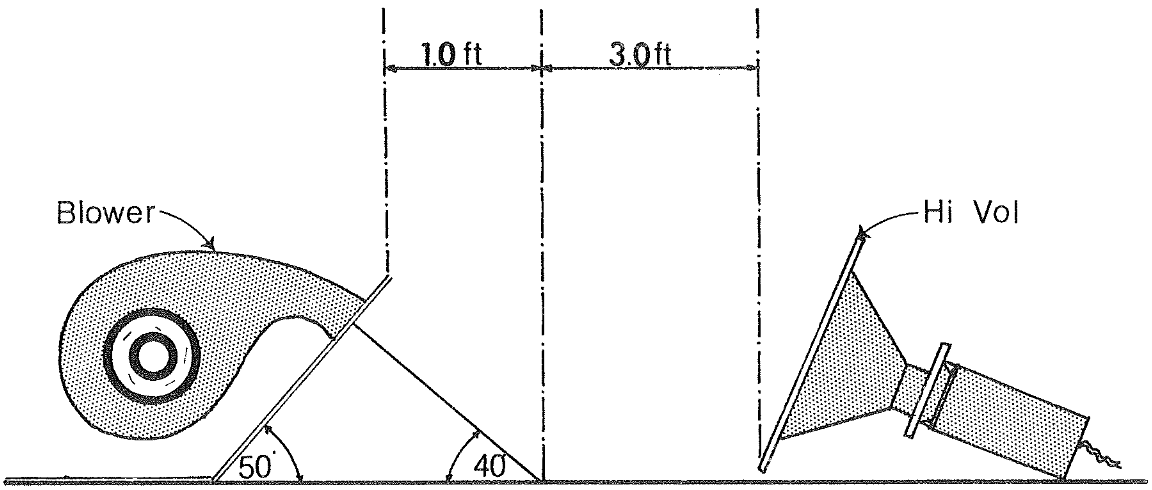


FIGURE 13 - SCHEMATIC DIAGRAM OF HI-VOL AND BLOWER ARRAGEMENT

in it, was then raised from the ground with the spatula, and turned over while the soil was still confined by the spatula. The soil surface in the cup was trimmed flush with the edges of the cup, and the soil was then saved in a tin can.

It is pointed out that after testing the first set of specimens it appeared that the benzene-extracted materials for most of the chemicals were not in the anticipated order of magnitude, Sultan (1974). Accordingly, extraction tests using benzene and water as the extracting fluids were run on laboratory-made control specimens. The results of these tests indicated further that the extracted material for most chemicals are still low, except that the water extracted material from the Norlig 41 and F-125 was significantly higher than that extracted by benzene.

Since this test essentially evaluates the degree of leaching out of each chemical individually with time, it was decided to continue the benzene as the extracting fluid, except in the Norlig 41 and F-125 case, where water is used instead.

In the laboratory the benzene extraction test was conducted on specimens (run in duplicates) obtained from each application zone. The weight of the extracted organics was measured to the nearest milligram (mg), and converted (according to the area of the cup) into grams per square yard (gm/yd^2).

The extraction procedure is outlined in Appendix B and is very similar to that outlined in the Public Health Service Publication No. 978, 1962 (p. 213), and the same as given by Sultan (1974).

Visual Inspection and Evaluation

In addition to the quantitative evaluation techniques discussed above, a qualitative evaluation is made periodically on the condition of each test plot. This evaluation includes condition of the surface, thickness and firmness of crust, color change, cracks, and vegetation growth. This inspection supplements the other tests and gives a handle in spotting erratic or unexpected results.

Evaluation Methods on Road Test

The following evaluation methods are conducted to evaluate the condition of the chemical treatment on the road. Most of the tests are conducted bi-weekly as the weather permits.

Sampling of Wind Blown Dust

This test is exactly the same as discussed for the dust control sites, and was conducted on each section of the road test.

Dust Collectors Across the Road

Dust collectors were installed across the road at the middle of each section. The dust collectors consist of plastic cups 3 1/2 inches diameter at the top, 2 3/4 inches diameter at the bottom, and 3 1/2 inches high. The cups were taped to the top of 2-inch wide plywood sticks, with their top approximately 3-feet above the ground. The containers were half-filled with distilled water and covered at the top with a wire screen with square openings of 2 millimeter size. The screen was taped to the side of the cup to prevent ants and other insects from crawling into the cup, as occurred when only a rubber band was used at first.

The cups were placed at a spacing of 20 feet for a distance of 140 feet and at a 50 foot spacing for an additional 100 feet at both sides of the road. The cups were left in place for a 21-day period and were periodically checked to make sure there was sufficient water in them. This test was considered to be relatively simple yet conforms, as nearly as possible, to ASTM designation D 1739 for collection and analysis of dust fall. The distance adopted for dust collection across the road (240 feet on both sides) was based on the results of similar reported testing by Hoover (1973), where the dust collected showed a very rapid drop-off from the road shoulder out to 30-40 feet, followed by a more gradual drop out to about 150 feet. Beyond 150 feet a nearly constant low deposition rate was reported by Hoover (1973).

At the end of the collection period, the cups were sealed and brought to the laboratory. Details of the laboratory filtration and determination of non-volatile solids (dust particles) are given in Appendix A. It is pointed out that this test will be conducted 3 to 4 times during the entire monitoring period.

Dust Collectors Along the Road

For this test the same type of cups are used and placed on the edge of the road (on both sides), half-filled with water. A pick-up truck is then driven continuously along the entire length of the road test sections, in both directions, at a constant speed of 30 mph. The cups are then picked up, sealed and returned to the laboratory where the amount of dust collected was determined as discussed above. This test was conducted on a bi-weekly basis.

<u>Adhesive-Sheet Dust Collection</u>

For the first few months of the field monitoring, attempts were made to collect dust on sheets of adhesive paper to see if they can replace and/or supplement the cup-collection method.

Along the cup collectors across the road, adhesive sheets (4 1/2 inch square) were placed flat with the adhesive side facing up, and pinned on top of plywood sticks similar to those mentioned before. This was done for one section of the road to evaluate the feasibility of this method.

In addition, the same size of adhesive sheets were attached to a 2 inch by 4 inch wood beam, 7 feet long. The beam was clamped to the bed of the pick-up truck making the distance between the adhesive sheet (facing the rear of the pick-up truck) at a 9 foot distance from the rear wheels. The pick-up truck was then driven at 30 mph, one section at a time, and the weight of dust collected on the adhesive sheet was measured.

These two attempts failed to provide a good method for dust collection and showed this technique to be not feasible. The adhesive sheets left across the road, lost their adhesive quality when exposed to the atmosphere and curled up within a few days. The sheets attached to the truck seemed to lose weight (moisture) when the adhesive side was exposed, and very erratic results including negative dust collection resulted. Accordingly, after two months of trials, this approach was discontinued.

<u>Visual Inspection and Evaluation</u>

In addition to the quantitative evaluation techniques given above, a qualitative evaluation is made periodically on the condition of each test section. This evaluation includes condition of the road surface, degree of dust control during traffic, riding quality, ruts, potholes, and surface cracking.

CHAPTER 4

PRELIMINARY FIELD RESULTS

Due to the short period of field monitoring to date (September 1974) and the preliminary nature of this progress report, only a brief evaluation of the field performances of the chemical treatments is given below.

Wind Erosion Sites

Since the ADOT Yard site was only sprayed at the last part of September 1974, the results discussed herein pertain to observations and measurements made on the AES Farm site.

AES Farm Site

As pointed out previously during the first three months of observation, the surface soil was more moist than usual due to the heavy summer rainfall received in Tucson. Preliminary observations for the various treated plots are briefly outlined in Table 2, including surface condition, color, crust, cracks, vegetation, and highest recorded dust concentration collected using the HiVol. The highest value was reported in lieu of other values since the site has been abnormally wet during the observation period.

Based on the data given in Table 2 and general field conditions, a preliminary performance rating for the top five of the applied chemicals may be given as follows:

1. Terrakrete #2
2. Surfaseal 1:10
3. Dust Control Oil 1/4 gsy
4. Norlig 41 + F 125
5. Coherex

It is pointed out that these data are only very preliminary in nature due to the short period of evaluation reported and the general moist condition of the surface due to heavy rains.

TABLE 2: PRELIMINARY OBSERVATIONS, AES-FARM SITE

Chem. No.	Chemical Name	Highest HiVol Collection $\mu g/m^3$	Description of Plot Condition
0	Water	64,301	Natural color, light vegetation, thin soft crust, some cracks
7	Aerospray 70	8,751	Lt. brown, v. light vegetn., hard crust 3/16 in., some cracks
13	Surfaseal 1:10	2,972	Brown, light vegetn., v. hard crust, 1/4 in., some cracks
13	Surfaseal 1:20	6,397	Lt brown, light vegetn., hard crust, 3/16 in., some cracks
20	Petroset SB	8,312	Natural, v. heavy vegetn., hard crust 3/16 in., some cracks
21	Coherex	4,857	Natural, v. light vegetn. med. crust 3/16 in., some cracks
25	Dresinate DS-60W-80F	7,122	Natural, light vegetn., hard crust 3/16 in., cracks
26	Paracol 1461	8,949	Natural, v. heavy vegetn., hard crust 3/16 in., cracks
27	Terrakrete #2	2,478	Natural, heavy vegetn., hard crust 1/4 in., light cracks
37	Dust Control Oil, 1/10 gsy	5,094	Grey-brn., med. vegetn., med. crust 3/16 in., some cracks
37	Dust Control Oil,1/4 gsy	3,441	Black, light vegetn., soft crust 5/16 in., light cracks
38	Dust Stop	5,862	Natural, med. vegetn., hard crust 3/16 in., some cracks
41	Foramine 99-194	8,921	Natural, v. light vegetn., v. weak crust, 1/16 in., many cracks

TABLE 2: CONTINUED

Chem. No.	Chemical Name	Highest HiVol Collection $\mu g/m^3$	Description of Plot Condition
46	Norlig 41 + F 125	4,490	Lt. brown, light vegetn., hard crust 3/16 in., some cracks

Traffic Erosion - Wilmot Road

The heavy rainfall during the summer months (June-August) caused a rather heavy overflow of sediment and debris from the sides of the road to the road surface. The heavy rainfall also caused some erosion near the shoulders.

Spray-on Application

Preliminary observations for the various sections of the road treated with the spray-on application are given in Table 3. The observations include the road condition, color, riding quality, observed dust behind traffic, loose material on the surface, and the highest recorded dust concentration using the HiVol.

Based on the data given in Table 3 and the general road conditions, a preliminary performance rating of the applied chemicals may be given as follows:

1. Dust Control Oil
2. Dust Bond 100 + Formula 125
3. Aerospray 70
4. Curasol AE
5. Foramine 99-194

Mixed-in Application

Preliminary observations for the various sections of the road treated by the mixed-in application are given in Table 4. The observations include the road condition, color, riding quality, observed dust behind traffic, loose material on the surface, and the highest recorded concentration using the HiVol.

Based on the data given in Table 4 and the general road conditions, a preliminary performance rating for the applied chemicals may be given as follows:

1. Redicote E-52
2. Dust Bond 100 + Formula 125
3. Dust Control Oil, Section (10a)
4. Dust Control Oil, Section (10b)

It should be noted again that these results are preliminary in nature, and the relative performances may vary between this stage (September 1974) and the end of the evaluation period (August 1975).

TABLE 3: PRELIMINARY OBSERVATIONS, WILMOT ROAD, SPRAY-ON APPLICATION

Chem. No.	Chemical Name	Highest HiVol Collection $\mu g/m^3$	Description of Road Condition
0	Water	63,367	Natural color, soft when wet, worn, rutted, large amount of loose material, large cloud of dust behind traffic.
7	Aerospray 70	4,932	Brown color, medium hard surface, medium wear and few ruts, small amount of loose material, light dust behind traffic.
9	Curasol AE	4,191	Dark brown, hard surface but worn, rutted with several potholes, substantial loose material on surface, moderate dust behind traffic.
18	Dust Bond 100 and F 125	5,286	Brown, hard surface, little wear, smooth surface with little loose material, very light dust behind traffic
37	Dust Control Oil	1,352	Black, very hard surface, some potholes near shoulders, minimal loose material, extremely light dust behind traffic
41	Foramine 99-194	16,918	Natural color, soft, worn and rutted surface, poor riding quality, large amount of loose material, almost as if untreated.

TABLE 3: PRELIMINARY OBSERVATIONS, WILMOT ROAD, SPRAY-ON APPLICATION

Chem. No.	Chemical Name	Highest HiVol Collection $\mu g/m^3$	Description of Road Condition
0	Water	63,367	Natural color, soft when wet, worn, rutted, large amount of loose material, large cloud of dust behind traffic.
7	Aerospray 70	4,932	Brown color, medium hard surface, medium wear and few ruts, small amount of loose material, light dust behind traffic.
9	Curasol AE	4,191	Dark brown, hard surface but worn, rutted with several potholes, substantial loose material on surface, moderate dust behind traffic.
18	Dust Bond 100 and F 125	5,286	Brown, hard surface, little wear, smooth surface with little loose material, very light dust behind traffic
37	Dust Control Oil	1,352	Black, very hard surface, some potholes near shoulders, minimal loose material, extremely light dust behind traffic
41	Foramine 99-194	16,918	Natural color, soft, worn and rutted surface, poor riding quality, large amount of loose material, almost as if untreated.

TABLE 4: PRELIMINARY OBSERVATIONS, WILMOT ROAD, MIXED-IN APPLICATION

Chem. No.	Chemical Name	Highest HiVol Collection $\mu g/m^3$	Description of Road Condition
0	Water	41,334	Natural color, soft when wet, worn, rutted, substantial amount of loose material, large dust cloud behind traffic
6	Redicote E52	1,246	Black, very hard, asphalt like surface, little wear, fairly smooth, no loose material, no dust behind traffic
18	Dust Bond 100 and Formula 125	1,897	Brown, hard surface, smooth, little wear, some loose material, very light dust behind traffic
37	Dust Control Oil Section (10a)	3,618	Black, hard in spots, many potholes and ruts, large loose material on surface, moderate dust behind traffic
37	Dust Control Oil Section (10b)	5,111	Black, hard in spots, very worn with ruts and potholes, substantial loose material, moderately heavy dust behind traffic

REFERENCES

1. Air Sampling Instruments (1966). American Conference of Governmental Industrial Hygienists, 3rd edition, Cincinnati.

2. Harding, C. I. and E. R. Hendrickson (1964), "Manual for Calibration and Use of High Volume Air Samplers in the Measurements of Suspended Particulate Matter," University of Florida Engineering and Industrial Experiment Station Bulletin, Series No. 117, Gainsville, August.

3. Hoover, J. M. (1971), "Surface Improvement and Dust Palliation of Unpaved Secondary Roads and Streets," Progress Report, Iowa Highway Research Board Project HR-151. Engineering Research Institute, Iowa State University, June.

4. Hoover, J. M. (1973), "Surface Improvement and Dust Palliation of Unpaved Secondary Roads and Streets," Final Report, Iowa Highway Research Board Project HR-151, Engineering Research Institute, Iowa State University, July.

5. Public Health Service, U.S. Dept. of H.E.W., Division of Air Pollution (1962), "Air Pollution Measurements of the National Air Sampling Network Analysis of Suspended Particulates 1957-1961," Public Health Service Publication No. 978, Washington, D.C.

6. Sultan, H. A. (1974), "Evaluation of Dust Control Oil and Coherex," Report AHD-RD-234, Prepared for Arizona Highway Department, Right-of-Way Section, Property Management Division, March.

APPENDIX A

SOME DETAILS OF FIELD AND LABORATORY TEST PROCEDURES

Development of HiVol Blower Dust Collection

This testing arrangement was initailly developed by Sultan (1974) based on actual field trials, and was modified for use in this project.

Inclination of Blower

With the steel support inclined at an angle of 50° with the horizontal as shown in Figure 13, the generated wind strikes the ground at an angle of 40° with the horizontal. This angle appeared to give the optimum dispersing of dust particles. Wind striking angles greater than 40° reduced the dispersing of the dust particles into the direction of the HiVol; while angles flatter than 40° diminished the wind capability to stir up the dust.

Distance Between HiVol and Blower

The distance between the tip of the blower and the tip of the HiVol was set at 4.0 feet. Original design, Sultan (1974), set the distance at 11.0 feet. However, using the later distance indicated still noticeable effects from small cross-winds and therefore the smaller distance was adopted for this project.

Time Duration of the Test

For an untreated dusty surface, the most part of the collected dust would be obtained within the first five minutes of the test. Sultan (1974) presented the results of a test conducted for up to 60 minutes of collection time on an untreated area. Within the first five minutes approximately 83 percent of the total dust amount was collected.

Calculation of Dust Amount

The difference between the original weight of the filter paper (W_o) and its final weight after the dust collection (W_f) gives the weight of the collected dust in grams.

$$\text{Dust collection in } \mu g/m^3 = \frac{W_f - W_o}{7.075} \times 10^6$$

Benzene Extraction Test

A benzene extraction was performed on surface soil specimens collected periodically in order to determine the amount of benzene soluble organic matter present including petroleum resin.

The following steps were followed:

1. Place the specimens in the extraction Thimble and place the latter inside the distilling flask (Public Health Service 1962, p. 213).
2. One hundred and fifty millimeters of reagent-grade, thiophene-free benzene were added to each sample. For the Norlig and F 125 chemical mixture, benzene was replaced by water as discussed in the report.
3. Place entire unit on a heater. Turn heater to calibration 70 and turn on the circulating cooling water.
4. The reflux process was carried out until the filtrate was reasonably clear; approximately four hours.
5. Shut off the heater and allow the entire system to cool off.
6. Filter the flask contents through glass-fiber filter paper, into a pre-weighed beaker. Rinse the extraction flask with a small amount of chloroform and pour also in the beaker.
7. The benzene plus chloroform was evaporated to dryness on a hot plate.
8. Weigh beaker after cooling to nearest milligram.
9. The difference in beaker weights was considered to represent the weight of the residual organic.
10. Calculations:

$$\frac{\text{Wt. of Residue (W gms)}}{5.96 \text{ in.}^2} \times \frac{(36)^2 \text{ in.}^2}{\text{yd}^2} \times \frac{1.19 \text{ yd}^2}{\text{m}^2} =$$

$$258 \text{ W gm/m}^2$$

* 5.96 in^2 = area of soil specimen (area of can)

Non-Volatile Solid Determination From Dust-Collection Cups

This test was performed on the contents of the dust collection cups after being returned to the laboratory, to determine the amount of collected dust-fall during the test period.

The following steps were followed:

1. Each collection cup was opened and any insects, seeds, or other large contaminates were removed using a fine-pointed tweezer. Three drops of hydrochloric acid were added to each cup to help dissolve organic matters.
2. A box of glass-fiber filters (100 sheets, 5.5 cm. diameter) were placed in an oven (103° C.) for 24 hours. After drying, the filter box was placed in a desiccator until needed for use.
3. Prior to use, the filters are removed from the box using the fine-pointed tweezer and each one is weighed to the nearest 0.0001 gm. After weighing, the filters are placed on numbered stainless steel racks (21 filters capacity).
4. As needed for each cup, one filter paper is removed from the racks and placed on the millipore filtering apparatus. Dust samples are then washed from the cups onto the filters and the contents are vacuum-filtered.
5. After filtering, the filter sheets are removed from the millipore apparatus and placed back (filter residue side up) on the stainless steel racks. The filters are allowed to air-dry for a few hours after which each filter is separated from the steel rack for a few seconds. This process prevents the filters from sticking to the rack when dried at 550° C. later on.
6. The steel rack with filters is then placed in a muffle furnace for a period of 20 minutes at 550° C. temperature. The rack and filters are then removed from the furnace and cooled for a few minutes. This cooling period does not exceed five minutes or filters may pick up moisture. The filters are then weighed to nearest 0.0001 gm.
7. The difference between initial weight and final weight of each filter represents the non-volatile weight of the dust solids.

8. A correction is usually made for this difference in weight, which accounts for the moisture loss from the filters when dried at 550° C.
9. The amount of dust can be reported in weights units, or can be converted to weight per acre per day per 100 vehicles as used by Hoover (1973).

APPENDIX B

CHEMICALS DONATED BY SUPPLIERS

Chemicals Donated for Field Use

The following is a tabulation of the chemicals donated for the field testing phase of this study. Other chemicals have been donated for the laboratory phase of the project. In addition, supplementary amounts were purchased for use in the field program.

	Chemical	Amount	Donated By
a)	Redicote E-52 (6)	4500 gallons	Arizona Refining Company and Armak
b)	Aerospray 72 (7)	20 gallons	American Cyanamid Co.
c)	Surfaseal (13)	10 gallons	Groutech Services, Inc.
d)	Dust Bond 100 (18)	1000 gallons	Ohm Research Products
e)	Petroset SB (20)	20 gallons	Phillips Petroleum Co.
f)	Coherex (21)	50 gallons	General Control Co.
g)	Dresinate 60W (25)	20 gallons	Hercules Incorporated
h)	Paracol 1461 (26)	20 gallons	Hercules Incorporated
i)	Terrakrete #2 (27)	20 gallons	Terrakrete
j)	Dust Control Oil (37)	2150 gallons	Standard Oil Company
k)	Dust Stop (38)	10 gallons	Standard Brands Chemicals
l)	Foramine 99-194 (41)	10 gallons	Reichhold Chemicals, Inc.
m)	Norlig 41 (46)	55 gallons	Pima County Highway Dept.